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Development of predictive models for paediatric unplanned hospital readmissions: A mixed-methods sequential explanatory study at a tertiary children's hospital in Western Australia

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received ethics approval from the Human Research Ethics Committee of Child and Adolescent Health Service - Princess Margaret Hospital (relocated and renamed as Perth Children's Hospital in June 2018) (HREC Reference number 2015015EP); Western Australian Department of Health (HREC Reference number 2015/55) and Curtin University Human Research Ethics Committee (HR184/2015).

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Abstract

Background

Paediatric patients are at high risk of experiencing an unplanned hospital readmission (UHR) since their transition from acute healthcare services typically requires caregivers to negotiate the transition process and manage post-hospital care at home. Studies examining paediatric UHRs and associated risk factors have been predominately conducted in America. Australian studies have focused on specific health condition related UHRs, such as asthma or mental health. There is a dearth of research identifying risk factors associated with paediatric all-cause UHRs in Australia. Existing evidence on the hospital-to-home transition process and recovery experience has mainly been generated from surveys or interviews with healthcare providers and parents/caregivers. There is a need to directly observe how transition information is communicated by healthcare providers, especially nurses to caregivers, and to gather qualitative information through interviews with those involved about their experience.

Aim & Objective

This study aimed to investigate paediatric UHR at a tertiary children's hospital in Western Australia (WA). The six study objectives were to (1) comprehensively review research-based evidence related to the transition of care at discharge for paediatric patients; (2) systematically examine predictive models for UHRs and to investigate and assess the characteristics of each model; (3) examine the prevalence and characteristics of all-cause UHRs at a tertiary children's hospital in WA from 2010 to 2014; (4) identify risk factors associated with 30-day all-cause unplanned hospital readmission at a tertiary children's hospital in WA based on an administrative inpatient dataset; (5) assess whether adding clinical information and written discharge documentation variables improve prediction of 30-day same hospital unplanned readmission compared to administrative information using machine learning analyses; and (6) observe and describe nurse-caregiver communication of paediatric hospital-to-home transition information.

Methods

An extensive analysis of the literature and research evidence was conducted to address Study Objectives 1 and 2. A mixed-methods sequential explanatory research design with two phases was selected to address Study Objectives 3 to 6. Phase 1 of the research design involved three stages of collection and analysis of quantitative data, while Phase 2 involved five stages of collection and analysis of qualitative data.

Phase 1/Stage 1 addressed Study Objective 3, a retrospective audit of a five-year administrative inpatient dataset examining prevalence and characteristics of paediatric UHRs. A total of 16 variables were extracted, including socio-demographic and administrative hospital information. Mean ± standard deviation or median were calculated for continuous variables, while counts and percentages were used for categorical variables. Results of Stage 1 informed the selection of the outcome measurement as 30-day all-cause readmissions for stage 2. Identification of the measurement also informed the sampling process for participants in Phase 2.

Phase 1/Stage 2 addressed Study Objective 4, which identified predictors of 30-day readmission by analysing the same 16 variables as in Stage 1 using forward stepwise multivariate logistic regression. The area under the receiver operating characteristic curve/c-statistic was calculated for the predictive model. Stage 2 informed which additional variables would be extracted and the selection of cases for Stage 3.

Phase 1/Stage 3 addressed Study Objective 5, which utilised machine learning analysis to develop predictive models by adding 11 clinical information variables and 13 written discharge document variables extracted from medical records. Three groups of variables consisting of a total of 40 variables were compared by sequentially fitting three logistic regression models: (1) Administrative variables only; (2) Administrative and clinical variables; (3) Administrative, clinical, and written discharge documentation variables. A multi-pronged approach to prediction was used to test consistency and robustness across models, including standard logistic regression to four machine learning approaches (stepwise logistic regression, random forest, elastic net, and gradient boosted trees). Results of Phase 1 identified a clear need to explore nurse-caregiver communication at discharge.

Phase 2 addressed Study Objective 6, which involved five stages, is guided by the Transitions Theory. Four core components of the theory include the nature of the transition, nursing therapeutics, transition conditions and patterns of response. Purposive sampling of patients with three health conditions associated with the most frequent UHRs was selected, including appendectomy, tonsillectomy and/or adenoidectomy, or bronchiolitis.

Phase 2/Stage 1 involved direct clinical observations of 31 transition experiences focusing on nurse-caregiver hospital-to-home transition information communication at the time of discharge; Stages 2–4, included semi-structured interviews of nurses and caregivers' perceptions and experiences of transitions of care at discharge and caregivers' views of post-hospital recovery since discharge; and Stage 5 reviewed the usage of hospital services post-discharge medical records for those patients in Stage 1. Phase 2 supplemented, elaborated on and confirmed the quantitative results of Phase 1 that the quality of transition information impacts the experience of children and caregivers at discharge and post-hospital discharge.

Findings

Study Objectives 1 and 2 were met and presented as Chapter Two consisting of three peer-reviewed journal publications and two chapter sections. A comprehensive literature analysis identified the limited Australian research evidence examining paediatric transition experience at discharge and all-cause unplanned hospital readmissions risk factors. A review of previously published research studies highlighted the need for a more robust research design, including quantitative and qualitative data, to address the overall aim. As a result, a mixed-method sequential explanatory research approach was adopted for this study. Study Objectives 3 to 6 were met and presented in Chapter Four as four peer-reviewed publications. Publication 4 (Phase 1/Stage 1) addressed Study Objective 3 and reported the 30-day UHR rate as 3.03% (discharge-base analysis) and 4.55% (patient-based analysis) at the participating hospital. Fifty-one percent of readmissions occurred by Day-5 post-discharge. The time intervals from discharge date to readmission date varied for diagnosis-specific readmissions of paediatric patients.

Publication 5 (Phase 1/Stage 2) addressed Study Objective 4 and identified seven significant predictors, including patients aged ≥ 13-year-old; utilised private insurance as an inpatient; with greater social-economic advantage; admitted on Friday; discharged on Friday/Saturday/Sunday; ≥ 4 diagnoses at the index admission; and length of stay (LOS) ≥ 15 days or longer. The model had a moderate predictive performance of a c-statistic of 0.645.

Publication 6 (Phase 1/Stage 3) addressed Study Objective 5 and found that the inclusion of written discharge documentation variables significantly improved readmission predictions compared with models based only on administrative and/or clinical variables in standard logistic regression analysis. The highest prediction accuracy was obtained using a gradient boosted tree model (c-statistic 0.654), followed closely by random forest and elastic net modelling approaches. Predictors of UHR included patients' social history (legal custody or Department for Child Protection), languages spoken at home other than English, completeness of *Nursing Admission and Discharge Planning Form*, and timing of issuing discharge summary.

Publication 7 (Phase 2/5 Stages) addressed Study Objective 6 and identified six common components of verbally delivered hospital-to-home transition information. The duration of nurse-caregiver communication and the approach used to deliver transition information primarily depended on nurses' years of experience and speciality practice area. Caregivers indicated they were either overwhelmed with the amount of information provided or felt the information was inadequate or inconsistent. Some caregivers perceived their child was not ready for discharge and felt uncertain about providing care at home.

Eight caregivers reported delayed recovery post-discharge from unexpected health issues. Seven presented to the Emergency Department within 2–19 days post-discharge, of which three were readmitted. Primary caregivers of the three readmitted patients all had limited English language proficiency and were not present when hospital-to-home transition information was provided.

Conclusion

Analyses and triangulation of the quantitative and qualitative data confirmed the literature that transitioning a paediatric patient from hospital to home is a multifaceted and challenging process. The findings also confirmed the complexity of deriving predictive models to predict paediatric unplanned hospital readmissions. Identifying predictors associated with paediatric readmission will facilitate healthcare providers to recognise and target children at higher risks of UHRs. These identified predictors need to be incorporated into the preparation and delivery of hospital-to-home transition information to reduce or prevent adverse events, such as unplanned Emergency Department (ED) visits and readmissions.

Gaining the insights of nurse-caregiver communication of hospital-to-home transition information at the time of discharge and during the recovery experience will inform the future development of an evidence-based, comprehensive transition framework. Key components of the framework include: specific transition information for patients at higher risk of UHRs, early commencement of the transition plan, implementation of a validated discharge readiness assessment tool, provision of interpreter services for families with language barriers, utilisation of “teach-back” technique when transition information is communicated, and completion and distribution of hospital discharge summaries. The framework could be utilised in clinical practice by healthcare providers to improve individualised transition planning and consistency of transition information delivery from healthcare providers to caregivers.

This study also recommends the inclusion of a comprehensive educational plan emphasising the importance of hospital-to-home transition information and discharge planning/process in ward orientation programs. This needs to be specifically focused for junior and casual staff to ensure consistency of information delivery. Ensuring tertiary hospitals have comprehensive electronic medical record systems is also warranted to facilitate access to clinical information and written discharge documentation information. Analysis of clinical data would in turn to inform changes in clinical practice care and potentially improve patient outcomes.

Future research should consider examining the most significant findings of this study that more than half of the UHRs occurred within five days post-discharge. A study examining WA linkage data including UHRs to the same or a different hospital across the breadth of WA is also recommended. This will provide opportunity to capture true prevalence of paediatric unplanned readmissions in WA.

This study will provide opportunity to improve the quality and safety of paediatric hospital-to-home transition and, as a result, reduce unplanned paediatric hospital readmissions.

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Table of Contents

List of Tables

Tables in Publication 1

Transitioning adolescent and young adults with chronic disease and/or disabilities from paediatric to adult care services – An integrative review. *Journal of Clinical Nursing*

Tables in Publication 2

Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review. *BMJ Open*

Tables in Publication 3

Risk factors associated with paediatric unplanned hospital readmissions: A systematic review. *BMJ Open*

Tables in Publication 4

A 5-year retrospective cohort study of unplanned readmissions in an Australian tertiary paediatric hospital. *Australian Health Review*

Tables in Publication 5

Risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in Western Australia. *Journal of Paediatrics and Child Health*

Tables in Publication 6

Using machine learning to predict paediatric 30-day unplanned hospital readmissions: A case-control retrospective analysis of medical records, including written discharge documentation. *Australian Health Review*

Tables in Publication 7

Nurse-caregiver communication of hospital-to-home transition information at a tertiary pediatric hospital in Western Australia: A multi-stage qualitative descriptive study. *Journal of Pediatirc Nursing*

List of Figures

Figures in Publication 1

Transitioning adolescent and young adults with chronic disease and/or disabilities from paediatric to adult care services – An integrative review. *Journal of Clinical Nursing*

Figures in Publication 2

Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review. *BMJ Open*

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Figures in Publication 6

Using machine learning to predict paediatric 30-day unplanned hospital readmissions: A case-control retrospective analysis of medical records, including written discharge documentation. *Australian Health Review*

List of Abbreviations

ASA	American Society of Anaesthesiologists
AUC	Area under the ROC curve
NSQHS	Australian National Safety and Quality Health Service
CCC	Chronic complex condition
CI	Confidence interval
ED	Emergency Department
ENT	Ear, Nose and Throat
XGBoost	Gradient booting trees
HMDS	Hospital Morbidity Data System
ICU	Intensive Care Unit
LASSO	Least Absolute Shrinkage and Selection Operator
LOS	Length of Stay
LEP	Limited English Proficiency
MAStARI	Meta-analysis of Statistics Assessment and Review Instrument
MyFT	My File Transfer
OR	Odds ratio
QARI	Qualitative Assessment Review Instrument
ROC	Receiver operating characteristic
RACHS	Risk Adjustment for Congenital Heart Surgery
SoNM&P	School of Nursing, Midwifery and Paramedicine
SEIFA	Socio-economic indexes for areas
SVM	Support Vector Machines
UMRN	Unique Medical Record Number
UK	United Kingdom
USA	United States of America
UHRs	Unplanned Hospital Readmissions
WA	Western Australia

Glossary of Terms

Primary caregivers	In this study, a primary caregiver means the legal guardian of a paediatric patient, for instance parent or foster parent.
Acute healthcare setting	In this study, acute care setting means acute hospital setting, in particular, Princess Margaret Hospital (PMH) for Children, Western Australia
Index admission	Hospital readmission is typically measured from an "index hospitalisation," which is the first hospitalisation for a particular clinical condition; subsequent admissions within a specified time period (30 days in this study) after the index hospitalisation are considered readmissions.
Calculation of unplanned hospital readmission prevalence	In this study, the prevalence of readmissions was calculated on both discharge-based and patient-based analysis because some patients had more than one index admission and readmission during the 5-year data retrieving period. If the patient had more than one unplanned readmission after being discharged within the 30 days, only the first readmission was included for the discharge-based analysis. Discharge-based analysis UHRs = Number of UHRs/Total number of discharges. Patient-based analysis UHRs = Number of patients experienced UHR/Total number of patients.

Publications Included in the Thesis

This thesis contains published works, all of which have been co-authored. The bibliographical details and descriptions of the works, and the contributions of each author are listed below. The publications are documented in order of their placement within the thesis chapters.

Publication 1

Zhou, H., Roberts, P., Dhaliwal, S.S., & Della, P. (2016). Transitioning adolescent and young adults with chronic disease and/or disabilities from paediatric to adult care services – An integrative review. *Journal of Clinical Nursing*, *25*, 3113–3130. http://doi.org/10.1111/jocn.13326

Huaqiong Zhou conducted the integrative review and developed the manuscript. Articles included in the integrative review were independently assessed by Huaqiong Zhou and Phillip Della. Huaqiong Zhou and Phillip Della independently extracted the systematic review data. Pam Roberts, Satvinder Dhaliwal, and Phillip Della critically reviewed the manuscript.

Publication 2

Zhou, H., Della, P., Roberts, P., Goh, L., &Dhaliwal, S.S. (2016). Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review. *BMJ Open*, *6*:e011060. http://doi.org/10.1136/bmjopen-2016-011060

Huaqiong Zhou conducted the literature review and developed the manuscript. Articles included in the integrative review were independently assessed by Huaqiong Zhou and Louise Goh. Huaqiong Zhou, Louise Goh and Satvinder Dhaliwal independently extracted the systematic review data. Phillip Della, Pam Roberts, Louise Goh, and Satvinder Dhaliwal critically reviewed the manuscript.

Publication 3

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Huaqiong Zhou conducted the literature review and developed the manuscript. Articles included in the integrative review were independently assessed by Huaqiong Zhou and Phillip Della. Huaqiong Zhou and Satvinder independently extracted the systematic review data. Pam Roberts, Satvinder Dhaliwal, and Phillip Della critically reviewed the manuscript.

Publication 4

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Huaqiong Zhou conducted the literature review, data analysis, interpretation, and developed the manuscript. All authors contributed to interpretation of the data for the work and critically reviewed the manuscript.

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Huaqiong Zhou conducted the literature review, data extraction, data analysis, interpretation, and developed the manuscript. All authors contributed to interpretation of the data for the work and critically reviewed the manuscript.

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Huaqiong Zhou conducted the literature review, data extraction, data analysis, interpretation, and developed the manuscript. All authors contributed to interpretation of the data for the work and critically reviewed the manuscript.

Publication 7

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Huaqiong Zhou conducted the literature review, data collection (observations, interviews, and medical records audit), data analysis, interpretation, and developed the manuscript. All authors contributed to interpretation of the data for the work and critically reviewed the manuscript.

Permissions of Contributing Authors

We confirm author contributions for all publications and that permission has been obtained from all authors to include the manuscripts in this PhD thesis.

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Additional Publications during the Candidacy not related to the Thesis

Book Chapters

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AlowenI, F., Ang, S.Y., Lim, M.L., Uthaman, T., Ayre, T.C., Della, P.R., & **Zhou H.** (2020) Shift-to-shift nursing handovers in multi-cultural and multi-lingual Tertiary Hospital in Singapore: An observational study. In: Watson B., Krieger J. (eds) Expanding Horizons in Health Communication. The Humanities in Asia, vol 6. Springer, Singapore

Journal Articles

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Ang, S.Y., Dhaliwal, S.S., Ayre, T.C., Uthaman, T., Fong, Y.F., Tien, C.E., **Zhou, H.**, & Della, P. (2016). Demographics and personality factors associated with burnout among nurses in a Singapore tertiary hospital. *BioMed Research International*. Article ID 6960184. http://dx.doi.org/10.1155/2016/6960184

Watts, R., **Zhou, H**., Shields, L., Taylor, M., Hunter, J., & Munns, A. (2014). Family-centered care for hospitalized children aged 0–12 years: A systematic review of qualitative studies. *The JBI Database of Systematic Reviews and Implementation Reports*, *12* (7), 204–283.

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Zhou, H., & Della, R.P. (2019). Improving the effectiveness and efficiency of paediatric discharge planning: linking a series of research studies. Oral presentation June 2019, The International Council of Nurses (ICN) Congress, Singapore.

Zhou, H., Della, R.P., & Roberts, P.A. (2018). An updated integrative review on transiting adolescents and young adults with chronic illness and/or disabilities from paediatric to adult healthcare services. Oral presentation October 2018, The Australian College of Children and Young Peoples Nurses 2018 International Conference, Perth.

Chapter 1

Introduction to the Study

Transitioning paediatric patients from hospital to home is recognised as a multifaceted and challenging process. Insufficient hospital-to-home transition planning and inconsistent delivery of transition information may result in an unplanned Emergency Department presentation and/or hospital readmission. While there have been multiple attempts to understand the complexities associated with the transition of care from the acute hospital setting to home, this has had minimal impact in terms of reducing the occurrence of unplanned hospital readmissions (UHRs). The development and use of reliable predictive models to assist the identification of patients at high risk of readmission is also limited. Further investigation of predictive models which identify at risk patients and facilitate strategies to be implemented to potentially reduce the likelihood of readmission, is warranted.

This thesis is presented as seven peer-reviewed journal publications, including three comprehensive literature analyses and four primary studies. The primary studies were conducted at a tertiary children's hospital in Perth, Western Australia (WA) and involved analysis of an administrative inpatient dataset, direct clinical observations, interviews of both nurses and caregivers plus examination of patient medical records. Together, the findings of these studies confirm not only the complexities associated with developing reliable predictive models for paediatric UHRs but also the inconsistencies in communicating hospital-to-home transition information.

Chapter One presents an overview of key concepts of the study including transitions of care, communication of hospital-to-home transition information for paediatric patients, UHRs, and risk factors associated with paediatric UHRs. The rationale for employing a sequential explanatory mixed-method research design for this study and the significance of research findings to patients' outcomes and healthcare services are discussed. Study aims and objectives are identified and situated within the context of transitioning paediatric patients from an acute hospital setting to home. The chapter concludes with an outline of the thesis.

1.1 Transitions of Care

Transitioning patients within and across health care facilities or from hospital to home has been gradually conceded as a complex process rather than a single event at a point in time. The transition of care process is defined as "a set of actions designed to ensure the coordination and continuity of healthcare as patients transfer between different locations or different levels of care within the same location" (Coleman & Boult, 2003, p. 556). Issues associated with the process of transitioning patients and their ongoing care needs are acknowledged as complex and multifaceted. Differing individual requirements of the transition process are acknowledged as dependent on the physical, intellectual and psych-social condition of each patient. As a result, they may present as an unplanned hospital readmission following a patient's discharge to their home or transfer to another facility (Noyola et al., 2014; Schattner, 2014; Wish, 2014).

Ensuring continuity in the delivery of ongoing care when transitioning patients from hospital (acute healthcare setting) to home (primary care setting) has been recognized as one of the most significant, costly and problematic aspects of healthcare practice (Kripalani et al., 2007). Ineffective communication during the delivery of transition of care information is identified as a major contributing factor to adverse events that directly risk patient safety (Garvey et al., 2012; Kaehne, 2011; Kripalani et al., 2007; Laugaland et al., 2011; Wong et al., 2010), accounting for 41% of avoidable hospital readmissions (Muecke et al., 2010; Russell et al., 2011; Wong et al., 2007).

An international study by Schoen et al. (2005) surveyed chronically ill adults in six countries about their experience of hospital-discharge and delivery of hospital-to-home transition information. Australian patients reported higher rates of communication failure throughout hospitalisation (14.2%; n = 351). The most frequent comment made by 5% of respondents, was that they did not receive clear instructions about symptoms to monitor following hospital discharge. This study also suggested transitioning patients experience a high rate (20%) of Emergency Department return visits and/or readmissions resulting from complications experienced during the recovery phase post-hospital discharge (Schoen et al., 2005).

An Australian Research Council -funded research project – Effective Communication in Clinical Handover (2011–2014) analysed the spoken, written and non-verbal communications used by healthcare providers during clinical handover of patients transferring between health facilities. The results identified both the scale and significance of problems associated with communicating information. These include (1) standardisation of transitioning processes and documentation; (2) skills and training required to engage high-risk patients and their carers actively in the transition process, and (3) patients and caregivers' confidence and understanding of their role in improving transition of care experience.

Encouraging patient and caregiver participation in care, especially in decision-making as part of the transition plan is therefore essential to improve patient safety and enhance quality outcomes. Research evidence suggests that when healthcare providers use communication strategies that invite patient/caregiver input, such as giving the patient space to tell their story, express their anxieties and ask questions, risks may be both identified and managed more effectively (Eggins & Slade, 2012; Russell et al., 2011; Slade et al., 2011).

1.2 Hospital-to-home Transition Information for Paediatric Patients

Compared to the adult literature, there are considerably fewer studies examining the experience of children who transition from hospital to home. Early research evidence noted that sufficient hospital-to-home transition planning and comprehensive transition of care information for the child post-discharge are critical to improve patients' and caregivers' post-discharge experience (Keatinge et al., 2009) and to prevent adverse outcomes for patients including unplanned ED visits and/or readmission (Berry et al., 2014; Nemetchek et al., 2019). Transition information provided to caregivers is described in two main forms in the literature. The first form uses education-based terms, such as 'discharge instruction' (Coleman et al., 2013; Lerret et al., 2014) or 'discharge teaching' (Lerret et al., 2015; Weiss et al., 2017). The second uses information sharing/exchange-based terms, including 'patient handover' (Hesselink et al., 2012) and 'transfer of information' (Lerret & Weiss, 2011). In this study, the information provided at the time of discharge is referred to as 'hospital-to-home transition information' to highlight the critical need to ensure continuity in the delivery of ongoing care for patients transitioning from hospital to home.

Previous studies have shown that caregivers perceived a higher level of readiness for discharge when provided with comprehensive hospital-to-home transition information. This also resulted in decreased unplanned hospital readmission rates for children (Lerret et al., 2015; Parikh et al., 2018). In this study readiness for discharge from a caregivers' perspective refers to whether caregivers feel ready to take their child home and fully understand the transition information and continued care requirements. Ineffective or insufficient communication of transition of care information increases the risk of a patient experiencing delayed recovery, unplanned ED visit, or readmission (Harlan et al., 2010).

Research also suggests healthcare providers may lack sufficient knowledge and understanding of the approach and potential benefits of preparing caregivers for transition from hospital-to-home and the ongoing care required post-discharge. As a result, patients and caregivers may lack confidence and understanding of their roles and how they contribute to the transition process and recovery experience (Berry et al., 2014; Keatinge et al., 2009). In Australian research up to 22% of patients and/or caregivers reported they had not been involved as much as they wanted in decisions about their transitional care (Canary & Wilkins, 2017; Eggins & Slade, 2012; Slade et al., 2011).

Caregivers take on significant responsibilities to provide continued care for their child/children post-discharge from an acute hospital (Pinto et al., 2015). Many patients require ongoing treatment, medication administration, follow-up appointments and monitoring of their health conditions to determine whether further medical advice or treatment is needed. In addition, caregivers also face the challenges of maintaining the family routine and juggling their own work and wellbeing (Ford et al., 2012; Pinto et al., 2015; Pinto et al., 2010). Caregivers and children described three types of experiences following discharge from hospital, uncomplicated recovery; prolonged recovery due to unexpected issues, for example, pain management following surgery; and unplanned Emergency Department presentation or hospital readmission because of worsened health conditions (Ford et al., 2012).

1.3 Unplanned Hospital Readmissions

Unplanned hospital readmission rate is defined by the Australian Institute of Health and Welfare (2013) as the percentage of unplanned or unexpected readmissions within 28 days of being discharged and which is related to the index admission. International literature, primarily measures UHR as within 30 days of discharge (Bosco 3rd et al., 2014; Markham et al., 2019; Schattner, 2014). In this study 30-day UHR measurement is used to allow for international comparison.

Literature has generally identified the UHR rates as either all-cause UHR or condition-specific UHR. All-cause UHR refers to an unplanned hospital readmission from any cause for a population within a specified time frame. In contrast, condition-specific UHR is the readmission of a patient with a specific health condition, for example asthma, within a specific population in a given time period (Chung et al., 2015). Australian research suggests more than 30% of Australian patients, who had undergone a surgical procedure, were unexpectedly readmitted to hospital within 28 days from their initial discharge, with issues related to the initial index admission. The three most frequently cited surgical procedures associated with those readmitted patients were tonsillectomy and adenoidectomy, prostatectomy or hysterectomy (Australian Institute of Health and Welfare, 2013). From a paediatric perspective, an Australian study by Awad et al. (2004) retrospectively examined 10,772 paediatric day case surgeries over a 3-year period and found that 242 (2.2%)

paediatric patients were unexpectedly readmitted to hospital following their discharge due predominantly to pain and/or surgical complications.

Unplanned hospital readmissions not only disrupt the routines of patient and/or family/caregivers but also results in significant additional cost to the healthcare system (Centers for Medicare & Medicaid Services, 2013; Jencks et al., 2009). In the United States of America (USA) it has been estimated that 7.8 million (20%) of patients discharged from hospital were readmitted to the same hospital or another hospital related to the index admission and this accounted for US$17.4 billion of hospital payments by Medicare (Centers for Medicare & Medicaid Services, 2013; Centre, 2011; Jencks et al., 2009). In the United Kingdom (UK) approximately 35% of patients were identified as having experienced a UHR, and this is estimated to cost 11 billion pounds per annum (5.3 million admissions in 2010/11) (Health & Social Care Information Centre, 2011). The estimated cost of UHRs in Australia is Australian $1.5 billion annually (Considine et al., 2019).

1.4 Risk Factors Associated with Unplanned Hospital Readmission

In view of the negative impact UHRs have on patients, caregivers and the healthcare system, there has been increased emphasis directed toward identification of paediatric patients, who are at higher risk of readmission (Auger & Davis, 2015; Beck et al., 2006; Coller et al., 2013; Khan et al., 2015; Toomey et al., 2016; Wijlaars et al., 2016). Identifying paediatric patients more at risk allows healthcare providers to implement strategies to improve delivery of hospital-to-home transition information prior to discharge and potentially reduce unplanned readmissions (Leppin et al., 2014). The reported significant risk factors associated with paediatric all-cause unplanned readmissions include comorbidity, type of health insurance, illness severity, age, gender, ethnicity, and day of admission (Auger & Davis, 2015; Beck et al., 2006; Coller et al., 2013; Khan et al., 2015; Toomey et al., 2016; Wijlaars et al., 2016).

The identification of risk factors relies largely on the number and types of variables included in the statistical analysis (Zhou, Roberts, et al., 2019) and this depends on how easily the administrative databases and/or medical records can be accessed. The main variables identified in literature are referred to as socio-demographic, hospital administrative variables (admission type, length of stay, principal diagnosis and comorbidities), and clinical/medical variables (vital signs or laboratory/image test results).

Additional studies investigated the quality of written discharge documentation, such as a follow-up plan or discharge summary, and whether it contributed to UHR (Coller et al., 2013; Feng et al., 2017; Topal et al., 2014). Results were varied, while all studies acknowledged the vital role written information has on the quality of hospital-to-home transition experience, inconsistencies in content of transition information were identified due to variations in data extraction and analysis of written information. An additional issue to emerge in these studies was associated with the extraction of written discharge documentation as a data collection method due mainly to the significant amount of time required and therefore the cost associated with extracting information (Choudhry et al., 2016; Coghlin et al., 2014; Olsen et al., 2012).

Several attempts have been made to develop predictive models as a way of potentially reducing avoidable/preventable UHR. Measurements included in the development of predictive tools varied across five studies due to differences in population, sample size and geographical location (Billings et al., 2012; Edward et al., 2013; Franchi et al., 2013; Halfon, 2002). The performance of predictive tools/models was reported as either low in terms of sensitivity and predictability or there was a lack of validation in clinical settings.

Recent research has utilised advanced machine learning analysis to predict UHRs instead of standard regression methods (Wiens & Shenoy, 2018). Machine learning refers to a field of computer science that aims to build and adapt models, which teach computer (machine) to "learn" through experience (existing data). Machine learning involves the construction of algorithms that adapt models to improve their ability to make predictions (Meyfroidt et al., 2009). The most frequently applied machine learning approaches in research studies include random forests, least absolute selection and shrinkage operator, and gradient boosted decision trees. The number of paediatric studies using an advanced machine learning approach remains limited. So far there have been six studies which have analysed administrative datasets. There is a need to base the development of predictive models on more comprehensive data extracted from medical records using machine learning analysis (Ehwerhemuepha et al., 2020; Janjua et al., 2019; Stiglic et al., 2014; Taylor et al., 2020; Wolff et al., 2019).

1.5 Study Setting

This study was conducted at a major paediatric hospital facility which is part of the Western Australian public health system. The Australian healthcare system has adopted a hybrid model where, in addition to the mandatory public health insurance, citizens, permanent residents, and refugees can either pay and/or use private health insurance in the public health system. Health insurance arrangements allow individuals access to both public and private hospitals (Dixit & Sambasivan, 2018). While the Commonwealth Government of Australia administers the public health insurance system known as the Medicare scheme, state and territory governments share responsibility for managing their individual state/territory based health care system. While comprehensive, the system is under pressure due to increased demand, shortage of workforce, greater acuity in care requirements, increased utilisation and rising costs.

The Western Australian public health system is recognised as one of the most effective and efficient by the Organisation for Economic Co-operation and Development (Dixit & Sambasivan, 2018). Western Australia spans more than 2.5 million square kilometres and is the largest area in the world covered by a single health authority. Western Australia's public health system (WA Health) consists of over 80 hospitals, including seven tertiary, eight secondary and 70 country sites (Government of Western Australia Department of Health, n.d.). There is only one public acute tertiary children's hospital in WA providing paediatric healthcare services to the community as part of the Children and Adolescent Health Service. Bed capacity at the time of this study was 220, and the hospital provided care for neonates, children, adolescents and young adults. Inpatient and outpatient visits total approximately 250,000 annually (Child and Adolescent Health Service, 2018).

The current Australian public health insurance system is struggling with increasing inpatient hospital demand and UHRs is one of the major contributing factors. In Western Australia, the prevalence of 28-day all-cause readmissions to the same hospital across all metropolitan public health services has increased from 2.1% (2010–11) to 3.9% (2014–15) (Government of Western Australia Department of Health, 2011, 2012, 2013, 2014, 2015).

1.6 Rationale for Study

Paediatric patients are at high risk of experiencing unplanned hospital readmission since their transition from an acute healthcare setting typically requires caregivers to negotiate and manage the transition process and post-transition care on their behalf (Beal et al., 2004; Berry et al., 2017). Studies examining the characteristics of paediatric UHR and associated risk factors have been predominately conducted in the USA. Australian studies identifying risk factors have focused on specific health conditions, such as asthma (Veeranki et al., 2017; Vicendese et al., 2015), or mental health (Barker et al., 2010). There is a dearth of research evidence examining the characteristics of paediatric patients who experience all-cause UHRs and the associated risk predictive factors in Australia.

Previous studies have focused on wide ranging, but very different aspects of the hospital to home transition of care experience. These studies have primarily been conducted in isolation with a single rather than multifaceted research focus. What is urgently required is an integrated, rigorous research approach, including both quantitative and qualitative methods. Existing evidence on the transition of care process and post-transition experience of children and caregivers has mainly been generated from surveys or interviews with parents/caregivers and healthcare providers. There is a need to directly observe and document how transition of care information is communicated by healthcare providers, especially from nurses to caregivers, and to gather qualitative information about the experience via interviews with those involved.

1.7 Aim and Objectives

This study aimed to investigate paediatric unplanned hospital readmission to a tertiary children's hospital in WA. The specific objectives related to this study were to:

1. Comprehensively review research-based evidence related to the transition of care at discharge for paediatric patients;
2. Systematically examine predictive models for UHRs and to investigate and assess the characteristics of each model;
3. Examine the prevalence and characteristics of all-cause UHRs at a tertiary children's hospital in WA from 2010 to 2014;
4. Identify risk factors associated with 30-day all-cause unplanned hospital readmission at a tertiary children's hospital in WA based on an administrative inpatient dataset;
5. Assess whether adding clinical information and written discharge documentation variables improve prediction of 30-day same hospital unplanned readmission compared to administrative information using machine learning analyses;
6. Observe and describe nurse-caregiver communication of paediatric hospital-to-home transition information.

1.8 Significance of the Study

This study aligns with World Health Organisation priorities for action on patient safety specifically in relation to communication and implementation of Australian National Safety and Quality Health Service (NSQHS) Standards (Australian Commission on Safety and Quality in Health Care, 2012). A significant aspect of the study is the development of a paediatric predictive risk model. A reliable model, based on hospital morbidity and clinical audit data, would fill a significant knowledge gap about what paediatric risk factors, including aspects of communication, are most salient for paediatric patients. Identification of specific risk factors would enable paediatric patients at high risk of an UHR following their initial index admission to be managed more effectively. Strategies aimed at reducing UHR could include individualised hospital-to-home transition planning.

Analysis of authentic clinical observations conducted in a paediatric hospital discharge context will enable the generation of objective descriptions of nurse-caregiver hospital-to-home transition of care communication. Systematic investigation of the content and communication of transition of care information using direct clinical observations could inform the development of an evidence-based, comprehensive framework that can be translated into resources and recommendations for patients and healthcare providers.

Outcomes resulting from this study could make a significant contribution to improving paediatric patient safety, reducing inefficiencies in hospital bed usage, and changing the economic impact associated with a poor transition experience from the acute hospital setting to home.

1.9 Thesis Structure

The thesis is presented in five chapters. Each chapter provides an outline detailing the layout and content. Seven peer-reviewed journal publications are embedded in the thesis, of which, three publications (Publication 1–3) are in Chapter Two and the remaining four (Publication 4–7) are in Chapter Four. Figure 1.1 displays the journal publications addressing each study objective.

Chapter One, *Introduction to the Study*, is an overview of the project's background, study setting, rationale and significance. Aims and objectives of the study have also been identified.

Chapter Two, *Exploring the literature*, including three publications (Publication 1–3). Publication 1 presents an integrative review examining the experiences and outcomes of transitioning adolescent and young adults between health care settings. In particular, the experiences of young adults with chronic disease and/or disabilities transitioning from paediatric healthcare settings to adult healthcare services are highlighted. An additional literature review examining paediatric hospital-to-home transition processes and post-transition recovery experiences is included and presented in Section 2.3. Publication 2 provides an updated systematic review on the performance of predictive models for 28-day or 30-day UHRs in the adult population. Publication 3 systematically reviews risk factors associated with paediatric UHRs. Section 2.6 of Chapter Two is an updated review of research evidence examining risk factors associated with paediatric unplanned readmission.

Chapter Three, *Methodology*, provides a detailed description of the research design. A sequential explanatory mixed-method approach is used as the overarching research design. The chapter provides a rationale for the approach and describes how each phase provides information to inform the development of the next. The first phase of the study utilised a retrospective cohort quantitative data collection strategy and this was followed by a prospective qualitative strategy. Within each phase, methods of sampling, data collection, data analysis and ethical considerations are noted.

Chapter Four, *Research Outcomes*, consists of four peer-reviewed published journal publications (Publication 4–7). Publication 4 investigates prevalence and characteristics of all-cause same hospital unplanned readmissions at a tertiary children's hospital based on a 5-year inpatient electronic administrative dataset. Publication 5 identifies risk factors associated with 30-day all-cause paediatric UHRs using the same dataset as the first publication. A predictive model is developed, and model prediction performance is evaluated using the collected dataset. Publication 6 addresses the research question whether the addition of clinical information and written discharge documentation variables improves unplanned readmission predication when compared to using administrative variables only. This publication also applied advanced machine learning analysis techniques in addition to standard logistic regression analysis to ensure consistency and robustness across models. Publication 7 qualitatively explores communication of hospital-to-home transition of care information between nurses and caregivers via analysis of direct clinical observations and semi-structured interviews. Patients' usage of hospital services within 30 days post-hospital discharge is also included as a measure of the quality of the transition of care experience.

Chapter Five, *Discussion*, discusses study findings based on the aim and objectives of this study. Recommendations for clinical practice, education, policymaking, and research are formulated based on the results. The project's strengths and limitations are discussed, and a reflection of the challenges is shared.

Chapter Six, *Conclusion*, provides final conclusion of the study. Knowledge translation activities and dissemination of research findings to the research site is also presented.

The reference list is presented as per the 7th APA referencing style comprising references cited in the thesis chapters and the seven publications. The Appendices are presented at the end of the thesis document including copyright clearance confirmation, publication engagement evidence, ethics approvals, and all relevant data collection documents.

Figure 1.1

Journal Publications and Additional Literature Supporting the Study Objectives

Objective 1 — **To comprehensively review the research-based evidence related to the transition of care at discharge for paediatric patients.**

- **Publication 1:** Transitioning adolescent and young adults with chronic disease and/or disabilities from paediatric to adult care services – An integrative review.
- A further comprehensive review on paediatric hospital to home transition experience and recovery post-hospital discharge was undertaken and presented in Chapter Two, Section 2.3.

Objective 2 — **To systematically examine predictive models for unplanned hospital readmissions and to investigate and assess the characteristics of each model.**

- **Publication 2:** Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review.
- **Publication 3:** Risk factors associated with paediatric unplanned hospital readmissions: a systematic review.
- New literature on risk factors associated with paediatric unplanned hospital readmissions was undertaken and presented in Chapter Two, Section 2.6.

Objective 3 — **To examine the prevalence and characteristics of all-cause unplanned hospital readmissions at a tertiary children's hospital in WA from 2010 to 2014.**

- **Publication 4:** A 5-year retrospective cohort study of unplanned readmissions in an Australian tertiary paediatric hospital.

Objective 4 — **To identify risk factors associated with 30-day all-cause unplanned hospital readmission at a tertiary children's hospital in WA based on an administrative patient dataset.**

- **Publication 5** Risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in Western Australia.

Objective 5 — **To assess whether adding clinical information and written discharge documentation variables improve prediction of 30-day same hospital unplanned readmission compared to administrative information using machine learning analyses.**

- **Publication 6** Using machine learning to predict paediatric 30-day unplanned hospital readmissions: A case-control retrospective analysis of medical records including written discharge documentation.

Objective 6 — **To observe and describe nurse-caregiver communication of paediatric hospital-to-home transition of care information.**

- **Publication 7** Nurse-caregiver communication of hospital-to-home transition information at a tertiary paediatric hospital in Western Australia: A multi-stage qualitative descriptive study.

Chapter 2

Exploring the Literature

2.1 Chapter Overview

Chapter Two explores in-depth Study Objectives 1 and 2. Key concepts examined include transitions of care processes, performance of predictive models, paediatric risk factors associated with unplanned hospital readmission, and current research evidence influencing risk prediction of UHRs. The chapter is presented in seven sections. Following Section 2.1 Chapter Overview, Section 2.2 presents Publication 1, an integrative review examining the current research evidence on adolescent and young adults with chronic disease and/or disabilities transitioning from paediatric to adult healthcare services. Section 2.3 presents a comprehensive literature review of hospital-to-home transition processes and recovery experiences of paediatric patients and their caregivers.

Section 2.4 and 2.5 present published systematic reviews (Publication 2 and 3) examining the (1) performance and utility of predictive models for 28-day or 30-day UHRs; and (2) risk factors associated with paediatric UHRs. These publications provide a deeper understanding of the effectiveness of risk predictions models and known risk factors, which contribute to UHRs.

Section 2.6 critically reviews the literature, which has emerged since publication of the systematic review in Section 2.5, to ensure the discussion and recommendations from this study are contemporary. Section 2.7 provides a summary to conclude Chapter Two.

2.2 Publication 1

Zhou, H., Roberts, P.A., Dhaliwal, S.S., & Della, P.R. (2016). Transitioning adolescent and young adults with chronic disease and/or disabilities from paediatric to adult care services – An integrative review. *Journal of Clinical Nursing*, *25*, 3113–3130. http://doi.org/10.1111/jocn.13326

The *Journal of Clinical Nursing* (JCN) was selected for this publication as it is an international, peer-reviewed, scientific journal that publishes high quality research evidence that is directly relevant to nursing practice. The JCN focuses on clinical needs and the implications for nursing interventions and models of service delivery. The impact factor of this journal was 1.456 for Year 2016. Confirmation of adherence to copyright requirements is evidenced in Appendix A.1.

This publication has been cited 52 times by 2 August 2021 as per Scopus (Appendix D.1). Scopus is an abstract and citation database that indexes to 36,000+ journals, books and conference proceedings across engineering, health sciences, humanities and science disciplines.

Specific objective of Publication 1 was:

- To comprehensively review the research-based evidence on transitions of care for adolescents and young adults with chronic illness/disabilities.

Main findings of Publication 1 were:

- A total of 61 studies were included.
- Six main themes emerged from data synthesis included *Timing of transition*; *Perceptions of the transition*; *Preparation for the transition*; *Patients' outcomes post-transition*; *Barriers to the transition*; and *Facilitating factors to the transition*.
- The identified five major barriers were *inadequate preparation prior to transition; lack of resources and accessibility of healthcare services; complex health conditions; excessive parental involvement in the care of patients; insufficient communication/information exchange among healthcare providers*.

JCN Journal of Clinical Nursing

Journal of Clinical Nursing

REVIEW

Transitioning adolescent and young adults with chronic disease and/or disabilities from paediatric to adult care services – an integrative review

Huaqiong Zhou, Pamela Roberts, Satvinder Dhaliwal and Phillip Della

Aims and objectives. This paper aims to provide an updated comprehensive review of the research-based evidence related to the transitions of care process for adolescents and young adults with chronic illness/disabilities since 2010.

Background. Transitioning adolescent and young adults with chronic disease and/or disabilities to adult care services is a complex process, which requires coordination and continuity of health care. The quality of the transition process not only impacts on special health care needs of the patients, but also their psychosocial development. Inconsistent evidence was found regarding the process of transitioning adolescent and young adults.

Design. An integrative review was conducted using a five-stage process: problem identification, literature search, data evaluation, data analysis and presentation.

Methods. A search was carried out using the EBSCOhost, Embase, MEDLINE, PsycINFO, and AustHealth, from 2010 to 31 October 2014. The key search terms were (adolescent or young adult) AND (chronic disease or long-term illness/conditions or disability) AND (transition to adult care or continuity of patient care or transfer or transition).

Results. A total of 5719 records were initially identified. After applying the inclusion criteria a final 61 studies were included. Six main categories derived from the data synthesis process are *Timing of transition; Perceptions of the transition; Preparation for the transition; Patients' outcomes post-transition; Barriers to the transition; and Facilitating factors to the transition.* A further 15 subcategories also surfaced.

Conclusions. In the last five years, there has been improvement in health outcomes of adolescent and young adults post-transition by applying a structured multidisciplinary transition programme, especially for patients with cystic fibrosis and diabetes. However, overall patients' outcomes after being transited to adult health care services, if recorded, have remained poor both physically and psychosocially. An accurate tracking mechanism needs to be established by stakeholders as a formal channel to monitor patients' outcomes post- transition.

What does this paper contribute to the wider global clinical community?

- Evidence of improvement in health outcomes of adolescent and young adults with chronic disease and/or disabilities post-transition by applying a structured multidisciplinary transition programme, especially for patients with cystic fibrosis and diabetes since 2010.
- The identification of 'readiness to transition' as a critical element to improve patient outcomes.
- The need to establish an accurate tracking mechanism to monitor patients' outcomes post-transition.

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Introduction

The need to provide transitioning care to adolescents and young adults was first recognised during the 1980s in the USA due to increased numbers of paediatric patients with chronic illnesses/disabilities surviving to adulthood (Blum 1991, Blum *et al.* 1993). Transitioning patients within and across health care facilities has been gradually conceded as a complex process rather than an event or a single step at a point in time (Department of Health Western Australia 2009, Gilliam *et al.* 2011, Stewart *et al.* 2014, Westwood *et al.* 2014). The transition of care process is, therefore, defined as 'a set of actions designed to ensure the coordination and continuity of health care as patients transfer between different locations or different levels of care within the same location' (Coleman & Boult 2003, p. 556). Experiences associated with transitioning adolescent and young adults not only impacts on their special health care needs, but also psychosocial development, including ability to consolidate identity, achieve independence and establish adult relationships (de Silva & Fishman 2014).

There are an estimated 4·5 million (18·4%) of youth aged 12–18 requiring special health care needs in the USA (McManus *et al.* 2013). Of these, it is reported only 40% of them receive transitional services to adult health care, work, and independence as per established national transition core outcomes (Department of Health Western Australia 2009, McManus *et al.* 2013). Additional research from the USA suggests delays in the transition of young adults with special care needs, approximately 445,000/year, results in these adults continuing to reside under paediatric health care services (Fortuna *et al.* 2012). In particular, Collins *et al.* (2012) and de Beaufort *et al.* (2010) found patients aged 16–17 years with chronic medical conditions remained predominantly under the care of paediatricians (70% of their visits); while patients aged 17–24 were continuing to be seen by a paediatrician for 16% to 36% of their visits (Heaton *et al.* 2013, Stewart *et al.* 2014).

The timing of the transition to the adult care services has always been the centre of debate. Late transition (>18 years old) can lead to poor patient outcomes mainly due to the late exposure to the adult care settings and lack of independence (van Staa *et al.* 2011b, Paul *et al.* 2013). Others argue that early transition could be associated with increased risk of psychosocial issues (Helgeson *et al.* 2013). The ideal time to transit adolescent and young adult with chronic illnesses/disabilities may not be associated with chronological age, especially with patients who have complex health conditions (O'Sullivan-Oliveira *et al.* 2014, de Silva & Fishman 2014).

Patients often feel anxious and concerned at the thought of being transited to adult care services. Providing sufficient preparation prior to the transition is, therefore, critical (Fegran *et al.* 2014, de Montalembert & Guitton 2014). Regardless of this awareness, research suggests many patients were unsure of the process with only 21% of parents/primary carers reporting their child had discussions with the adult health care provider prior to the transition (McManus *et al.* 2013). Patients also reported that the transition was not carried out systematically due to what they believed was a lack of coordination (Bindels-de Heus *et al.* 2013).

Patients have also observed differences between the two care settings during the transition process (de Silva & Fishman 2014). Paediatric health care providers sometimes ignore the growing independence of adolescents. In contrast, adult care providers encourage adolescent patients to take responsibility for their health even though this may lead to neglect of physical, psychological and social development (Valenzuela *et al.* 2011, Hanna & Woodward 2013, Huang *et al.* 2014, de Silva & Fishman 2014). As a result, adolescents and young adults often feel lost in adult care services leading to lower rates of follow-up appointments, attendance and medication compliance (van Staa *et al.* 2011a).

A range of approaches and strategies (Kingsnorth *et al.* 2007, Crowley *et al.* 2011), especially structured transitioning programmes, have been developed and implemented to improve patients' health outcomes (Grant & Pan 2011, Chaudhary *et al.* 2013). Evidence on the effectiveness of these programmes is not conclusive, which may be due to wide variations in the structure and delivery of those programs (Doug *et al.* 2011, Hankins *et al.* 2012).

Aim

This paper aims to provide an updated comprehensive review of the research-based evidence related to the transitions of the care process for adolescents and young adults with chronic illness/disabilities since 2010. The results of this review will recommend critical elements for developing transition programmes.

Methods

Design

The design is an integrative review, a method of research that appraises, analyses and integrates literature on a topic so that new frameworks and evaluations are generated (Torraco 2005). This methodology allows the inclusion of studies with diverse data collection methods (Whittemore & Knafl 2005). The PRISMA statement was also used, in combination with the integrative review, to structure the review, minimise analysis bias and systematically present findings.

Literature search strategies

This review was conducted to synthesise the research evidence from 2010 to 31 December 2014. Articles eligible for inclusion were those published in English with full-text access. Eligible studies were peer reviewed, with clear evidence of research methodology, including qualitative, quantitative, mixed methods and systematic reviews.

A search was carried out on the following databases: CINAHL, Embase, MEDLINE, PsycINFO and AustHealth. Database-specific subject headings and relevant text words were used. Search strategies contained terms related to (adolescent or young adult or adolescent* or teen*) and (chronic disease or long-term ill* or long-term condition* or chronic ill* or chronic condition* or disability or disabled children or disabled person) and (transition to adult care or continuity of patient care or transfer* or transition*).

Search outcomes

The combined database search generated a total of 5719 records, 120 duplicates were removed. Titles and abstracts were appraised to confirm those that fitted the review question (n = 5491 excluded). The remaining 108 records were reviewed against selection criteria. A further 47 records were excluded as conference abstracts (26), nonresearch paper (17), and nonmedical transition (4). A hand search of the reference lists was also conducted with no further results. A hand search of the reference lists was also conducted, and no additional studies were identified. A total of 61 studies were included. Figure 1 is a flowchart of the process of the study selection.

Data evaluation

The quality of included articles was appraised independently by the first author (HZ) who has more than 20 years of paediatric nursing experience, and the fourth author (PD), a professor of nursing. Meta-analysis of Statistics Assessment and Review Instrument (MAStARI) and Qualitative Assessment Review Instrument (QARI) were used to assess the methodological quality of the 61 studies (The Joanna Briggs Institute 2011). No studies were further excluded on the basis of quality assessment.

Data extraction and synthesis

Item-by-item comparison of extracted data enabled coding and grouping, which identified six main categories. All authors validated emerging patterns throughout the analysis process (Whittemore & Knafl 2005). The categories provided the framework to organise the literature and compare the studies systematically (Torraco 2005).

Results

Study demographics

Sixty-one studies were included (see Table 1), and the majority was conducted in the USA (31), followed by UK (7), Canada (7) and the Netherlands (6). The study designs employed included nonexperimental quantitative studies (35), qualitative design (15), mixed methods design (6), and systematic review (5). Of the 35 quantitative studies, the majority were conducted using survey. Semi-structured individual interviews and focus group were the primary data collection methods of the qualitative studies. The main focus of the studies included chronic illness/condition in general (24), disabilities (9), and diabetes (5).

Six categories emerged from the 61 studies: *timing of transition; perceptions of the transition; preparation for the transition; patients' outcomes post-transition; barriers to the transition; and facilitating factors to the transition.* The data analysis also identified a further 15 subcategories.

Category 1 Timing of transition

The category timing of transition (12/61 included studies) consisted of three subcategories: *timing to educate patients about transition process; the preferred timing to transit;* and *the age transited.*

Three studies explored the preferred timing to begin the education of paediatric patients with chronic illnesses/disabilities about the transition process. Two studies suggested the most appropriate time is early teens (11–12 years) or time of the diagnosis (10–14 years) (Price *et al.* 2011,

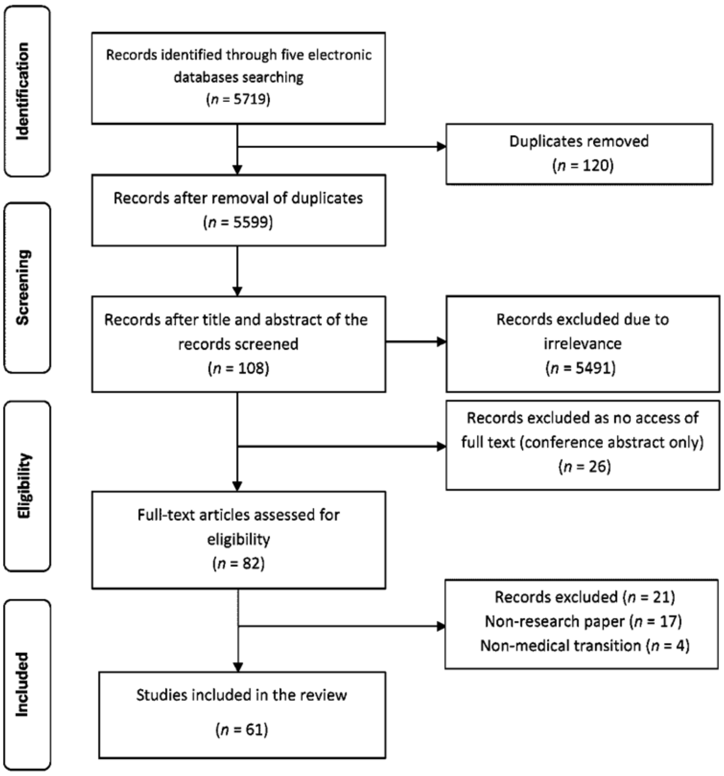

Figure 1 Flow chart for the search and study selection process (PRISMA).

de Silva & Fishman 2014); whereas Sebastian *et al.* (2012) argued 14 years or later.

Nine studies investigated the preferred timing of being transited to adult care services. Eight studies suggest that preferred timing relates to chronological age (mid teen – early twenties) (de Beaufort *et al.* 2010, Dowshen & D'Angelo 2011, Gilliam *et al.* 2011, Godbout *et al.* 2012, Sebastian *et al.* 2012, Fernandes *et al.* 2014, Rutishauser *et al.* 2014, de Silva & Fishman 2014). Others are of the view that the timing of transit should not rely on chronological age, but be based on the level of maturity and responsibilities of each patient (Gilliam *et al.* 2011, O'Sullivan-Oliveira *et al.* 2014, de Silva & Fishman 2014).

Five studies examined the age of patient transited to adult care services. Of the five studies, four indicated that transition occurred between the ages of 18, or after graduating from high school, to 19 years (Huang *et al.* 2011, Garvey *et al.* 2012, Godbout *et al.* 2012, Sebastian *et al.* 2012). The remaining study reported greater delays with patients in their early twenties (Fortuna *et al.* 2012).

Category 2 Perceptions of the transitions

Twenty-eight included studies investigated the perceptions of patients, parents and health care providers towards the transition process.

From patients' perspective, 13 studies examined their pre-transition perceptions. Patients expressed negative feelings towards the idea of transition. They felt anxious about the thought of the upcoming transition (Valenzuela *et al.* 2011, Chaudhary *et al.* 2013, Rutishauser *et al.* 2014, Thomson *et al.* 2014) or were unwilling to be transited (Bryant *et al.* 2011) because they were uncertain or concerned about the process (Bryant *et al.* 2011, Godbout *et al.* 2012, Applebaum *et al.* 2013, Swift *et al.* 2013, de Silva & Fishman 2014). In particular, patients were worried if they would be accepted by the adult care services (Swift *et al.* 2013, Stewart *et al.* 2014). However, in three other studies, patients verbalised they were ready and keen to transit (Wong *et al.* 2010, van Staa *et al.* 2011b, Dickinson & Blamires 2013).

Patients, after transit to the adult care services, acknowledged challenges and considerable differences between the

Table 1 Characteristics of the 61 included studies

First author (year) country of origin	Health condition	Study design	Data collection method	Sample	Main results – six categories: Timing of transition	Perceptions of the transition	Preparation for the transition	Outcomes post-transition	Barriers	Facilitating factors
Blackman (2014) USA	Cerebral palsy (CP)	Quantitative	Survey	80 AYACD (15–17 years)		✓				
de Silva (2014) USA	Inflammatory bowel disease	Literature review	Search was not reported	31 articles (1999–2013)	✓	✓		✓	✓	✓
Fernandes (2014) USA	Chronic disease	Quantitative	Survey	155 AYACD (16–25 years) 104 parents	✓				✓	
Huang (2014) USA	Chronic disease	Quantitative	RCT	81 AYACD (12–20 years)	✓	✓			✓	
Knapp (2014) The Netherland	Chronic disease	Quantitative	Survey	376 matched pairs of adolescent (≥16) -parent		✓	✓			
McLaughlin (2014) USA	Chronic disease	Quantitative	Survey	169 Internists 195 GPs		✓				
O'Sullivan-Oliveria (2014) USA	Chronic disease	Qualitative	Four focus groups	28 HCPs	✓				✓	
Rutishauser (2014) Switzerland	Chronic disease	Quantitative cross-sectional	Survey	AYACD 283 pre-transfer 89 post-transfer	✓	✓			✓	
Shrewsbury (2014) Australia	Obesity	Systematic review	Search 1982–2012	Three primary-documents and 24 2nd documents				✓	✓	
Stewart (2014) Canada	Disability	Qualitative phenomenological study	Individual and focus group interview	57 in total 15 AYACD (19–30 years); 16 parents; 25 HCPs; seven researchers			✓		✓	
Thomson (2014) Canada	Epilepsy	Systematic review	Search 1994–2014 (12–25 years patients)	54 included studies		✓				
van Staa (2014) USA	Chronic disease	Quantitative	Survey	518 AYACD (18–25 years)		✓	✓			
Zhang (2014) Australia	Chronic disease	Literature review	Search was not reported	31 articles published from 1999–2013			✓			
Applebaum (2013) USA	Rheumatol-ogy and general	Mixed methods	Survey & focus group	AYACD (13–21 years) 35 survey 20 AYACD +13 parents interview		✓	✓			
Baumann (2013) Switzerland	Neuro-disabilities	Quantitative	Chart review	267 AYACD (16–25 years)				✓		

Table 1 (continued)

First author (year) country of origin	Health condition	Study design	Data collection method	Sample	Main results – six categories: Timing of transition	Perceptions of the transition	Preparation for the transition	Outcomes post-transition	Barriers	Facilitating factors
Bindels-de Heus (2013) The Netherlands	Profound intellectual & multiple disabilities	Quantitative	Survey	131/583 parents of AYACD with PIMD (16–26 years)			✓		✓	
Chaudhary *et al.* (2013) USA	Cystic fibrosis	Quantitative	Survey	91 adult CF AYACD mean age 30·8 ± 9·3		✓		✓		
Dickinson (2013) New Zealand	Juvenile idiopathic Arthritis (JIA)	Qualitative	Focus groups	Eight AYACD with JIA (16–21 years)		✓	✓	✓		
Garvey (2013) USA	Type 1 diabetes	Quantitative	Survey	65 Respondents (response rate 32%) mean age 26·6 ± 3·0	✓					
Hilderson (2013) Belgium	JIA	Qualitative	Semi-structured in-depth interview	11 AYACD (18–30 years)		✓	✓			
Hunt (2013) USA	Chronic disease	Quantitative	Survey	179/11,218 Adult-centered hospitalists responded		✓			✓	
McManus (2013) USA	Chronic disease	Quantitative	Survey	17,114 parents respondents of AYACD (12–18)			✓			
Paul (2013) UK	Mental health	Quantitative	Survey	154 AYACD mean age 18·1 (SD = 0·8)				✓	✓	
Schwartz (2013) USA	Cancer	Mixed methods	Survey & focus groups	14 AYACD (16–28 years) Parents (n = 18) HCPs (n = 10)			✓			
Sonneveld (2013) The Netherlands	JRA; Type 1 diabetes; neuro-muscular disorder	Quantitative	Survey	127 AYACD (12–25); 166 parents; 18 HCPs		✓		✓	✓	
Stinson (2013) Canada	Chronic disease	Systematic review	Search period (1995–2012)	14 Included studies			✓			
Swift (2013) UK	ADHD – mental health	Qualitative	Semi-structured interview	Parents and 10 ADHD patients aged ≥17 years		✓	✓			✓
van der Toorn (2013) The Netherlands	Chronic urological condition	Quantitative	Survey	80 AYACD (mean age 21) seven parents			✓		✓	✓

Table 1 (continued)

First author (year) country of origin	Health condition	Study design	Data collection method	Sample	Main results – six categories: Timing of transition	Perceptions of the transition	Preparation for the transition	Outcomes post-transition	Barriers	Facilitating factors
Collins (2012) USA	Chronic disease	Quantitative	Survey	113 Paediatric HCPs					✓	✓
Fortuna (2012) USA	Chronic disease	Quantitative	Survey	Cross-sectional data of two national survey – AYACD (22–30 years) delayed transition	✓		✓			
Garvey (2012) USA	Type 1 diabetes	Quantitative	Survey	258 (53%) AYACD mean age 19·5 ± 2·9					✓	
Godbout (2012) France	Chronic endocrine conditions	Quantitative	Survey	73/153 AYACD mean age 24·7 ± 4·5	✓	✓	✓	✓	✓	
Hankins (2012) USA	Sickle cell disease (SCD)	Quantitative	Pre-post measures	83 AYACD (17–19 years)				✓		
Helgeson (2012) USA	Type 1 diabetes	Quantitative	Survey	118 AYACD mean age 18·05(SD = 0·36)				✓		
Hovish (2012) UK	Chronic disease	Mixed methods	Case note review & interview	11 AYACD (no age provided); six parents; three clinicians in CCS; six Clinicians in ACS					✓	✓
Pakdeeprom (2012) Thailand	Chronic disease	Quantitative	Survey	100 AYACD (14–20 years)			✓			
Sebastian (2012) UK	Inflammatory bowel syndrome (IBS)	Quantitative	Survey	Gastroenterologists 358/729 (62%) adult & 82/132 (49%) paediatrics	✓				✓	✓
Bhaumik (2011) UK	Intellectual disability	Mixed methods	Mapping; survey; grounded theory – interview	Mapping/informants from three services; survey – carers of AYACD 79/140 (56%); interview – 24 Carers		✓	✓	✓	✓	
Brewer (2011) USA	Disabilities	Quantitative	Pre-post programme	14,733 AYACD average age: 17·6				✓		
Bryant (2011) USA	Haemo-globionopathy	Qualitative phenomenological study	Semi-structured interview	14 AYACD (19–15 years)		✓				

Table 1 (continued)

First author (year) country of origin	Health condition	Study design	Data collection method	Sample	Main results – six categories: Timing of transition	Perceptions of the transition	Preparation for the transition	Outcomes post-transition	Barriers	Facilitating factors
Croke (2011) USA	Disabilities	Mixed methods	Survey data; observations; & semi-structured interview	403 AYACD (15–18 years); Sample size not reported for qualitative data collection				✓		
Davies (2011) Canada	Neurological disorder	Qualitative	In-depth interview	17 Parents of 11 AYACD (18–21 years)		✓			✓	✓
Dowshen (2011) USA	HIV/AIDS	Review	Search was not reported	Five studies				✓	✓	
Duke (2011) USA	Chronic disease	Quantitative	National Survey	18,198 Parents of AYACD (12–17 years)			✓			
Dupuis (2011) Canada	Cystic fibrosis	Qualitative	Semi-structured Interview	26 participants seven families (seven AYACD, seven mums and four dads); Aged 15–18 years; eight HCPs		✓			✓	
Gilliam (2011) USA	HIV	Qualitative	Semi-structured face-2- face & phone interview	19 key informants/HCPS from 14 Adolescent Trials Network Clinics	✓	✓		✓	✓	✓
Goossens (2011) Belgium	Congenital heart disease	Quantitative	Observations & database	749 Patients with CHD ≥21 in 2009				✓		
Huang (2011) USA	Chronic disease	Qualitative	Focus group	10 young adults (three IBD; four diabetes; three CF) & 24 HCPs	✓				✓	
Kaehne (2011) UK	Intellectual disabilities	Qualitative	Semi-structured interview	Three local authorities					✓	
Kingsnorth (2011) Canada	Complex disability	Mixed methods	11 fields notes & focus group	30 participants for 11 peer support session; eight Parents of AYACD (12–18 years)		✓				✓
Maslow (2011) USA	Chronic disease (CD)	Quantitative	Data from a national survey	13,136 non-CD 829 with CD mean age 28·8				✓		
Nishikawa (2011) USA	Chronic disease	Quantitative	Data from a national survey	18,198 AYACD (12–17 years)				✓		
Park (2011) USA	Chronic disease	Quantitative	Review document and database	Framework and researches; National survey data				✓		

Table 1 (continued)

First author (year) country of origin	Health condition	Study design	Data collection method	Sample	Main results – six categories: Timing of transition	Perceptions of the transition	Preparation for the transition	Outcomes post-transition	Barriers	Facilitating factors
Price (2011) UK	Type 1 diabetes	Qualitative	Semi-structured interview	11 AYACD & two returned after a year for a 2nd interview	✓	✓		✓		
Sawicki (2011) USA	Chronic disease	Quantitative	Survey	192 AYACD (16–26 years)			✓			
Valenzuela (2011) USA	HIV	Qualitative	Semi-structured interview	10 HIV from AYACD (24–29 years)		✓				
van Staa (2011a) The Netherlands	Chronic disease	Qualitative	Semi-structured interview	24 AYACD after transfer (15–22 years) 24 parents; 17 HCPs		✓		✓		
van Staa (2011b) Netherlands	Chronic disease	Quantitative	Survey	954/3,648 AYACD completed (12–19 years)			✓			
de Beaufort (2010) Canada	Diabetes	Quantitative	Survey	92/578 (16%) of the International Society for Paediatric and Adolescent Diabetes	✓		✓			
Fredericks (2010) USA	Liver transplant recipients	Quantitative	Survey	71 liver transplant recipient (11–20 years) & 58 parents			✓			
Wong (2010) Hong Kong	Chronic disease	Quantitative	Survey	137 AYACD (16–19 years) 67 parents		✓			✓	✓

two health care services with regard to environment and care delivery (Price *et al.* 2011, Valenzuela *et al.* 2011, Hilderson *et al.* 2013, Huang *et al.* 2014, de Silva & Fishman 2014, Van Staa & Sattoe 2014). In general, some patients felt satisfied with the transition process (Bhaumik *et al.* 2011, Price *et al.* 2011, Godbout *et al.* 2012, Chaudhary *et al.* 2013, Sonneveld *et al.* 2013) and considered the transition as an opportunity for individual growth (van Staa *et al.* 2011a, Valenzuela *et al.* 2011). Other patients were less satisfied with the transition process, and they even felt pushed into the adult care service (Bhaumik *et al.* 2011, Bryant *et al.* 2011, de Silva & Fishman 2014) without sufficient preparation (Blackman & Conaway 2014, Van Staa & Sattoe 2014).

For parents/carers, leaving paediatric care services was more challenging than for patients (van Staa *et al.* 2011a). Prior to the transition, parents/primary carers indicated concerns about the process (Kingsnorth *et al.* 2011, Swift *et al.* 2013). They also felt stressed about the future, and this was over and above the ongoing suffering of living with their child (Dupuis *et al.* 2011, Kingsnorth *et al.* 2011). Parents were also worried about being labelled as over-advocating or being 'difficult' in the transition process. Only limited evidence revealed positive feelings of the parents towards the transition and this related to their awareness of the transition plan (Wong *et al.* 2010, Knapp *et al.* 2014).

Only one study explored parental perceptions on their child's transition process. Parents expressed their feeling of being abandoned and lost during the transition process. They were also fearful in navigating adult care services (Davies *et al.* 2011).

In terms of how health care providers perceived the transition process variations were evident between paediatric and adult services. Adult health care providers considered paediatric service providers were over protective; whereas adult health care providers were perceived as uncaring towards the adolescent and young adult patients by paediatric health care providers (de Silva & Fishman 2014). Also, 40% of adult health care providers felt uncomfortable caring for the young adult patients (Hunt & Sharma 2013). Further half of them were unwilling or not keen to accept the young adult patients (McLaughlin *et al.* 2014).

Category 3 Preparation for the transition

It has been recognised that preparing the adolescent and young adult patients for transition impacts significantly on patients outcomes post-transition (Bindels-de Heus *et al.* 2013, Dickinson & Blamires 2013). It is essential, therefore, to assess the patients' readiness for the transit. However, no single assessment tool/instrument has been widely accepted as the most reliable tool (de Silva & Fishman 2014).

A systematic review conducted by (Stinson *et al.* 2013) focused on the transition readiness assessment instruments/tools and concluded that the tools from the eight included studies were neither reliable nor valid, including Transition Readiness Assessment Questionnaire (TRAQ). In a more recent review, ten transition readiness assessment tools were examined with a focus on the psychometric properties of the tool. The review argued that TRAQ demonstrated adequate content validity, construct validity, and internal consistency. As a result TRAQ was recommended as the best-validated tool to assess the adolescents and young adults' readiness for the transition (Zhang *et al.* 2014).

In other research, Schwartz *et al.* (2013) identified that the Social-Ecological Model of Adolescent and Young Adult Readiness to Transition (SMART) proved to be a valid tool. The reliability was supported by other studies that examined the four-specific components disease-related knowledge (Fredericks *et al.* 2010, van der Toorn *et al.* 2013), skills/self-efficacy (Fredericks *et al.* 2010, Sawicki *et al.* 2011, van Staa *et al.* 2011b, Applebaum *et al.* 2013, van der Toorn *et al.* 2013), relationships/communication (van der Toorn *et al.* 2013), and psychosocial/emotions (Fredericks *et al.* 2010). The SMART measured the patients' beliefs/expectations, developmental maturity (patient only), goals/motivation to determine if the patients are ready to be transferred to the adult care service (Schwartz *et al.* 2013).

Additional characteristics also identified as impacting the quality of the preparation process include gender (Fredericks *et al.* 2010, Sawicki *et al.* 2011, McManus *et al.* 2013), age (Fredericks *et al.* 2010, Sawicki *et al.* 2011, McManus *et al.* 2013, Knapp *et al.* 2014), ethnicity group (McManus *et al.* 2013), family annual income (McManus *et al.* 2013), severity of the illness (Sawicki *et al.* 2011, McManus *et al.* 2013), level of psychosocial support (Pakdeeprom *et al.* 2012), patients' attitude towards transition (van Staa *et al.* 2011b, Pakdeeprom *et al.* 2012), source and type of paediatric care (Duke & Scal 2011), and health insurance access (Fortuna *et al.* 2012, McManus *et al.* 2013).

Category 4 Patients' outcomes post-transition

Five included studies evaluated the effectiveness of transition programmes. In general, patients valued the structure and guidance offered by the programmes, especially those that assisted patients to gain independence socially and physically (Chaudhary *et al.* 2013, Huang *et al.* 2014), to comply with adult clinic visits (Hankins *et al.* 2012), and to engage in career development activities (Brewer *et al.* 2011, Croke & Thompson 2011). Patients also appreciated being informed about drugs and alcohol prevention and meeting adult health care providers prior to transition (Price *et al.* 2011). However, regardless of the implemented available transition programmes, patients' anxiety levels towards the transition did not alter (Chaudhary *et al.* 2013).

Sixteen studies measured the outcomes of the patients who had not been involved in a structured transition program. There was no systematic evaluation of the outcomes mainly due to the lack of tracking mechanisms for transferred patients (Gilliam *et al.* 2011). The transition record was often incomplete, so the total number of reported transitions was based on estimation (Bhaumik *et al.* 2011, Gilliam *et al.* 2011). Patients articulated that the care they received post-transition was inconsistent and of a less standard compared to the paediatric setting (Bhaumik *et al.* 2011, Goossens *et al.* 2011, Park *et al.* 2011, van Staa *et al.* 2011a, Helgeson *et al.* 2012, Paul *et al.* 2013, Sonneveld *et al.* 2013). This was evidenced by poor medication adherence (van Staa *et al.* 2011a, de Silva & Fishman 2014) and low clinic attendance or even cessation of follow-up appointments (Goossens *et al.* 2011, van Staa *et al.* 2011a, Helgeson *et al.* 2012, de Silva & Fishman 2014). Also, two studies examined the social outcomes of patients compared to those without chronic health conditions. Patients with chronic illnesses/disabilities experienced poor educational and vocational opportunities with low graduating rates from college and lower incomes (Maslow *et al.* 2011, Baumann *et al.* 2013).

Despite the lack of structured transition programmes, four studies reported positive patient outcomes a year or more after being transited. These included general satisfaction with care provision (Dickinson & Blamires 2013), treatment (Godbout *et al.* 2012) and advice on their future life (Nishikawa *et al.* 2011). One study also reported that patients had similar rates of marriage and having children as when compared to those without childhood illness (Maslow *et al.* 2011).

Category 5 Barriers to the transition

Five major barriers were identified as impacting the transition process. The first barrier related to inadequate preparation prior to transition. Patients reported not being referred to a specific adult HCP (Garvey *et al.* 2013), not receiving information from an adult HCP (Wong *et al.* 2010, Kaehne 2011, Garvey *et al.* 2012, Paul *et al.* 2013, Rutishauser *et al.* 2014, de Silva & Fishman 2014), not being offered a visit prior to transition to the adult care service (Garvey *et al.* 2012, Hilderson *et al.* 2013), and poor communication between the health care providers (Wong *et al.* 2010, Kaehne 2011, Garvey *et al.* 2012, de Silva & Fishman 2014). Patients also reported a lack of satisfaction with the transition process due to unavailability of structured written-plans (Bhaumik *et al.* 2011, Gilliam *et al.* 2011, Kaehne 2011, van Staa *et al.* 2011a, Shrewsbury *et al.* 2014) and the lack of coordination of the process (Bhaumik *et al.* 2011, Davies *et al.* 2011, Huang *et al.* 2011, Kaehne 2011, Paul *et al.* 2013, Sonneveld *et al.* 2013).

Ability to access and use adult care services was considered as the second major barrier. Issues include lack of resources (Bhaumik *et al.* 2011, Davies *et al.* 2011, Gilliam *et al.* 2011, Huang *et al.* 2011, Collins *et al.* 2012, Godbout *et al.* 2012, Sebastian *et al.* 2012, Paul *et al.* 2013, O'Sullivan-Oliveira *et al.* 2014, Stewart *et al.* 2014), limited availability of the clinicians' time (Bhaumik *et al.* 2011, Collins *et al.* 2012, Sebastian *et al.* 2012), limited health insurance coverage (Dowshen & D'Angelo 2011, Gilliam *et al.* 2011, Huang *et al.* 2011), long waiting lists (Hovish *et al.* 2012), and lack of a tracking mechanism after patients are transited (Gilliam *et al.* 2011). Inconsistencies in the provision of care to patients were also considered as a limitation. This was seen as resulting from the different model of care delivered in the adult care setting as compared to the paediatric setting (Huang *et al.* 2011, Garvey *et al.* 2012, 2013, Hovish *et al.* 2012). Specifically, insufficient communication, especially handing over patients' information from paediatric to adult health service providers were identified (Dowshen & D'Angelo 2011, Gilliam *et al.* 2011, Huang *et al.* 2014, de Silva & Fishman 2014, Stewart *et al.* 2014).

Complex health conditions posed the third barrier to the transition process. The transition was impacted according to health service providers by patients' impaired cognitive development and mental health issues (Davies *et al.* 2011, Gilliam *et al.* 2011, van der Toorn *et al.* 2013). Other issues included patients' negative attitude towards the transition (Wong *et al.* 2010, Gilliam *et al.* 2011, Rutishauser *et al.* 2014, de Silva & Fishman 2014), difficulties leaving a familiar environment (Dowshen & D'Angelo 2011, van der Toorn *et al.* 2013, Fernandes *et al.* 2014, O'Sullivan-Oliveira *et al.* 2014, Rutishauser *et al.* 2014), insufficient knowledge and self-management skills (Gilliam *et al.* 2011, Sonneveld *et al.* 2013, de Silva & Fishman 2014) and especially poor medication and follow-up adherence (Gilliam *et al.* 2011, van der Toorn *et al.* 2013).

Excessive parental involvement in the care of patients was perceived as the fourth barrier to the transition by both nurses and physicians (Huang *et al.* 2011, de Silva & Fishman 2014). This was evidenced by parents' negative attitude towards adult care services (Wong *et al.* 2010, O'Sullivan-Oliveira *et al.* 2014), over controlling of their child (Huang *et al.* 2011, Sonneveld *et al.* 2013, de Silva & Fishman 2014), and over-reliance on the paediatrician (Bindels-de Heus *et al.* 2013, van der Toorn *et al.* 2013, Fernandes *et al.* 2014, de Silva & Fishman 2014).

The final barrier involves the inability of some paediatric health care providers to relinquish care of the patient (Dowshen & D'Angelo 2011, de Silva & Fishman 2014). Paediatric health care providers found it difficult to hand over patients to the adult care services due to long-established rapport with patients and their families (Gilliam *et al.* 2011, O'Sullivan-Oliveira *et al.* 2014). In contrast, adult health care providers faced challenges relating to non-familiarity with the treatment and clinical parameters of the patients (Dupuis *et al.* 2011, Huang *et al.* 2011, Hunt & Sharma 2013, Stewart *et al.* 2014).

Category 6 Facilitating factors to the transition

Nine included studies explored factors that enable the transition process. Facilitating factors include preparation prior to transit (Wong *et al.* 2010, Hovish *et al.* 2012), a structured written plan/program to guide the transition process (Gilliam *et al.* 2011, Hovish *et al.* 2012, Sebastian *et al.* 2012), a key health care provider from paediatric care services to coordinate the transition process (Collins *et al.* 2012, Hovish *et al.* 2012), the quality of health care providers and relationship built-up with the patients (Wong *et al.* 2010, Swift *et al.* 2013), parents acting as a facilitator (Davies *et al.* 2011, Kingsnorth *et al.* 2011, van der Toorn *et al.* 2013), and patients' self-management skills (Wong *et al.* 2010, de Silva & Fishman 2014).

Discussion

We conducted this integrative review to synthesise the research evidence from 2010–2014 on transitions of care for the adolescents and young adults with chronic illnesses/disabilities. This integrative review adds to the body of knowledge of 16 previous review papers published ≤2010 (Refers to Table 2).

Congruent evidence was found in this review that patients should be made aware they will need to transition to adult services. The ideal timing to transit patients to adult care services broadly ranged from the late teens to the early twenties. It was argued that patients should be transited according to their developmental stage and self-management abilities, which is similar to three prior review papers (While *et al.* 2004, Jalkut & Allen 2009, Fegran *et al.* 2014). In reality, however, patients were mostly transited in their late teens, especially at the 'iconic' age of high school graduation (Watson *et al.* 2011, Hanna & Woodward 2013).

The majority of patients in this review expressed negative feelings towards transition, which was consistent with four previous review papers (Jalkut & Allen 2009, Wang *et al.* 2010, Hanna & Woodward 2013, Fegran *et al.* 2014). Some patients were even apprehensive about their future when surrounded by older and sicker patients (Lugasi *et al.* 2011). Consistent evidence from this and a previous review (Lugasi *et al.* 2011) suggests that parents/carers felt reluctant towards the transition with general concern expressed about the process and feelings of abandonment. Health care providers with adolescent care experience considered the transition as part of their routine practice while others with only adult care experience felt uncomfortable to care for adolescent and young adults. Paediatric health care providers, however, displayed a lack of trust in adult health care providers by being unwilling to hand over care of the patients (Jalkut & Allen 2009).

Evidence from this review indicates there has been an increased effort to prepare patients prior to transition by assessing readiness, which was not formally recognised in any of the previous review papers. However, inconclusive evidence was found on the effectiveness of transition readiness assessment tool.

This review compared to the seven previous reviews found that most 'programs' identified in the literature were approaches or services, and not formally structured transition programs. The main content of the approaches or services from previous reviews included (1) introduction of transition coordinator; (2) self-management skill training; (3) flexibility of adult clinic service delivery; and (4) assessment of readiness (Kingsnorth *et al.* 2007, Crowley *et al.* 2011, de Jongh *et al.* 2012, Hanna & Woodward 2013). It was noticed that most approaches/services developed were for specific health conditions, i.e., cystic fibrosis (Doug *et al.* 2011), diabetes (Crowley *et al.* 2011, Hanna & Woodward 2013), and physical disabilities (Kingsnorth *et al.* 2007) rather than for more generic use. Four studies argued that patients with health conditions, such as HIV/AIDS, severe intellectual disability and obesity, received very little attention when transitioning from paediatric to adult health services (Dowshen & D'Angelo 2011, Gilliam *et al.* 2011, Maslow *et al.* 2011, Shrewsbury *et al.* 2014).

Also, Grant and Pan (2011) analysed five structured transitioning programmes for the young adult population

Table 2 Characteristics of the 16 previously published review articles

First author (year) country of origin	Health condition	Study design	Search period	Included studies	Main results – six categories: Timing of transition	Perceptions of the transition	Preparation for the transition	Outcomes post-transition	Barriers	Facilitating factors
Fegran (2014) Denmark	Chronic disease	Qualitative meta-synthesis	1999 – November 2010	18 studies	✓	✓				
Hanna (2013) USA	Diabetes	Systematic review meta-analysis	Not reported	23 studies published from 1992–2012	✓	✓		✓		
Bloom (2012) USA	Chronic disease	Literature review	1986–2010	15 studies				✓		
de Jongh (2012) UK	Chronic disease	Systematic review meta-analysis	1993–2009	Four RCTs included				✓		
Crowley (2011) UK	Chronic disease	Literature review	1998–2010	10 studies				✓		
Doug (2011) UK	Palliative care	Literature review	1995- February 2008	92 studies				✓		
Grant (2011) Canada	Chronic disease	Content analysis	Not reported	Five transition models				✓		
Lindsay (2011) Canada	Chronic disease	Integrative review	2000 – August 2010	34 studies					✓	
Lugasi (2011) Canada	Chronic disease	Meta-summary review	1994–2009	46 studies		✓		✓	✓	✓
Watson (2011) UK	Complex healthcare needs	Scoping review	Not reported	19 studies published from 1990–2010	✓					

First author (year) country of origin	Health condition	Study design	Search period	Included studies	Main results – eight categories: Timing of transition	Perceptions of the transition	Preparation for the transition	Outcomes post-transition	Barriers	Facilitating factors
Lotstein (2010) USA	Chronic disease	Literature review	Not reported	33 studies published from 1990–2010					✓	
Rapley (2010) Australia	Chronic disease	Integrative review	Not reported	74 Studies published from 1989–2008						✓
Wang (2010) USA	Chronic disease	Literature review – an ecological approach	1999–2008	46 studies		✓			✓	
Jalkut (2009) USA	Congenital heart disease	Literature review	1950–2008	28 studies	✓	✓				
Kingsnorth (2007) Canada	Physical disabilities	Systematic review	1985–2006	Six studies				✓		
While (2004) UK	Chronic disease	Literature review	1981–2001	126 studies	✓					✓

with chronic illnesses/disabilities. Overall, the appraised intervention/services and programmes were found to be useful, especially for diabetic patients trying to maintain glycosylated haemoglobin levels (Crowley *et al.* 2011, Hanna & Woodward 2013). However, the validation and sustainability of most of the intervention and programs were questioned (Kingsnorth *et al.* 2007, Doug *et al.* 2011, Grant & Pan 2011, Watson *et al.* 2011, de Jongh *et al.* 2012, Hanna & Woodward 2013). There is limited evidence on developing and implementing transitioning programmes for young adults with complex health needs, such as cerebral palsy and autism (Watson *et al.* 2011).

The review also found poor patients' outcomes both clinically and psychosocially after being transited without structured transition programmes, which was supported by two previous review papers (Lugasi *et al.* 2011, Bloom *et al.* 2012, Hanna & Woodward 2013). Some patients articulated that they were treated like adults being part of decision-making and taking more control of their health conditions (Lugasi *et al.* 2011).

Both this review and five previous reviews agreed on five major barriers hindering the transition process, including lack of planned transition process, insufficient preparations, poor health care service accessibility, ineffective communication between health care services and a negative attitude by patients towards the transition process (Jalkut & Allen 2009, Lotstein *et al.* 2010, Wang *et al.* 2010, Lindsay *et al.* 2011, Lugasi *et al.* 2011).

Facilitating factors associated with a smooth transitioning process were identified by four earlier review studies and were consistent with the outcomes of this review. Patients and their carers appreciated gradual preparation following a structured transition programme, consistency of care, high quality of adult health care providers, parental support, and the patients taking responsibilities of their own health (While *et al.* 2004, Rapley & Davidson 2010, Lugasi *et al.* 2011).

The limitation of this integrative review is associated with the search strategy which might have excluded relevant non-English research studies. The main weakness of the included studies in this integrative review was the lack of objective data resulting from compromises made to research design. More than half of the included studies (32/61) was nonexperimental self-report surveys. Only two out of 15 included qualitative studies specified the methodology and underlining philosophy being employed – phenomenological theory.

An integrated, rigorous research approach including both quantitative and qualitative methods to examine effectiveness of the transition programme is urgently recommended. Due to inconclusive evidence, further validation of the two identified transition readiness assessment tools (SMART vs. TRAQ) is needed. Most importantly, inconsistent outcomes measures need to be addressed to improve the quality of patients' transitioning experience.

Conclusion

In the last five years, there has been improved health outcomes for adolescents and young adults with chronic illnesses/disabilities post-transition through the use of a structured multidisciplinary transition programme, especially for patients with cystic fibrosis and diabetes. However, overall patient outcomes following the transit, if recorded, have remained poor both physically and psychosocially. Active preparation for transitioning paediatric patients with ongoing special health care needs should commence in their early teens. Parents/primary carers, paediatric health care providers, and the receiving adult health care providers also needed to be included in the preparation. Patients' readiness for transition needs to be accurately and regularly assessed by applying validated measurement tools. The priority for stakeholders and health care providers for both paediatric and adult services is to develop a standardised and evidence-based transition program, which must be user-friendly to all patients rather than condition specific. The information with regard to patients' diagnosis, investigation, management plan, and family/social background is required to be communicated and shared by the health care providers. Training programs also need to be organised for adult health care providers to improve their medical knowledge and communication skills. This review also strongly recommends the need for accurate tracking mechanism to be established by health care services to monitor patients' outcomes post-transition, which will ultimately improve the transitioning care for adolescents and young adults with chronic illnesses/disabilities.

Contributions

Study design: HZ & PD; Data collection and analysis: HZ, PD, PR & SD; and manuscript preparation: HZ, PR, PD & SD.

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2.3 Review of Paediatric Hospital-to-home Transition Processes and Recovery Experiences

Following publication of the integrative review examining the experience of adolescents and young adults transitioning from paediatric to adult healthcare services, a literature review was conducted to explore paediatric hospital-to-home transition processes and recovery experiences. The objectives of the literature review were to synthesise research evidence focussed on (1) healthcare provider and caregivers' perceptions of the transition process; (2) content and delivery of hospital-to-home transition information; (3) caregivers perceptions of readiness for discharge; (4) post-hospital recovery experience; (5) impact of limited English proficiency on the transition process and the recovery experiences of patients/caregivers; and (6) effectiveness of interventions to improve paediatric transition processes and recovery experiences.

2.3.1 Search strategy and search outcomes

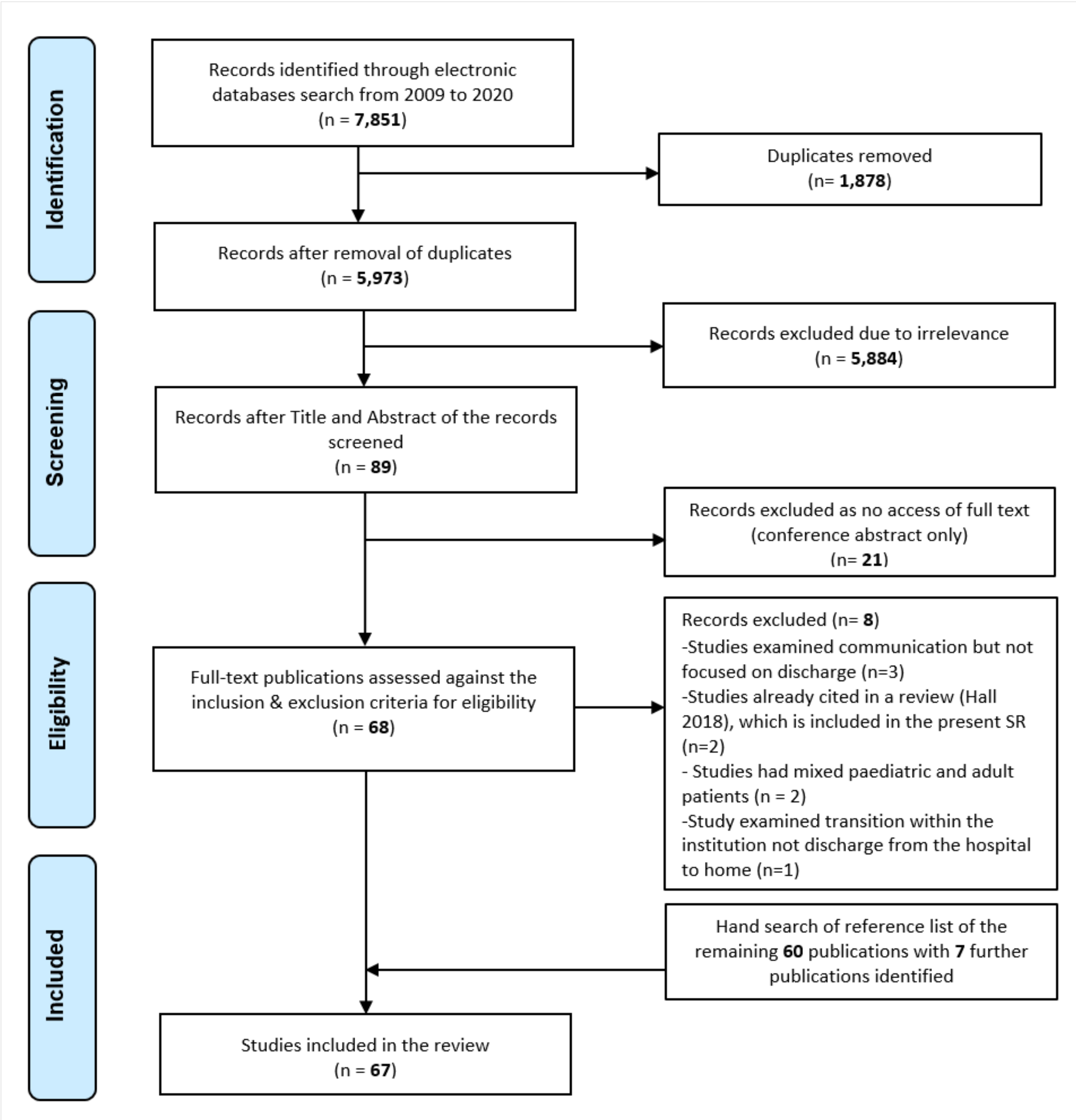
Three electronic databases, namely Medline, CINAHL, and Embase (Ovid), were initially searched from 2009 to 2019 on 7th January 2020, followed by an updated search of Year 2020 on 8th January 2021. Key search terms were 'child/infant/adolescent/paediatric', 'discharge/discharge plan/discharge procedure' 'discharge service/program', 'communication', and 'transition'/'continuity of care'.

Search strategies focused on inclusion of studies which examined the transition process and recovery experience of both caregivers and paediatric patients discharged from hospital to home. Studies published in English with full-text access were eligible for inclusion. Studies published in peer-reviewed journals with detailed description of study design and methods were also included. Conference abstracts were excluded. Studies that involved transitioning patients between health care institutions were excluded from this review as the focus related to discharging patients from acute healthcare services to home. Studies examining communication but not focused during the transition process and time of discharge were also excluded.

The screening process used for the initial search is illustrated in Figure 2.1. A total of 7,851 records were identified. Of those 1,878 duplicated records were removed leaving 5,973 records to be screened. A further 5,884 records were excluded due to irrelevance. Of the remaining 89 records, 21 conference abstracts were also excluded. Full text of 68 records were retrieved and reviewed against the selection criteria, a further eight studies were then excluded as three were not focused on communication during the transition process and at the time of discharge, two were cited in a previously published literature review, two had mixed paediatric and adult patients, and one examined transition between institutions not from hospital to home. Examination of the reference lists of the remaining 60 studies identified seven additional studies to be included in this literature review resulting in a total of 67 studies.

Figure 2.1

Flow Chart for the Search and Study Selection Process (PRISMA)



Assessment of the quality of each study was conducted using the Joanna Briggs Institute critical appraisal tools which examines specific study designs of all included studies (The Joanna Briggs Institute, 2011). In particular, the Meta-analysis of Statistics Assessment and Review Instrument (MAStARI) was used to assess quantitative studies and the Qualitative Assessment Review Instrument (QARI) was for the qualitative studies. No further studies were excluded based on the assessment outcomes.

2.3.2 Characteristics of included studies

A total of 67 studies were included in the literature review with a notation that six studies addressed more than one objective. Table 2.1 is a summary of characteristics of all the included studies. The majority of studies were conducted in the USA (n = 51, 76%), followed by Australia (n = 4), Canada (n = 4), Brazil (n = 2), and the UK (n = 2). One study was identified from Norway, Saudi, and Uganda. Half of the included studies employed quantitative research design (n = 34), 22 were qualitative, eight were literature reviews, and three were mixed-methods studies.

The main data collection methods utilised for the majority of included studies were survey, medical record audits, or one-on-one or focus group interviews. There were 48 included studies conducted at single site locations, 12 were multi-sites, and seven reviewed existing evidence. The main results extracted from the 67 studies were synthesised and are presented in Table 2.1 according to the six previously identified objectives of this literature review.

2.3.3 Paediatric hospital-to-home transition process

A total of nine studies from four countries, USA (n = 5), Australia (n = 2), Norway and Uganda, examined hospital-to-home transition processes from healthcare providers and/or caregivers' perspectives. The overwhelming views expressed by both the healthcare providers and caregivers in relation to the transition processes were associated with the complexities and barriers. Healthcare providers, in three studies, commented that paediatric hospital-to-home transition process are more often than not dependent on individual hospital protocols or physician preferences (Berry et al., 2014; Canary & Wilkins, 2017; Nemetchek et al., 2019). Complexities and barriers identified by healthcare providers as hindering the transition process included (1) shortage of both human and physical resources due to heavy workload (Nemetchek et al., 2019); (2) differing expectations (Barone et al., 2020; Nageswaran et al., 2020), (3) lack of role clarity (Barone et al., 2020; Nemetchek et al., 2019), and (4) communication breakdown between healthcare providers and caregivers (Nageswaran et al., 2020; Voie et al., 2018). Healthcare providers did identify two positives, teamwork (Canary & Wilkins, 2017; Nemetchek et al., 2019) and motivation as contributing factors influencing effective transition processes (Nemetchek et al., 2019).

Three qualitative studies reviewed caregivers' experiences using semi-structured interviews. Caregivers identified three barriers as hindering the transition process (Barone et al., 2020; Canary & Wilkins, 2017; Nemetchek et al., 2019). These included lack of resources (Barone et al., 2020; Canary & Wilkins, 2017), insufficient hospital-to-home transition information (Barone et al., 2020; Nemetchek et al., 2019), and insufficient psychological preparation in relation to the ongoing medical care needs of their child following discharge. This was more evident for caregivers who had children with complex medical conditions (Barone et al., 2020; Canary & Wilkins, 2017).

In addition, some caregivers suggested a paucity of information about the transition process (Aydon et al., 2018; Barone et al., 2020) and lengthy delays between notifications of discharge and physically leaving the hospital (Keatinge et al., 2009) impacted their view of the transition process. Other caregivers felt they were rushed out of the hospital (Aydon et al., 2018) and this impacted their perception of the quality of transition of care information provided at the time of discharge. They were also of the view that this potentially could increase the likelihood of adverse outcomes such as unplanned ED visit and UHRs post-hospital discharge (Berry et al., 2014).

2.3.4 Content and delivery of hospital-to-home transition information

Five studies from three countries, USA (n = 3), Australia and Canada, examined hospital-to-home transition of care information and found that predominantly this information was provided verbally by healthcare providers to caregivers. Additional written information was provided to some caregivers but this was not consistent across the research (Curran et al., 2018; Gutman et al., 2018; Keatinge et al., 2009; Lakhaney & Banker, 2020; Unaka, Statile, Haney, et al., 2017). Two specific aspects of hospital-to-home transition information delivery were examined by the research. These included what components of hospital-to-home transition of care information are essential and what determines quality of information delivery as perceived by both healthcare providers and caregivers. Quality of hospital-to-home transition of care information considers measures such as usefulness, comprehensiveness and consistency.

Healthcare providers listed seven key components as comprising hospital-to-home transition of care information from their perspective. These include date of admission and discharge, discharge diagnosis, treatment and investigations during hospitalisation, discharge medication, immunisations status, imaging or laboratory test results, and follow-up arrangements (Coghlin et al., 2014; Lakhaney & Banker, 2020). Caregivers on the other hand indicated the main components of transition information from their perspective needed to include warning signs suggesting the need for further medical attention (Curran et al., 2018; Gutman et al., 2018; Unaka, Statile, Haney, et al., 2017), medication administration (Glick et al., 2017; Gold et al., 2020; Gutman et al., 2018; Lerret et al., 2014), who to contact (Unaka, Statile, Haney, et al., 2017), restrictions of activities (Lerret et al., 2014), and principal admitting diagnosis (Unaka, Statile, Haney, et al., 2017).

Three studies examined caregivers' views on the quality of transition information delivered verbally by healthcare providers prior hospital discharge. Two studies suggested caregivers were satisfied with the components included in the information and the delivery (Bhansali et al., 2016; Weiss et al., 2017) while the third reported they had received inconsistent transition of care information (Keatinge et al., 2009). Inconsistencies included the contents and amount of transition information, information was not based on patients or family needs, or timing of delivering information (Keatinge et al., 2009).

Quality of written transition of care information was measured in terms of comprehension and usefulness. In an American study of medical records auditing, researchers found almost 40% (n = 200) of written information corresponded to a 10th-grade reading level which is considered suboptimal in terms of how easy it was to understand. The accepted literacy level of written information for caregivers is 8th-grade (Unaka, Statile, Haney, et al., 2017). In research by Keatinge et al. (2009) 12 caregivers who had contacted the Emergency Department post-hospital discharge were interviewed. Seven caregivers indicated that the written hospital-to-home transition of care information was generally not helpful.

Two studies investigated what evidence of provision of hospital-to-home transition information by healthcare providers was recorded in the patients' notes. In an American study by Rush et al. (2020), 368 electronic patient medical records were reviewed and of those 41% did not have any written evidence about what transition information was provided. This was similar to findings in a Jamaican study which reviewed 131 medical charts. Of those reviewed, 14% of charts recorded client teaching had been provided within the first 72 hours of admission, and 18.3% on the day of discharge. Only 6.9% records had written evidence of the commencement of hospital-to-home transition planning within 24 hours of admission (Abdul-Kareem et al., 2019).

2.3.5 Caregivers perceptions of readiness for discharge

Readiness for discharge refers to a patient's readiness, from a medical perspective, to be discharged from hospital to home and whether the caregiver is sufficiently prepared and feels comfortable and confident to provide ongoing care (Lerret, 2009; Lerret et al., 2015; Weiss et al., 2017). Two studies examined caregivers' views on whether they felt well-informed by the healthcare providers before discharge regarding the continued care needs for their child and would they be able to recognise signs and symptoms of improvement/deterioration and required care (Aydon et al., 2018; Bhansali et al., 2016). While most caregivers indicated they felt sufficiently informed, some caregivers, did indicate they felt they received limited transition of care information some of which was not fully understood requiring them to ask staff for clarification (Aydon et al., 2018; Ronan et al., 2020). Others indicated they felt either overloaded with the transition information, or that they were given inconsistent or conflicting information from the healthcare providers (Lerret, 2009; Ronan et al., 2020).

In terms of the quality of transition of care information, comprehension and consistency were positively associated with both caregiver's (Glick et al., 2017; Lerret, 2009; Lerret et al., 2014; Lerret et al., 2015; Weiss et al., 2017) and nurse's perception of readiness for discharge (Weiss et al., 2017). Effective/efficient coordination and delivery of hospital to home transition of care information was also found to be significantly associated with higher level of caregiver readiness for discharge (Lerret, 2009; Lerret et al., 2015).

From a psychological perspective some caregivers identified they did not feel ready to take their child home (Bhansali et al., 2016; Gaskin et al., 2020; Keatinge et al., 2009), while others described feeling uncertain about looking after their child at home without the constant monitoring and support from healthcare providers (Ford et al., 2012; Ronan et al., 2020; Solan et al., 2015).

Socio-demographic factors were also cited in three studies as impacting both healthcare providers and caregivers' perception of readiness for discharge. One study from the USA reported patients of white race experienced shorter hospital length of stay (LOS) and were associated with higher scores on the readiness assessment by nurses (Weiss et al., 2017). Four additional American studies also found that caregivers, who were immigrants, with a mental health condition (Lion et al., 2020; McGowan et al., 2019), and limited English proficiency (Glick et al., 2017; McGowan et al., 2019; Obregon et al., 2019) reported lower level of perceiving they were ready for discharge.

Caregivers' perception of whether they felt ready for discharge was significantly associated with how well in retrospect patients coped post-discharge, how the family managed (Lerret & Weiss, 2011; Lerret et al., 2015; Weiss et al., 2017) and if patients adhered to the medical requirements and follow-up requirements post-hospital discharge (Lerret & Weiss, 2011).

2.3.6 Post-transition recovery experience

Caregivers experiences of the post-transition recovery phase following hospital discharge varied across 16 reviewed studies. Some caregivers felt their experiences were straightforward while others experienced delayed recovery, or even complications requiring readmission for their child (Ford et al., 2012; Leary et al., 2020; Lion et al., 2020). Most caregivers were relieved when they returned home and gradually developed confidence in their child's needs following discharge (Ford et al., 2012; Gaskin et al., 2020; Pinto et al., 2015; Solan et al., 2015). They expressed feeling more comfortable and in control in their home environment (Aydon et al., 2018; Pinto et al., 2015). As well, they enjoyed the autonomy of caring for their child without having direct monitoring and instructions from the healthcare providers (Aydon et al., 2018; Pinto et al., 2015). During the recovery period, some children, developed ongoing issues which required management. These included ongoing pain (Ford et al., 2012; Pinto et al., 2010), decreased appetite, lethargy, limited movement, poor quality of sleeping, and anxiety or even aggression (Pinto et al., 2010). Caregivers of these children experienced higher levels of anxiety, feelings of isolation, and poor general health. As a result, caregivers expressed in retrospect that they did not feel confident taking care of their child at home (Barone et al., 2020; Gaskin et al., 2020; Pinto et al., 2010).

Caregivers also encountered issues such as patient non-compliance with discharge medication and difficulty in terms of attendance at follow-up appointments and for laboratory/imagining tests. Apprehension in relation to possible new symptoms and reoccurrence that may require readmission was found to also add to the caregivers' view of the post-hospital discharge experience (Lerret et al., 2014; Pinto et al., 2015; Ronan et al., 2020). As a result, caregivers felt the need to be vigilant in monitoring the child's condition in an effort to avoid possible readmission, but this resulted in caregivers feeling exhausted and sleep deprived (Gaskin et al., 2020; Leary et al., 2020; Pinto et al., 2015). In addition, caregivers also identified challenges associated with maintaining family routine and fulfilling other social responsibilities (Aydon et al., 2018; Barone et al., 2020; Gaskin et al., 2020; Lerret et al., 2014; Pinto et al., 2015). Many caregivers described feeling overwhelmed providing the required continued care to their child post-hospital discharge and as a result they felt they were neglecting the needs of other family members (Lerret et al., 2014; Pinto et al., 2015; Ronan et al., 2020).

Four studies explored coping strategies utilised by caregivers in dealing with the challenges of having a child discharged from an acute hospital. Caregivers generally relied on their immediate or external families for emotional support and physical assistance during the child's recovery period (Lerret et al., 2014; Pinto et al., 2015). Others indicated they had learnt from other children's experiences or friends' who had a child who had been discharged from hospital (Pinto et al., 2015). Some caregivers also utilised community services, such as visiting nurse or local child health nurse, for additional support and information (Aydon et al., 2018). Most importantly, caregivers remained vigilant in monitoring and assessing the child's health conditions to avoid readmission (Ford et al., 2012; Lerret et al., 2014; Pinto et al., 2015).

Nine studies examined reasons and contributing factors resulting in unplanned ED representations or UHRs. A mixed methods study conducted in American using survey, interview and chart audit reported 14.4% of unplanned ED visits following hospital discharge (Weiss et al., 2017). Two studies reported the 30-day UHR rate of 1.9 – 6.7% (Parikh et al., 2018; Weiss et al., 2017). The main reasons for ED presentation and unplanned readmission were related to child's illness not resolving or had worsened (Navanandan et al., 2017), medication dosage error, child not adhering to treatment, or missed follow-up appointments (Glick et al., 2017).

Patients' age, type of health insurance, medical history, readiness for discharge and ineffective communication of transition of care information were identified as the predictors for unplanned ED visits and hospital readmission. Child's age and nurses' assessment of discharge readiness were inversely associated with ED use post-hospital discharge (Weiss et al., 2017). Patients with complex medical conditions and utilising public health insurance increased the likelihood of readmission (Glick et al., 2017).

Four studies identified ineffective communication of transition of care information as associated with adverse outcomes post-hospital discharge. Some caregivers indicated they did not receive all key components of transition information (Navanandan et al., 2017) while others experienced difficulties in understanding and applying information due to limited English proficiency (LEP) within the family (Glick et al., 2017), mental exhaustion, information overload, and usefulness of information (Glick et al., 2017; Glick et al., 2020; Solan et al., 2015).

These findings were supported by research evidence that caregivers were calmer if they perceived that transition of care information given prior to discharge corresponded to what they experienced at home (Pinto et al., 2010). Caregivers also expressed the need for individualised transition of care information rather than generalised information (Gold et al., 2020; Lerret et al., 2014; Pinto et al., 2010). This included information specifically about nutrition, behaviour, schooling, management of symptom reoccurrences, and administration of discharge medication. Caregivers also emphasised the need to have more time communicating with the healthcare providers regarding the transition information prior to discharge (Pinto et al., 2010; Ronan et al., 2020).

2.3.7 Impact of caregivers with limited English language proficiency on patients' transition and recovery experience

Twelve included studies examined the impact of language proficiency on patients' experiences of the hospital-to-home transition of care and recovery experience. The overwhelming view from these studies was the negative impact on patients' health outcomes and experience due to their caregivers' limited language proficiency. All included studies examined a range of issues associated with language proficiency and recovery experiences including communication between healthcare providers and caregiver and comprehension of transition information.

A large American study retrospectively examined 72-hour ED return visits resulting in hospitalisation. Of 119,782 patients 11.7% of families were identified speaking a language other than English as their primary language. Compared to families with English as their first language, they had 30% greater chance of experiencing a returned ED visit and admission (Gallagher et al., 2013). This suggests that language proficiency of the caregiver is a significant issue impacting recovery experiences for patients. This is supported in an American qualitative study using semi-structured in-depth interviews with 18 parents. Caregivers with LEP experienced challenges associated with parental role shift, care for patients requiring ongoing use of medical equipment, and adherence to provider advice (White et al., 2017).

Four observational cohort studies (Gallagher et al., 2013; Ju et al., 2017; Samuels-Kalow et al., 2017; Samuels-Kalow et al., 2013) and one survey (Morrison et al., 2014) assessed health outcomes of paediatric patients with LEP families compared with patients with fluent English speaking families. The results demonstrated that patients of families with LEP are at higher risk of medication errors (OR = 3.7) (Samuels-Kalow et al., 2013), unplanned ED visits (OR = 1.3 to 3.49) (Gallagher et al., 2013; Morrison et al., 2014; Samuels-Kalow et al., 2017), and UHRs (Ju et al., 2017). A qualitative study interviewing 31 caregivers of 20 children who present to an ED in America also identified receiving conflicting information due to limited health literacy or been judged when they represented to ED (Samuels-Kalow, Rhodes, et al., 2016).

Three of the studies, conducted in the USA (n = 2) and Canada, identified five main factors impacting communication between caregivers with LEP and healthcare providers. Davis (2019) surveyed 31 hospital associated language services of the USA and analysed written transition information handout for caregivers at the time of discharge. Gutman (2018) analysed 47 video recordings of ED encounters with LEP families in Canada. Factors included use of medical jargon by healthcare providers when communicating with caregivers (Samuels-Kalow, Rhodes, et al., 2016), limited use of translation services by both healthcare providers and caregivers (Davis et al., 2019; Gutman et al., 2018), difficulties in translating the uncommon languages for immigrants (Davis et al., 2019), aligning professional interpreter service and the discharge event (Davis et al., 2019; Samuels-Kalow, Rhodes, et al., 2016) and the final factor related to a lack of protected time for healthcare providers to communicate transition information due to heavy workload (Samuels-Kalow, Rhodes, et al., 2016).

Two further studies assessed comprehension of caregivers with LEP. The first study was conducted across at multi-site neonatal intensive care unit utilising a comprehensive eight question assessment tool. Of the caregivers who responded 31% could only answer up to a maximum of three questions (Enlow et al., 2019). Caregivers' comprehension scores corresponded with the nurses' rating of patient readiness for discharge, but not with the caregivers' perceptions of their own readiness for discharge (Enlow et al., 2019). The second study involved video recording of 101 communication encounters in the ED with Spanish-speaking caregivers at the time of discharge (Gutman et al., 2018). Thirty-one percent of those videoed did not use interpreter services and only 13% of caregivers were asked their level of comprehension on the discharge information. This further highlights the challenges caregivers with limited language proficiency experience in understanding transition information.

The conclusions from these studies indicated that the recovery experience is significantly impacted if the caregivers' English language proficiency is limited. As a result, patients were found to be at higher risk of medication errors, unplanned ED visits related to the initial index admission and unplanned readmissions of patients within 30-days.

2.3.8 Interventions to assist caregivers with limited English language proficiency

In responding to the impact LEP has on caregivers' experiences and patients' recovery following hospital discharge, studies have explored families' needs. Caregivers with LEP expressed their desire for structured transition of care information using simplified language. They indicated they required not only verbal communication but also a physical hands on demonstration of specific care (Samuels-Kalow, Rhodes, et al., 2016).

Five studies examined the interventions implemented to assist families of LEP (Davis et al., 2019; Gutman et al., 2018; Hamline et al., 2018; Samuels-Kalow, Hardy, et al., 2016; Zurca et al., 2017). Interventions included professional interpreter services, teach-back technique to deliver transition of care information, and processes undertaken to facilitate communication. The use of professional interpreter services for families with LEP was evaluated by two USA studies. A cross-sectional survey conducted in one of the studies revealed that over 80% of the LEP families (n = 52) indicated in retrospect that having an interpreter would have helped their understanding of the information discussed by the physicians and nurses. Nineteen of the 52, who participated in multidisciplinary team meetings about their hospitalised child, voiced the need of an interpreter but only one family was provided the service (Zurca et al., 2017). The second study examined the effectiveness of having a professional interpreter at the time of discharge and found this was associated with significantly higher quality of transition of care information content and delivery (odds ratio (OR) = 7.1; 95% confidence interval (CI) [1.4–37.0]) and improved caregiver's level of comprehension (OR = 6.1; 95% CI [2.3–15.9]) (Gutman et al., 2018).

Three studies suggested use of teach-back technique in preparing families with LEP for the delivery of hospital-to-home transition information. Teach-back technique, is a communication method used by healthcare providers to engage and confirm patient and/or caregivers understanding of the information provided to them (Gutman et al., 2018; Hamline et al., 2018; Samuels-Kalow, Hardy, et al., 2016). In general, caregivers in two studies felt the technique could assist in confirming and clarifying information reducing the likelihood that key hospital-to-home transition of care information is not forgotten or misunderstood (Gutman et al., 2018; Hamline et al., 2018). Some participants, however, felt they were being treated differently, whilst those participants with sufficient health literacy felt the technique was unnecessary. Therefore, when applying the technique, it is suggested that healthcare providers present a clear explanation of the intention of the teach-back technique to encourage parents not to take offence (Samuels-Kalow, Hardy, et al., 2016).

Only one included study examined the processes and policies healthcare services utilise to facilitate communication with patients and/or their families with LEP (Davis et al., 2019). The study was conducted at a children’s hospital in America and analysed whether hospitals had processes/policies in place to ensure provision for translation of hospital-to-home transition of care information. Thirty one children’s hospitals and associated language services were analysed. The majority of the services had a written translation policy (81%) and translated hospital-to-home transition of care information (74%). Healthcare services did however have differing policies associated with interpreters assisting with translation of information verbally. Healthcare services generally used pre-translated documents (87%) or staff interpreters (81%). Other options used to improve communication included document libraries, pre-translated electronic health record templates, staff-edited machine translations, and sight translation, which refers to in-the-moment verbal translating of a written document in the target language (Davis et al., 2019).

2.3.9 Effectiveness of interventions to improve transition and recovery experiences

Nineteen of the 67 included studies examined the effectiveness of differing strategies or approaches to improve the transition and recovery experience for caregivers and paediatric patients. Interventions mainly focused on hospital-to-home transition of care information content, delivery and transition processes. To improve hospital-to-home transition information delivery, studies implemented a wide range of different options such as iPad App or audio recordings of hospital-to-home transition of care information (Lerret et al., 2020; Lion et al., 2019), provision of comprehensive written transition information (Akinsola et al., 2017; Almidani et al., 2017; Jiang et al., 2018; Parikh et al., 2018), written transition information at 7th grade literacy level (Unaka, Statile, Jerardi, et al., 2017) , and sending General Practitioner discharge summaries electronically or via automatic faxing (Harlan et al., 2010). Interventions to facilitate the transition process were the allocation of a transition care coordinator in charge of the process (Hall et al., 2018; Logsdon & Little, 2020; Sklansky et al., 2019; Vigna et al., 2018), provision of a discharge care bundle (Hamline et al., 2018; Holland et al., 2016; Parikh et al., 2018; Parikh et al., 2020; VanderVeen, 2020), implementation of electronic medical records (Olivarez et al., 2017), and use of teleconference (Patra et al., 2020) or text message reminder following discharge (Kenyon et al., 2019).

Outcome measurements used to determine the effectiveness of implemented strategies/approaches varied across the 13 studies and included the number of adverse events (UHRs or unplanned ED presentation), hospital to home transition experiences (LOS, discharge timing – prior to noon, satisfaction, medication compliance, and quality of life), and usefulness of hospital-to-home transition of care information (how easy it is to read, understanding/comprehension, ease of use, helpfulness, discharge documentation record compliance). The most statistically significant results across the 19 studies were interventions related to the delivery of hospital-to-home transition of care information and these included information written in native language (Jang et al., 2018; Lerret et al., 2020), allocation of discharge care coordinator for hospital to home transition planning (Hall et al., 2018; Logsdon & Little, 2020; Vigna et al., 2018), designated time for the multidisciplinary team to discharge a patient (Sklansky et al., 2019; VanderVeen, 2020), standardised or electronic discharge summary process (Harlan et al., 2010), and provision of a transition bundle including follow-up care, hospital-to-home transition planning, teach-back based parental education, and contingency planning (Hamline et al., 2018; Parikh et al., 2020).

2.3.10 Summary

This section has presented a comprehensive literature review examining the research evidence related to transitioning paediatric patients from inpatient wards or the Emergency Department to home and the subsequent post-transition experience. A total of 67 studies were identified using comprehensive database and hand searches. The analysis of the literature confirmed that discharging a paediatric patient is a multifaceted and challenging process. Hospital-to-home transition processes and practices vary considerable across hospitals and this may impact the quality of the delivery of transitions of care information and potentially increases the likelihood of adverse events, such as unplanned Emergency Department visits or readmission following the initial discharge.

Hospital-to-home transition of care information is commonly offered shortly before the patient leaves hospital. As a result, caregivers may not fully comprehend the information and/or seek clarification of their child's care needs at home. The content of transition information is not tailored to individual needs hence some caregivers felt satisfied with the information while others felt the information they received was either overwhelming, insufficient or inconsistent.

Caregivers also expressed mixed feelings about how ready they thought their child was to go home and as a result caregivers and patients had varied recovery experiences. Assessing level of readiness for discharge is not a routine procedure in all hospitals. However, research literature has shown patients, who experienced delayed recovery or adverse outcomes also experienced limited hospital-to-home transition preparation and had a lower level of perceived readiness for discharge. The negative health outcome experience is even more prominent in patients from families with limited English proficiency when interpreter service support is not arranged. To date, interventions to improve paediatric discharge and recovery experience while mainly targeting transition information delivery and the discharge process, remains largely inconsistent across studies and settings.

Overall, a standardised paediatric hospital to home transition guideline needs to be developed to facilitate delivery of information which is comprehensive, understood and useful (Nemetchek et al., 2019). The guideline should include when the hospital to home transition plan is initiated, monitoring and evaluation of progress, and documentation of completion of the transition plan (Berry et al., 2014). Caregivers also suggests more advanced notice of hospital to home transition plans are need from the staff (Aydon et al., 2018; Solan et al., 2015). Timing of information delivery is considered critical. Caregivers preferred early preparation for the hospital-to-home transition plan, for instance, commencing at the time of admission, but not during a child's medical procedure (Keatinge et al., 2009).

A hospital-to-home transition checklist and readiness for discharge assessment are also suggested to be used to monitor and follow up with the transition plan, although some healthcare providers perceived the assessment could delay the discharge process (Canary & Wilkins, 2017). In preparation for discharging a patient and their families, caregivers suggested healthcare providers use plain language (Keatinge et al., 2009) and that ambiguous terms are removed from hospital-to-home transition information (Berman et al., 2019). Specific and targeted transition information should be provided to meet individualised needs (Keatinge et al., 2009). For patients of LEP families, an interpreter should be arranged and teach-back techniques should be applied when communicating transition information (Hamline et al., 2018). Both caregivers and healthcare providers recommended that written information should include clear instruction in bullet points (Canary & Wilkins, 2017; Keatinge et al., 2009) and that this is translated to their native language for LEP families as well as being provided in English (Gold et al., 2020; Jang et al., 2018).

Furthermore, caregivers need to be prepared not only physically but also psychologically for fatigue and disappointment due to delayed recovery. Strategies need to be discussed with caregivers to balance family, work, and child's needs as well as self-care (Berman et al., 2019). Caregivers expressed their need to be connected post-hospital discharge with community-based support services (Canary & Wilkins, 2017; Martens et al., 2018; Nemetchek et al., 2019), physical resources and financial support (Berman et al., 2019; Leary et al., 2020; Martens et al., 2018), dietary supplies and instructions, medical needs and knowledge and telephone contacts (Martens et al., 2018; Ronan et al., 2020).

Table 2.1

Characteristics and Main Findings of the Included 67 Studies

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
		Transition Process		
Barone 2020 USA	Pilot of novel program using photovoice methodology	A tertiary children's hospital	11/12 consented families of children with medical complexity returned photographs/7 completed interviews. 15 healthcare providers Interviewed	Clinician perceptions • Families not sufficiently prepared to go home with medical technology • Lack of continuity of care Parental perceptions • Desire for considerations from healthcare providers to individual family context including resources, housing suitability, financial status when making decisions on hospital-to-home transition
Nagewaran 2020 USA	Qualitative study – Focus group	9 hospitals 5 community agencies	14 hospital- and community-based stakeholders 18 home health nurses	Domain 1: Home health orders • Specific and accurate home health orders • Discharge summary completion before leaving the hospital Domain 2: Communication • Discharge summary provides useful information for home health providers/Primary care provider • Primary care provider desires communication with hospital-based healthcare providers Domain 3: Resources • Unavailable resources for Primary care provider to solve clinical problems (nurse-to-nurse hand over or who to contact when needs clarification) Domain 4: Caregiver preparation • The importance of transition preparation • Differences between hospital care-based practice and home care-based practice

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Nemetchek 2019 Uganda	Qualitative – Focus groups & in-depth interviews	7 hospitals (5 public & 2 private not-for-profit)	58 (Nurse, Physician, Administrator) Focus groups x 14 In-depth interviews x 7	Barriers • Insufficient resources and education for caregivers • Discharge process based on hospital specific protocols or clinician preference • Ineffective communication between healthcare providers and caregiver • Lack of human and physical resources of healthcare services Enablers • Teamwork • Motivation to improve paediatric transitions to home Recommendations • A standardised national paediatric discharges guideline • Appropriate community referral and follow-up
Aydon 2018 Australia	Qualitative – Open-ended question interviews, online survey and telephone interviews	A tertiary Women & Infant Hospital	Neonatal ICU 40 parents (20 couples)	• Lack of informed discharge process or not well understood • Felt rushed out the hospital
Berman 2018 USA	Qualitative – In-depth, Semi-structured interviews	A tertiary children's hospital	15 parents (14 mothers & 1 father) of 18 NICU patients	5 broad categories of needs • Communication: Clear, concise, ongoing, timely • Parent role clarity: Transition process to remove patient monitoring • Emotional support: Preparation for the level of fatigues/disappointment; Balance self-care and child's needs; establish community connection • Knowledge and training: Continuity of care information, Management of unexpected health issues or equipment related issue • Financial support
Voie 2018 Norway	Qualitative – Open-ended question interviews	A tertiary children's hospital	2 NICU nurses and 2 Public health nurses.	3 Main challenges • Different expectations and lack of communication between NICU nurses and public health nurses • Lack of role clarity and interactions between the two groups of nurses • Public health nurses' competence was not recognised by NICU nurses and caregivers

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Canary 2017 USA	Qualitative – Focus groups and interviews	A regional tertiary care centre	Parents (3 in a focus group + 5 interviews) Primary care providers (13 in a focus group + 2 interviews) Hospitalists (6 interviews)	Discharge problems • Parents: Medication problems, delay in discharge, lack of communication opportunities • Parents & Healthcare providers: Delay in getting prescribed medication • Healthcare providers: Insufficient communication on medication administration Teamwork • Teamwork is essential to effective discharge processes for all parties Ideal discharge • Parents: Early preparation of discharge – at the time of admission; Suggestions of a discharge checklist & readiness assessment • Healthcare providers: Concerns over potential delay by assessing readiness for discharge • All groups: To streamline discharge documentation – Discharge instructions with bullet points and specific follow up plan
Berry 2014 USA	A narrative literature review	Literature search not reported	Not reported	Impact of Lack of standards for paediatric hospital discharge care delivery • Poor quality of paediatric hospital discharge • Hindered quality improvement efforts • Adversely affects the health and wellbeing of children and their families after they leave the hospital Recommended discharge process framework • Initiate paediatric discharge care; Develop discharge care plans • Monitor discharge progress; Finalise discharge
Keatinge 2009 Australia	Two qualitative studies - Semi-structured interview	A 38-bed regional hospital's general paediatric ward	All-cause; Study 1: 7 parents, who telephoned a paediatric telephone triage service seeking information about their child's post-discharge care. Study 2: 12 parents of children admitted to a regional hospital's general paediatric ward.	Varied timeframe from notification of discharge to physical leaving the hospital

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Transition Information Communication & Readiness for Discharge				
Gold 2020 USA	Qualitative focus-group-based study	A children's hospital	24 parents of children with medical complexity 12 native English speakers vs. 12 native Spanish speakers	Parental ideals for discharge medication education • Information quality: Complete, consistent information, and in preferred language • Information delivery: Appropriate education timing and delivery by experts • Individualised information: Consideration of parental literacy and level of information desired • Self-efficacy: Information results in parents' confidence to provide continuity of care at home
Glick 2020 USA	Quantitative comparison study	An urban public hospital	English/Spanish speaking parents of inpatients ≤12years with at least 1 daily discharge meds	Parent perceived and actual comprehension of instructions for discharge • Actual comprehension was lower than parental perceived comprehension • Plan complexity and low health literacy were associated with overestimation of comprehension
Rush 2020 USA	Quantitative chart audit	A tertiary children's hospital	Electronic medical records of 368 patients ≥1 chronic complex condition (CCC)	• Discharge communication was documented for 59% patients • Communication was significantly less likely to occur for patients with technology dependence, older patients, and those who were admitted to a teaching service • The quality of discharge summaries did not differ for patients with or without technology dependence
Lakhaney 2020 USA	Quantitative chart audit	A teaching children's hospital	Completion rate, accuracy and quality of 200 discharge summaries	• 7 elements: admission date, discharge date, discharge diagnosis, medications, • immunisations, pending laboratory tests, and follow-up appointments discharge diagnosis, medications, and follow-up appointments had the lowest rates of completion and accuracy • The quality of the hospital course and patient instructions was varied • No difference in quality scores on the basis of the number of authors or medical complexity • Significant more inaccuracies in discharge medications for patients with CCC than those without (63% vs 35%; p<0.001)
Abdul-Kareem 2019 Jamaica	Quantitative – Chart audits	6 units of a tertiary hospital	131 Mixed adults (88) & Paeds (43) charts	• 14% records had documented evidence of client teaching within 72h of admission • 18.3% reflected client teaching on the day of discharge • 6.9% records had documented evidence of nurses commencing discharge plan within the first 24h of admission

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Curran 2018 Canada	Qualitative – A 4-round modified Delphi study	12 hospitals (9 paediatrics)	1st Round = 41 ED clinicians 2nd Round = 38 ED clinicians 3rd Round = 37 ED clinicians 4th Round = 37 ED clinicians	• Consensus of 30 content items over 6 illness presentations: diarrhoea/vomiting, abdominal pain, fever, and bronchiolitis, asthma, minor head injury without concussion • Majority of items (n = 19/63.3%) were associated with instructions on instances when to return to the ED department
Unaka 2017 USA	Quantitative – Chart review Written discharge instruction Readability (FRY Readability Scale); Understandability (Patient Education materials Assessment Tool-PEMAT); Completeness (5 criteria)	A large urban tertiary children's hospital	Randomly selected 200 charts – patients median age = 3.1 Years	• Median readability score corresponded to a 10th-grade reading level • Median PEMAT score was 73% ✓ 36% of instructions scored below 70% – Suboptimal understandability • Completeness: ✓ Diagnosis was described in only 33% of the instructions ✓ Explicit warning signs were listed in most instructions, but 38% did not specify contact details if warning signs developed
Weiss 2017 USA	Quantitative – Survey & Telephone interview & Electronic records audit	2 Units of a paediatric hospital: a 16-bed medical respiratory & a 22-bed neurologic unit	194 parents of children had ≥2 days hospital stay from 2012 – 2013	• Quality of teaching (9.1/10) • The amount of content about discharge was 6.1/10 • Parental perception of discharge teaching delivery was positively associated with both parent (B = 0.54) and nurse perception (B = 0.16) of readiness for discharge • White race and shorter length of stay were associated with higher nurse assessment scores on readiness for discharge
Bhansali 2016 USA	Qualitative – A descriptive interview & records review	A tertiary children's hospital	174 parents within 24 hours of hospital discharge	• 15% felt less than "completely prepared" • 83% matching within interview responses and the medical record, but more for hospital course events than the discharge plan • Few significant differences in understanding between trainee-based teams and the attending physician–run unit

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Lerret 2015 USA	Quantitative – Survey 6 questionnaires at discharge & 5 questionnaires post-discharge	5 paediatric transplant centres	Solid organ transplant; 51 parents on the day of discharge; 49 Parents at 3-week post-discharge; 47 Parents at 3-month & 6-month post-discharge	• Care coordination (p = 0.02) and quality of discharge teaching (p<0.01) was significantly associated with parental readiness for discharge • Readiness for discharge was significantly associated with ✓ Post-discharge coping difficulty (p = 0.04) & medication administration (p = 0.03) at 3 months post-discharge ✓ Post-discharge coping difficulty (p = 0.04) & family management (p = 0.02) at 6 months post-discharge
Coghlin 2014 USA	Quantitative – Online or by fax Survey	16 paediatric hospital medicine programs	All-cause; 201 of 320 Primary Care Providers (63%) and 71 of 147 hospitalists (48%) responded	**7 clinical elements were reported as essential** by >75% of both primary care providers and healthcare providers: • Dates of admission and discharge; Discharge diagnoses; Brief hospital course • Discharge medications; Immunizations given during hospitalisation • Pending laboratory or test results; Follow-up appointments Primary Care Providers • Received discharge communication significantly less often than healthcare providers (71.8% vs 85.1%; p<.01); • Considered communication to be complete significantly less often than healthcare providers (64.9% vs 79.1%; p<.01)
Lerret 2014 USA	Mixed-methods – Observations & Interview	3 paediatric hospitals	Solid organ transplant; 37 parents	• Discharge teaching included medication knowledge, restrictions and warning signs • Readiness for discharge depended on discharge education method (consistency vs. complexity and support vs. need for encouragement)
Keatinge 2009 Australia	Two qualitative studies – Semi-structured interview	A 38-bed regional hospital's general paediatric ward	All-cause; Study 1: 7 parents, who telephoned a paediatric telephone triage service seeking information about their child's post-discharge care. Study 2: 12 parents of children admitted to a regional hospital's general paediatric ward.	Both studies • Verbal as well as written information is helpful • Plain language usage is important • Information provided by healthcare providers are sometimes inconsistent • Parents need information specific to their particular circumstances Study 1 • The amount and delivery method of discharge information varied • All parents received some verbal information • Written discharge summary is generally not helpful • The telephone triage role is to ""filling the gap"" • Information needs and when & how: Access to reassurance & Specific requirements for additional discharge information

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
				Study 2 • Information should be simple and concise in language • Brochure is needed for a particular illness and an information sheet relating to post-discharge care • Timing to deliver information – not when child having a procedure • Time frame between discharge notification and exit from hospital varies • Lack of sleep and its impact on retention of discharge information
McGowan 2019 USA	Quantitative – Survey Fragile Infant Parental Readiness Evaluation	A Women & Infants Hospital	Immigrant (n = 176) and native (n = 556) mothers of babies at NICU>5days	• Immigrant mothers were more likely to be older, gravida>1, multiracial or people of colour, and non-English speaking; have less than a high school education; and receive Medicaid but less likely to have child protective services involvement, substance abuse, and mental health disorder (MHD) • Immigrant mothers with poorer perceptions of infant well-being, maternal well-being, maternal comfort, and time impact. • Immigrant status, non-English primary language, and MHD are associated with lower readiness scores • Increased years of in the USA and MHD is related to low readiness scores
Obregon 2019 USA	Quantitative – Survey	A major tertiary medical centre	1037 discharged families (NICU); 90 had LEP	• No difference of being prepared for discharge for both groups • LEP families were less likely to be prepared with technical baby care skills (AOR = 0.32; 95% CI 0.13–0.81)
Aydon 2018 Australia	Qualitative – Open-ended question interviews, online survey and telephone interviews	A tertiary Women & Infant Hospital	NICU 40 parents (20 couples)	Transition from hospital to home pre-discharge • First impression: Overwhelmed with 'high-tech' equipment but impressed with staff competence • What do I need to know: Information needs changes over time; well informed about the care and progress vs. lack of information that needing to ask the staff vs. overloaded information vs. inconsistent or conflicting information • Being involved in my baby's care: staff needs to assess parental needs as parents can do more as baby stabilises • Getting ready to take my baby home: Lack of informed discharge process or not well understood Transition from hospital to home • Preparing to go home: Parents are taught continuity of care to prepare for home • Discharge day: Many parents felt rushed when leaving the hospital and suggest more notice and a better plan from the staff

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
				• Arriving at home: ✓ Most parents felt prepared but some did not feel mentally/physically ready ✓ Some expressed being anxious about taking their baby home without the constant monitoring and support from nursing and medical staff 3 main recommendations from both Pre- & Post-Discharge • Effective parent – staff communication • Feeling informed and involved • Being prepared to go home
Martens 2018 USA	Qualitative – a semi-structured telephone interview	A children's hospital	Foster parents	4 Main Themes & 13 Subthemes • Knowing the child: Medical history, Baseline and routine & First meeting the child • Medical legal issues: Custodial determination & Access to information • Complexities of multi-stakeholder communication ✓ Contact with biological parents ✓ Department of Health and Human Services communication ✓ Communication with the inpatient team Post-discharge preparation and support ✓ Availability of nonmedical supplies; ✓ Availability of dietary supplies and instructions ✓ Medical needs and knowledge; Telephone contacts; Home services
Lerret 2011 USA	Quantitative study – Survey	3 paediatric hospitals	Solid organ transplant; 37 parents	• Care coordination was associated with readiness for hospital discharge • Readiness for hospital discharge subsequently impacted post-discharge coping difficulty, adherence difficulty with medical follow-up, and family impact
Lerret 2009 USA	Integrative review	Literature search ended 2008	38 included studies	• Four concepts impacting on discharge readiness: Support, identification of unique and individual needs, education, and communication and coordination • The varying perceptions of readiness for discharge between healthcare providers and patients underscore the importance of communication and coordination • Common themes: Meaningful interaction and confidence building

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Post-Transition Recovery Experience				
Barone 2020 USA	Pilot of novel program using photovoice methodology	A tertiary children's hospital	11/12 consented families of children with medical complexity returned photographs/7 completed interviews 15 healthcare providers were interviewed	• Develop new routines and seek normality • Learning how to be a parent and a family • Impact of medical technology usage on everyday life • Experience social stigma and isolation
Gaskin 2020 UK	Longitudinal mixed methods using semi-structured interview and survey	A tertiary children's hospital	16 parents of 12 infants following 1st stage cardiac surgery	Prior to Discharge • All parents experienced signs of stress disorder • 4 had symptoms of PTSD • Fear and uncertainty about going home 8-week following Discharge • Feeling relived, relaxed and positive Survival – Psychological needs • Anxiety and depression score decreased Survival – Physical and physiological needs • Self-care • Home preparation and alteration to adapt equipment needs Survival – Financial needs • A burden to family that unable to resume work
Leary 2020 USA	Qualitative semi-structured interview	A paediatric hospital of an urban academic medical centre	20 parents of children with medical complexity during 30-Day UHRs	Challenges faced with chronicity of care and transitions of care, which contribute to readmission • Frequency of hospital utilisation • Symptom confusion • Lack of inpatient continuity • Resources need but not received • Difficulty filling prescripts
Ronan 2020 UK	Systematic review	13 included studies from Jan 2009 – Sept 2019	Parents' experience of hospital-to-home transition	Experiences & Needs • Emotional processes ✓ Before discharge: Sense of loss, fear, concerned, unprepared and uncertain ✓ Home: Overwhelmed, exhausted and stressed

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
				• Communication ✓ Significant communication breakdown between hospital and community services – lack of coordination ✓ Mixed experience of communication between parents and healthcare providers – Poor vs. prepared and confident ✓ Desire to be involved in the planning period to avoid confusion ✓ Need to be contacted immediately post-discharge Priorities for the transition • Coordination ✓ Discharge readiness – fit for discharge ✓ Early education and preparation for discharge is needed ✓ Desire to be home early in the day not in the evening or overnight • Support and resources for the transition ✓ Inconsistent delivery of discharge information • Desire a healthcare provider, especially an experienced nurse, in the community
Lion 2020 USA	Survey on Day-3 of admission & 2–8 weeks post-discharge	A children's hospital	Day-3: 3651 (61%) families completed survey; then 1734 (48%) completed the follow-up survey	• System barriers, skill barriers, cultural distance, and marginalization are associated with socially disadvantaged/low income families and 30-Day UHR
Aydon 2018 Australia	Qualitative – Open-ended question interviews, online survey and telephone interview	A tertiary Women & Infant Hospital	NICU 40 parents (20 couples)	• Enjoyed the autonomy of caring for their baby at home and felt more comfortable and in control • Caring at home environment resulted in new challenges • Accessing community services to build a network for support and information
Parikh 2018 USA	Quantitative – Online survey	45 hospitals in the PHIS	Asthma (5–17 years) 17,115 respondents /16,457	• 30-day UHR rate: 1.9–3.9% • 3-month UHR rate: 5.7–9.1%

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Canary 2017 USA	Qualitative – Focus groups and interviews	A regional tertiary care centre	Parents (3 in a focus group + 5 interviews) Primary care providers (13 in a focus group + 2 interviews) Hospitalists (6 interviews)	Care chasm • Parents: Lack of support or resources to meet needs at discharge • Lack of a detailed plan of care • Parental emotional struggles over the complexities of providing complicated care at home; or need to internalise new realities for the sick child Discharge paradox • Contradiction: Ongoing significant medical care needs that provided in the hospital but being told ready for discharge
Glick 2017 USA	Systematic review	Literature search ended 1st January 2017	64 studies consisted of 48 ED studies and 16 Hospital studies	• Medication dosing and adherence errors • Missed follow-up appointments • Misunderstood return precaution instructions • Errors related to complex discharge plans (multiple medicines or appointments), limited English proficiency, and public or no insurance
Navanandan 2017 USA	Quantitative – Survey	A paediatric ED	72hours returned ED visits 500 caregivers	• 495 had returned ED visits • Reasons included child's illness not resolved (51%) or worsened (41%) • 41% of caregivers were not instructed on all key components of discharge; • 47% of caregivers were no educated on anticipated duration of illness; • Complete delivery of discharge instructions was associated with ED satisfaction (OR = 5.7; 95% CI 3.8–8.5)
Weiss 2017 USA	Quantitative – Survey & Telephone interview & Electronic Records audit	2 clinical units of a paediatric hospital: a 16-bed respiratory medical unit & a 22-bed neurologic care unit	194 parents of children had ≥2 days hospital stay from 2012–2013	• Post-discharge coping difficulty within 3 weeks was 1.7/10 • ED visit (30-day) without readmission: n = 28 (14.4%) • 30-day readmission: n = 13 (6.7%) • Nurse: Discharge readiness was negatively associated with readmission • Parents: College qualifications more prone to post-discharge coping difficulties • Parent: Readiness was negatively related to post-discharge coping difficulty • Child's age was inversely associated with ED use post-discharge • A higher admission synergy score (indicating minimal vulnerability/ high predictability/high resilience) were positively related to readmission

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Solan 2015 USA	Qualitative – Focus groups & Individual interviews	A 500-bed tertiary children's hospital	All-cause; 61 parents of 11 focus groups & 4 individual interviews	4 main themes & subthemes • *"In a fog"*: Barriers to comprehending information are mental exhaustion; Handling uncertainty; Information overload; Usability of information • *"What I wish I had"*: Information desired; Suggested improvements in the discharge process • *"Am I ready to go home?"*: Emotional discharge readiness; Clinical discharge readiness • *"I'm home, now what?"*: Knowing contacts to seek help; Desiring a call or nurse home visit; Caring for a sick child; Confidence in caring for a sick child
Pinto 2015 Brazil	Qualitative – Symbolic interactionism/theoretical reference & Grounded theory Unstructured interview & Observation	Family preference (Home x 4; Day care x 4; Parent's workplace x 3)	11 families with child had acute health conditions & experienced UHRs; Diagnoses: bronchiolitis x 4, gastroenteritis x 2 and others; 15 interviews Jan 2008 to July 2009;	• Resuming control of child: ✓ Prioritizing the child and providing continuing treatment ✓ Monitoring and making decisions without direct support of healthcare providers ✓ Recognizing the signs of child improvement ✓ Feeling relieved about return home ✓ Remaining alert ✓ Feeling apprehensive/threatened balancing family function • Facing difficulties adjusting to new demands ✓ Having conflicts; Feeling overwhelmed ✓ Fears relapsing of the child's disease ✓ Being touched by other disease experiences ✓ Developing confidence in the child's recovery; Remaining shaken • **Theme 1**: Mobilising to restore functional balance – Family struggles to resume normality post-hospitalisation • **Theme 2**: Suffering from possibility of a child's readmission – Family is impacted from the possibility of readmission from disease recurrences • **Theoretical model**: Seeking prevention of child rehospitalisation to avoid suffering
Lerret 2014 USA	Mixed-methods study Quantitative observations & Interview	3 paediatric hospitals	Solid organ transplant; 37 parents	• Coping at home post-discharge: ✓ 'The new normal'; 'Watchful waiting', 'Medications' • Knowledge needs: Situation specific vs. generic information • Adherence difficulties: Medications, follow up appointment and/or laboratory test or imaging investigation

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Ford 2012 Australia	Qualitative – Exploratory interpretive study Diaries & Semi-structured interviews	A children's unit within a tertiary general hospital	All Cause; Families of 8 children (9–12 years) with 1 to 9 days admission; 4 elective and 4 emergency surgeries; 1 patient required unplanned readmission	6 Main themes • The central role of the family: Mother as well as immediate/extended families • Going home: Feeling relived or nervous/uncertain about ability to care the child • Preparation for discharge and information: Felt fully informed or not well-prepared • Pain: Children are expected and experienced different level of pain • Increased vigilance in assessing the child's progress and well-being • Different trajectories of recovery process: Straightforward or delayed recovery or even complications requiring re-hospitalisation
Pinto 2010 Brazil	Integrative review Recovery post-hospital discharge	Literature search 1990–2005	16 included studies	• Biopsychosocial manifestations ✓ Harms to family cohesion along the recovery process ✓ Child: Loss of appetite, apathy, aggression, separation anxiety, trouble sleeping, pain, limited mobility and self-care ability ✓ Parents: Higher anxiety after discharge, low confidence in child's recovery, feeling of isolation, less healthy • Factors related to biopsychosocial manifestation ✓ Children: Number, time, and cause of admissions, quantity of invasive procedures, age and gender of patients ✓ Parents: Severity of disease, longer hospitalisation, duration of staying home with child after hospital discharge • Support and information needs ✓ More time of healthcare providers to communicate post-hospital discharge care ✓ Information was too generalised: Suggesting nutrition, behaviour, going back to school, symptom reoccurrences prevention, use of medication prescribed ✓ Parents were calmer when perceiving that information received regarding child's health recovery corresponded to what they were experiencing at home

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Impact of caregivers with limited English language proficiency on patients' transition and recovery experience				
Davis 2019 USA	Mixed-methods study – multimodal analysis Translating discharge instruction for LEP	Children's Hospital Association language services (n = 200) were contacted	Online survey to Children's Hospital Association language services contacts (n = 31); Online environment scan of Children's Hospital Association translation policy (n = 22); County-level census data	• 81% with written translation hospital policy • 74% translated discharge instructions • Either pre-translated documents (87%) or staff interpreters (81%) • Barriers ✓ Difficulty translating uncommon languages ✓ Mismatched discharge and translation time frames ✓ Inconsistent clinical staff use of translation services ✓ Institutional policies differed regarding the appropriateness of allowing interpreters to assist with translation • **Strategies**: To establish document libraries, pre-translated electronic health record templates, staff-edited machine translations, and sight translation
Enlow 2019 USA	Quantitative – Survey The Parent Health Literacy Activities Test	Multi-site NICU of tertiary hospital	137 participants	• 31% unable to answer ≥3 of 8 questions • Lower scores were significantly associated with lower ratings of discharge readiness by nurses, but not parents • Scores improved slightly from admission to discharge (p = 0.049)
Gutman 2018 USA	Qualitative Video-recorded ED visits for Spanish-speaking LEP families	ED of a tertiary children's hospital	101 discharge communication interactions from 47 LEP patient visits	• 31% of communications did not use professional interpretation • 70% patients received complete discharge education content ✓ 65% received instructions on medication dosing ✓ 55% were given return precautions • 13% included an open-ended question to assess caregiver comprehension, but included teach-back. • Professional interpreter use was associated with ✓ Complete discharge education content (OR = 7.1; 95% CI 1.4–37.0) ✓ High-quality provider assessment of caregiver comprehension (OR = 6.1; 95% CI, 2.3–15.9)

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Ju 2017 USA	Quantitative – Retrospective cohort study	A children's tertiary hospital	67,473 encounters	• 7-day UHR rate = 3.9% • 30-day UHR rate = 8.2% • LEP patients were more likely to be younger, poorer, Hispanic, lower severity of illness (SOI), government-subsidized insurance • No increased risk of UHRs compared LEP to EP • White LEP increased odds (AOR = 1.46 for 7-day & AOR = 1.32 for 30-day) compared to white EP • Poorest LEP higher risks (AOR = 1.77 for 7-day & AOR = 2.00 for 30-day) compared with the poorest EP patients • Hispanic ethnicity (AOR = 1.26 for 7-day & AOR = 1.14 for 30-day) • Greater SOI (AOR = 1.04 for 7-day & AOR = 1.05 for 30-day) • Presence of a complex chronic condition (AOR = 2.31 for 7-day & AOR = 3.03 for 30-day)
Zurca 2017 USA	Quantitative – A cross-sectional study	An urban tertiary care PICU	109 English- & 52 LEP with Spanish-Speaking parents responded the survey (88% rate)	LEP families were significantly less likely to: • be engaged in the rounds • understand the material discussed on rounds • be present during medical team evaluation of child • report medical team spent enough time speaking with them • report PICU nurses spent enough time speaking with them • rely on their nurses for medical updates • 53% of physicians and 41% nurses used an interpreter "often"
Samuels-Kalow 2017 Canada	Quantitative – A secondary analysis; Chart review	A tertiary care paediatric ED	202 English- & Spanish-Speaking parents of children 2–24months with fever and/or respiratory illness	• 23% LEP • 6.9% of the sample had a return visit within 72 hours • After adjustment for confounders, LEP was associated with ✓ Higher risk of ED Return visit within 72 hours (OR = 3.49; 95% CI 1.02–11.90) ✓ Decreased risk of a second visit within the year (OR = 0.28; 95% CI 0.12–0.66)
White 2017 USA	Qualitative – In-depth, Semi-structured interviews	Seven different hospitals	18 mothers and fathers of NICU babies (mean LOS = 63.58 days)	• 3 types of parental uncertainties: Parental role shift, caring through equipment, and adherence to provider advice • Coping strategies: Reorientation, calibrating appropriate responses, and limiting exposure • Parental experiences, communication interactions, and expectations in the NICU complicate parental uncertainties post-discharge and negatively affect parental perceptions of self-efficacy, readiness and competency

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Samuels-Kalow 2016 Canada	Qualitative – A modified grounded theory In-depth interviews Health literacy	Two tertiary care centres (Adult & Paediatric)	Levels of health literacy screened and balanced in the purposive sampling 31 parents & 20 patients	Main Barriers related to • ED providers ✓ Use of medical terminology -need for simplified/lay language and materials both verbal and written ✓ Need for verbal teaching and demonstration ✓ Desire for increased information • Systems of care ✓ Absence of protected time for discharge communication • Concern over conflicting information by limited health literacy • Concern over provider judgment regarding ED returns
Samuels-Kalow 2016 Canada	Qualitative In-depth interviews on ED	Two tertiary care centres (Adult & Paediatric)	Levels of health literacy screened and balanced in the purposive sampling 31 parents & 20 patients	• **All participants** perceived teach-back technique could ✓ Help them confirm learning ✓ Avoid forgetting key information ✓ Improve doctor-patient communication • **Participants with sufficiency health literacy** felt teach-back being waste of time or unnecessary • **Participants with limited health literacy** felt teach-back being condescending or judged • The suggested techniques for introducing the technique include ✓ Encouraging parents not to take offense ✓ Being explicit about the reasons for verifying comprehension
Morrison 2014 USA	Quantitative – Survey	A paediatric ED	503 caregivers	• 55% low health literacy • Children of caregivers with low health literacy is associated with ✓ Prior ED visits (AOR = 1.5; 95% CI 1.2–1.8) ✓ Increased non-urgent index ED visit (AOR = 2.4; 95% CI 1.3–4.4)
Gallagher 2013 USA	Quantitative – Retrospective cohort study	ED of a paediatric tertiary hospital	119,782 patients over 32 months	• 11.7% a language other than English as their primary language • Return ED visit 1.2% vs. 1.6% of LEP patient • LEP patient is more likely represent to ED (OR = 1.3; 95% CI 1.12–1.50) • After controlling for age, emergency severity index, time of day (AOR = 1.43; 95%CI 1.23–1.66) are significantly associated with ED revisit
Samuels-Kalow 2013 Canada	Quantitative – Prospective observational study	A tertiary care paeds ED	145 (69%) of 210 English- & Spanish-Speaking parents of children 2–24months with fever and/or respiratory illness	• 32%parents (n = 46) had an acetaminophen dosing error. • Spanish-speaking parents were significantly more likely to have a dosing error (OR = 3.7; 95% CI 1.6–8.1), • Even after adjustment for language of discharge, income, and parental health literacy (ARO = 6.7; 95% CI 1.4–31.7)

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Interventions to improve transition process and recovery experience				
Lerret 2020 USA	Two group Pre-Post quasi experiment study – ePED app	24-bed Surgical vs. Medical Wards of a paediatric hospital	211 vs. 184 paediatric patient discharges	• Higher quality of discharge teaching scale-delivery No difference in care coordination measures
Logsdon 2020 USA	QI Project – Logic model for the evaluation design A discharge coordinator role Parental knowledge, Nurses satisfaction of discharge process	16-bed paediatric CCU	Pre: 40 parental knowledge assessments vs. Post: 31 18 nurses surveyed	• A 12.71% increase in discharge before noon increased by 12.71% • A 11.92% decrease in LOS • Less deficits of parental knowledge Nurses were satisfied with discharge process
Parikh 2020 USA	RCT H2H – A patient-centred 5-component program	A children's hospital	32 children (K-8th grade on Medicaid for asthma)	• Medication in-hand at discharge (100%) • School-based asthma therapy (100%) • Referral for home trigger assessments (100%) – 87.5% families reported extremely helpful • 4-week post-discharge home visits (44%) • Communication with primary care provider (100%) • Patient navigator support at 3 days (81.3%) No difference in healthcare usage outcomes
Patra 2020 USA	Pre-post pilot study Bundle intervention: Risk identification and intervention – use of handouts, scheduling of follow-up appointments, post-discharge phone call, facilitated by advanced paediatric provider	A rural academic children's hospital	Patients: Pre-1321 vs. Post-1413	• Significant improvements in patient satisfaction measures on the discharge domain ✓ Speed of discharge process (78.9 vs 82.6, p = 0.008) ✓ Instructions for discharge (79.7 vs. 88.6, p<0.0001) ✓ Discharge readiness (79.7 vs. 88.6, p<0.0001) ✓ Overall discharge process (79.4 vs. 86.1, p<0.0001) • 97.8% usage of discharge risk assessment checklist ✓ Identified risks may complicate transition of care in approx. half of the patients ✓ 3.75% patients with an incorrect or no primary care provider in the EMR • Significant improvement in arranging primary care provider appointment before discharge • Significant improvement in patients receiving handouts • No significant difference in 7-Day UHR LOS: Significant decrease (4.08 vs. 3.43 days, p = 0.005)

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
VanderVeen 2020 USA	Narrative review on multidisciplinary approach for hospital-to-home transition	15 peer-reviewed studies from 2001 to 2019	Patient with bronchopulmonary dysplasia	• Reduced UHR rate • Approach includes Respiratory support, Pharmacologic interventions, Immunisations, Nutrition, Developmental therapies, and follow-up programs Improved patients health outcomes – decreased rate of readmission for patients on supplemental O2
Lion 2019 USA	Quantitative – Survey Audio recorded discharge instruction card	A children's hospital	Day surgery – 66/83 (79.5%) Parents with LEP randomly assigned to Intervention (n = 31) and Control (n = 35)	• 61% high school education and 89.2% spoke Spanish • 4.5/5 for ease of use, helpfulness and understandability • 94% shared the card with others; 45.2% listened >5 times • Parents used the card reviewing medications and engaging others in providing care for the child
Jang 2018 USA	Quantitative – RCT Standardised Quiz & Survey Written discharge instruction in native language	A medical centre	20 LEP parents need interpreter of children (ENT) randomly into written discharge instructions in Spanish/10 and English/10	• No difference in comprehension scores between the two groups • 91% parents preferred written instructions in Spanish and could improve comprehension (p<0.01) • No significant effect on patient satisfaction
Kenyon 2019 USA	Quantitative – A pilot RCT Survey Text message reminder post discharge	A tertiary children's hospital	Parents of patients 2–13 years Intervention (n = 21) Control (n = 20)	• 78% families (n = 32) transmitted medication adherence data • 96% caregivers (n = 25) chose to receive daily reminders • No difference in daily medication adherence between groups • Adherence trajectories were lower than the 80% threshold
Sklansky 2019 USA	Quality improvement A multidisciplinary discharge timing designation in the electronic health record	A tertiary urban children's hospital	20,133 discharges	• Discharges before noon increased by 6.2% • LOS significantly decreased from 47 to 43hours
Hall 2018 Australia	Systematic review – Meta-analysis /Caseworker-assigned discharge plan	Literature Search ended November 2017	4 RCT studies included	• Intervention group significantly less readmitted compared to controls • No significant effects on ED or GP presentations • One study reported quality of life, but no differences between groups

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Hamline 2018 USA	Meta-Analysis Hospital-to-home interventions: Provider communication interventions (PCIs); Care coordination interventions (CCIs); Family engagement interventions (FEIs)	Systematic Review Search ended July 2017	71 included studies	• PCIs: Communication between the inpatient and outpatient healthcare providers • CCIs: Care coordination, defined as those that involved intentional organisation of patient care activities • FEIs: Family engagement, which included family education and/or involvement in patient care • Follow-up care (CCI); Discharge planning (CCI); Teach-back based parental education (FEI); Contingency planning (FEI) were associated with reduction in UHR and ED revisit post hospital discharge • Bundled CCIs and FEIs were associated with lower use in patients with chronic illnesses and neonates
Parikh 2018 USA	Quantitative – Online survey Discharge education bundles x 2	45 hospitals in the PHIS	Asthma 5–17 years patients 17,115 respondents /16,457	• 2-discharge bundle: Content of education + communication with the primary medical doctor • 3-discharge bundle: Content of education + medications in hand + home-based environmental mitigation; • Discharge bundles decreased 30-day UHRs but not statistically significant
Vigna 2018 USA	Quantitative – Survey Discharge specialist role impacts on readiness for discharge readiness	A paediatric heart centre	30 patients in intervention (discharge specialist Role) and 30 on control group	• Overall average score of the composite proportion responding with "Strongly Agree" was higher among intervention group, compared to control (p<0.001) • 12/18 items significantly higher
Almidani 2017 Saudi Arabia	Quantitative – Chart review Standardisation process of discharge summary	Paediatric department of a tertiary hospital		• A significant drop in the number of delinquent records • From 1,131 delinquent records at the end of the fourth quarter of 2011 vs. 15 in the fourth quarter of 2016 • The discharge documentation compliance rate has improved from 50% and maintained around 80%s
Akinsola 2017 USA	Quality improvement Chart review ED written discharge care instruction (DCI) compliances	A tertiary ED	329 DCI (Pre) vs. 1,434 DCI (Post)	• Intervention: Written discharge instruction complement verbal instructions • 8 key elements of good quality discharge instruction: ✓ Customized note; Explanation of presenting complaint/diagnosis ✓ Test(s) performed; Test(s) results ✓ New medication(s); Reason for medication(s) ✓ Reasons to follow-up; Follow-up physician's/specialty name • Bundle measure of all 8 elements increased from 23% (PRE) to 79% (POST) (p<0.001)

Reference	Study Design/ Data Collection	Setting	Participants	Main Results
Olivarez 2017 USA	Quantitative – A cross-sectional observational study Electronic Medical Records (EMR) implementation	A tertiary care paediatric ED	English- & Spanish-Speaking	• Minimal differences between English and Spanish- speaking families in interactional elements and basic dialogue during discharge. • Spanish-speaking families had longer wait times to discharge once the decision to discharge was made. • Implementation of EMR added efficiency in terms of seeing a physician after arrival and equalizing the discharge instruction process between both groups.
Unaka 2017b USA	Quality improvement Pre: Audit and feedback of data vs. Post (6months): Readability scored; Chart review Discharge instructions	A 42-bed unit of a large, urban tertiary children's hospital	A multidisciplinary team of physicians, nurses, and parents	• Quality improvement Cycle ✓ Education and implementation of a general discharge instruction template ✓ Visible reminders and tips for writing readable discharge instructions ✓ Implementation of disease-specific discharge instruction templates ✓ Individualized feedback to staff on readability and content of written discharge instructions • Discharge written instructions at 7th grade • Readability level increased from 13% to 98% and sustained for 4months • The reliable use of the templates was associated with improvements
Holland 2016 USA	Qualitative Study – Chart review Exploratory thematic analysis using Omaha System Text from 67 clinical notes	A 86-bed magnet children's hospital	All-cause; 28 patients (9 ±6.2 years) with ≥ one discharge plan documentation entries by Social workers or Discharge planning nurses	• A total of 517 phrases were mapped • 11 of the 42 Omaha System problems were identified. The most frequent problem was health care supervision (297/517; 57.4%). • 3 Omaha System intervention categories were used: Teaching, guidance, and counselling, case management, and surveillance
Harlan 2010 USA	Quality improvement – PDSA prospective, cross-sectional Identification of primary care provider; Electronic and legible discharge instructions; and Automatic faxing to primary care provider	A 271-bed tertiary paediatric hospital	All-cause; 2,530 patient discharged over 34 weeks 730 Pre-intervention 236 Intervention 1,562 Post-intervention	• Success and timeliness of discharge information transfer to primary care providers were significantly improved • Contents remained unchanged • Potential causes of suboptimal discharge communication include ✓ Multiple individuals working on parts of the discharge process ✓ Leverage Points: ▪ Poor education of patient about home needs ▪ Handwritten discharge order ▪ Duplicate entry of same information • Incomplete discharge instructions

2.4 Publication 2

Zhou, H., Della, P.R., Roberts, P.A., Goh, L., &Dhaliwal, S.S. (2016). Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review. *BMJ Open, 6*:e011060. http://doi:10.1136/bmjopen-2016-011060

The *BMJ Open* was selected for this publication as it is a well recognised and cited journal with impact factor of 2.659 in 2016. It is a fully online, open access journal, publishes medical research studies from all disciplines and therapeutic areas. Confirmation of adherence to copyright requirements is evidenced in Appendix A.2. This publication has been cited 115 times by 2 August 2021 as per Scopus (Appendix D.1).

Specific objectives of Publication 2 were:

- To provide an updated systematic review on predictive models for 28-day or 30-day unplanned hospital readmission
- To investigate and assess the characteristics of predictive models.

Main findings of Publication 2 were:

- A total of 60 studies with 73 unique predictive models were reviewed.
- A wide-range c-statistic was reported in 56/60 studies (0.21–0.88). 11 of 13 predictive models for medical condition-related readmissions were found to have consistent moderate discrimination ability (c-statistic ≥ 0.7).
- Only two models were designed for the potentially preventable/avoidable readmissions and had c-statistic>0.8.
- The variables ‘comorbidities’, ‘length of stay’ and ‘previous admissions’ were frequently cited across 73 models.
- The variables ‘laboratory tests’ and ‘medication’ had more weight in the models for cardiovascular disease and medical condition-related readmissions.

Open Access Research

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Utility of models to predict 28-day or 30-day unplanned hospital readmissions: an updated systematic review

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ABSTRACT

Objective: To update previous systematic review of predictive models for 28-day or 30-day unplanned hospital readmissions.

Design: Systematic review.

Setting/data source: CINAHL, Embase, MEDLINE from 2011 to 2015.

Participants: All studies of 28-day and 30-day readmission predictive model.

Outcome measures: Characteristics of the included studies, performance of the identified predictive models and key predictive variables included in the models.

Results: Of 7310 records, a total of 60 studies with 73 unique predictive models met the inclusion criteria. The utilisation outcome of the models included all-cause readmissions, cardiovascular disease including pneumonia, medical conditions, surgical conditions and mental health condition-related readmissions. Overall, a wide-range C-statistic was reported in 56/60 studies (0.21–0.88). 11 of 13 predictive models for medical condition-related readmissions were found to have consistent moderate discrimination ability (C-statistic ≥0.7). Only two models were designed for the potentially preventable/avoidable readmissions and had C-statistic >0.8. The variables 'comorbidities', 'length of stay' and 'previous admissions' were frequently cited across 73 models. The variables 'laboratory tests' and 'medication' had more weight in the models for cardiovascular disease and medical condition-related readmissions.

Conclusions: The predictive models which focused on general medical condition-related unplanned hospital readmissions reported moderate discriminative ability. Two models for potentially preventable/avoidable readmissions showed high discriminative ability. This updated systematic review, however, found inconsistent performance across the included unique 73 risk predictive models. It is critical to define clearly the utilisation outcomes and the type of accessible data source before the selection of the predictive model. Rigorous validation of the predictive models with moderate-to-high discriminative ability is essential, especially for the two models for the potentially preventable/avoidable readmissions. Given the limited available evidence, the development of a predictive model specifically for paediatric 28-day all-cause, unplanned hospital readmissions is a high priority.

Strengths and limitations of this study

- This is an updated systematic review (2011–2015) of the literature relating to risk predictive models for unplanned hospital readmissions.
- This updated systematic review followed rigorous methodology applying comprehensive electronic database search, strict inclusion, exclusion and quality assessment criteria to synthesise current literature on characteristics and properties of risk predictive models for 28-day or 30-day unplanned hospital readmissions.
- The outcomes of the predictive models included in this systematic review were restricted to 28-day or 30-day unplanned hospital readmission.

INTRODUCTION

Unplanned hospital readmissions cause a disruption to the normality of patients and/or family/carers' lives and result in a significant financial burden on the healthcare system.[1 2] In the USA, it has been estimated that 7.8 million (20%) of hospital-discharged patients were readmitted. This accounted for $17.4 billion of hospital payments by Medicare.[3 4] In the UK, the figures suggested ~35% of unplanned hospital readmissions, costing 11 billion pounds per annum (5.3 million admissions in 2010/2011).[5]

Unplanned hospital readmission rate is considered as a performance indicator to measure a hospital's quality of care.[6 7] Unplanned hospital readmission is defined as the percentage of unplanned or unexpected readmission to the same hospital within 28 days of being discharged.[8 9] However, the literature has widely used

30 days within the context of measurement of hospital readmissions.[1 6 7]

One of the strategies to reduce the unplanned hospital readmission rate is the application of predictive models to identify patients at high risk for readmission. Preventive approaches can then be developed and applied to target the identified high-risk patients. A previous systematic review[10] was conducted in 2011 on the risk predictive models for adult medical patients' hospital readmissions. A total of 30 studies with 26 predictive models were included, and the overall performance of reviewed models was poor. It is, however, worth noting that studies conducted in developing nations and studies that focused on paediatric patients and adult psychiatric and surgical patients were excluded.

Since 2011, there has been increased interest in either developing new predictive models or validating existing models due to high inpatient demand on the healthcare system.[11–15] However, the performance of risk predictive models has varied significantly. The purpose of this systematic review is to update previous systematic review on predictive models for 28-day or 30-day unplanned hospital readmissions and to investigate and assess the characteristics of these models.

METHODS

Search strategy and data sources

An electronic database search was carried out using the CINAHL, Embase and MEDLINE to identify studies published between 2011 and 2015. The key search terms included 'unplanned readmission* or rehospitali*' AND ('predict*' AND 'model*') OR 'ROC or C-statistic*' OR 'sensitivity or specificity' (see online supplementary appendix 1 for full search strategy).

Inclusion/exclusion criteria

Articles eligible for inclusion were those published in English with full-text access from 2011 to 2015. Only peer-reviewed studies were included in this review. The study design of included studies needed to be clearly stated together with details of the performance of the risk predictive model reported. Abstract-only references were excluded. Studies included in the previous systematic review[10] were excluded due to overlapping of the search period (1985–August 2011). Studies that included patients discharged from hospital but still receiving treatment, that is, intravenous antibiotics, via ambulatory care or hospital in the home programmes were also excluded.

Study selection and data extraction

Initial literature searches were conducted by HZ and PD. Two authors (HZ and LG) independently screened titles, abstracts and appraised full papers against the inclusion and exclusion criteria. The process of exclusion was relatively straightforward and only a handful of studies warranted discussion between the authors (HZ, LG, SD, PD and PR) and to reach consensus as to whether they met the inclusion criteria.

Data were extracted from the final included studies by three authors (HZ, LG and SD). The data extraction included study characteristics, model performance and key variables of the predictive model. Study characteristics included study setting, population, data source, the timing of data collection, sample size, study design, model name if applicable, model utilisation outcome and readmission rate (table 1). Measures assessing predictive model performance, including discrimination, calibration, cut-off values used to identify patients at high risk of being readmitted to the hospital, sensitivity, specificity, positive predictive value (PPV) or negative predictive value (NPV), were extracted (table 2). Model discrimination is commonly assessed using C-statistic or the area under the receiver operating characteristic curve. Values of the C-statistic measurement range from 0.5 to 1.0. A value of 0.5 indicates that the model is no better than chance at making a prediction of membership in a group, and a value of 1.0 indicates that the model perfectly identifies those within and not within a group. Models are typically considered reasonable when the C-statistic is higher than 0.7 and strong when the C-statistic exceeds 0.8.[71] Variables of the readmission risk predictive model were also extracted and presented in table 3. The studies were grouped based on the model utilisation outcome in the three tables. Disagreements between two reviewers about the extracted data were resolved through group discussion.

Quality appraisal

Six domains of potential bias[72] were used to appraise the quality of included studies critically. The assessment of risk for bias was completed by two independent reviewers (HZ and SD). The ratings of 'yes', 'partly', 'no' or 'unsure' were given to each domain and then an overall risk of 'low' or 'high' was assigned to each study. The six domains are:

1. Study participation: 'Was source population clearly defined?' and 'Was the study population described?' or 'Did the study population represent source population or population of interest?'
2. Study attrition: 'Was completeness of follow-up described and adequate?'
3. Prognostic factor measurement: 'Did prognostic factors measure appropriately?'
4. Outcome measurement: 'Was outcome defined and measured appropriately?'
5. Confounding measurement and account: 'Were confounders defined and measured?'
6. Analysis: 'Was analysis described and appropriate?' and 'Did analysis provide sufficient presentation of data?'

Data synthesis

Pooling of quantitative data was not possible as the included studies were not homogeneous. Therefore, the

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Table 1 Characteristics of 49 included studies on 28-day or 30-day unplanned hospital readmission (UHR) predictive models

Reference	Model name	Model outcome	Study design/data source	Sample size	Age group (years)	Duration of retrieved data source	Readmission rate
All-cause UHRs (14)							
Escobar *et al*[16] USA	ED 30 Discharge 30 LACE (validation)	30-day all-cause readmissions	Retrospective cohort *21 hospitals* *Electronic medical records*	A total of 360 036 patients 179 978 derivation set 180 058 validation set	Mean=64.1	1 June 2010–31 December 2013	Derivation: 12.5%; Validation: 12.4%
Yu *et al*[17] USA	Institution-specific prediction model LACE (validation)	30-day all-cause readmission	Retrospective cohort *3 hospitals*	Hospital 1=2441 Hospital 2=26 520 Hospital 3=45 785	≥65	Not reported	H1=23% H2=20% H3=18%
Baillie *et al*[18] USA	Prediction model	30-day all-cause readmissions	Retrospective and prospective cohort *3 hospitals*	Retrospective: 120 396 discharges prospective validation	Not reported—adult	August 2009–September 2012	Retrospective: 14.4%; Prospective: 15.1%
Choudhry *et al*[12] USA	ACC Admission and Discharge model	30-day all-cause readmissions	Retrospective cohort *8 hospitals*	A total of 126 479 patients 94 859 derivation set 31 619 internal and 6357 external validation	Mean=66.01 (readmission) 57.65 (no readmission)	1 March 2010–31 July 2012	7.25%
Gildersleeve and Cooper[19] USA	Risk of readmission score (RRS)	30-day all-cause readmission	Retrospective cohort *1 community hospital*	Derivation: 8700 patients Validation: 8189 patients	Mean=60.6 Mean=65	2010 2011	14.1% 14.8%
Kruse *et al*[20] USA	Unnamed	30-day all-cause readmission	Retrospective cohort *91 hospitals—Health Facts Database*	463, 351 Index admissions	≥18	1 October 2008–31 August 2010	9.7%
Richmond[21] USA	Unnamed	30-day all-cause readmission for patients≥65 years	Retrospective cohort *state-level database*	4717 patients split into a derivation (80%) and validation sample (20%)	Mean=77.27	January 2010–December 2012	14.4%
Shulan *et al*[22] USA	Unnamed	30-day all-cause readmission	Retrospective cohort *centralised database*	8718 patients Derivation (50%) Validation (50%)	Mean=67.04 (UHRs); 66.43 (no UHRs)	2011	16.2%
van Walraven *et al*[23] Canada	LACE+ (extension of a validated index)	30-day all-cause readmission	Retrospective cohort *centralised database*	499 996 patients/ 858 410 index hospitalisations	>18	2004–2009	11.8%
Cotter *et al*[13] UK	LACE index (validation)	30-day all-cause readmission	Retrospective cohort *centralised database*	507 patients	Mean=85	2010	17.8%

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Table 1 Continued

Reference	Model name	Model outcome	Study design/data source	Sample size	Age group (years)	Duration of retrieved data source	Readmission rate
	Regression model		Retrospective cohort *centralised database*	502 patients (validation cohort)			14.8%
Khan *et al*[24] USA	Rehospitalisation Risk Score	30-day all-cause readmission	Retrospective cohort *10 hospitals/EMRs*	227 patients	Average=79	Single day on 26 January 2011	15%
Lee[25] Korea	Unnamed	28-day all-cause readmission	Retrospective cohort *1 tertiary hospital*	11 951 patients Derivation (70%); Validation (30%)	Ranged from 0 to 70 +	2009	28.9%
van Walraven *et al*[26] Canada	CMG score (case-mix groups) LACE index (validation) Combined CMG score and LACE index	30-day all-cause readmission	Retrospective cohort *4 health databases*	Random 200 000 patients of 3 277 033 Derivation: 100 000 Validation: 100 000	Mean age of Derivation: 58 Validation: 57.9	1 April 2003–31 March 2009	6.8%
van Walraven *et al*[27] Canada	LACE+ LACE+ with CMG score	30-day all-cause readmission	Retrospective cohort *4 health databases*	Random 500 000 of 3 277 033 patients then 1/2 derivation and ½ validation	Mean=57.9 (derivation); 57.9 (validation)	1 April 2003–31 March 2009	14%
Cardiovascular disease-related UHRs including pneumonia (11)							
Hebert *et al*[15] USA	CHF model PNA model AMI model Combined model	30-day readmission on Congestive heart failure/ pneumonia/acute myocardial infarction	Retrospective cohort *A tertiary medical centre*	A total of 3968 patients Derivation: 3572 Historical validation: 1756 Random sample: 396	Mean=61	1 August 2009–31 July 2011 1 August 2008–31 July 2009	16.2% 17.7% 16.2%
Iannuzzi *et al*[28] USA	Vascular surgery readmission risk score	30-day readmission on patients after vascular surgery	Retrospective cohort *National Surgical Database*	24 929 patients	Mean=69.5 (UHRs); 69.7 (no UHRs)	2011	10.1%
Keyhani *et al*[29] USA	CMS-based model CMS-based model plus social Risk factors CMS-based model plus social risk and clinical factors	30-day readmission on patients with stroke	Retrospective cohort *114 hospitals*	3436 patients	Mean=69.5 (UHRs); 66.9 (no UHRs)	2007	12.8%
Rana *et al*[30] Australia	Electronic medical record (EMR) model HOSPITAL score (validation) Comorbidities (validation)	30-day readmission on ischaemic heart disease of patients after AMI	Retrospective cohort *A regional health service—tertiary hospital*	1660 AMI admissions Derivation cohort: 1107 Validation cohort: 553	Mean=67.8 (derivation cohort); validation cohort: 68.4	January 2009–December 2011	6.3%

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Zhou H, *et al.* *BMJ Open* 2016;**6**:e011060. doi:10.1136/bmjopen-2016-011060

Table 1 Continued

Reference	Model name	Model outcome	Study design/data source	Sample size	Age group (years)	Duration of retrieved data source	Readmission rate
Shahian *et al*[31] USA	Unnamed	30-day readmission post coronary artery bypass grafting	Retrospective cohort *National Database (846 hospitals)*	162 572 admissions	≥65	2008–2010	12.6–23.6%
Shams *et al*[32] USA	Potentially avoidable readmission (PAR)	30-day avoidable readmission on pneumonia/HF/AMI/COPD	Retrospective cohort *Veterans Health Administration data* Internal validation	5600 admissions	HF: mean=71.3 (PAR); vs 68.6 (no UHRs) AMI: mean=73.3 (PAR) vs 69.3 (no UHRs)	2011–2012	13.09%
			External validation	478 patients		August and September 2012	
	CMS endorsed model (validation)	30-day readmission					
Sharif *et al*[33] USA	Unnamed	30-day readmission on patients aged 40–64 years with COPD	Retrospective cohort *A large national commercial insurance database*	8263 patients	Mean=57 (UHRs); no UHRs—age not reported	January 2009–November 2011	8.9%
Lucas *et al*[34] USA	Complex all-variable model; parsimonious readmission score	30-day readmissions on patients post general, vascular, and thoracic surgery	Retrospective cohort *National Surgery Database*	A total of 230 864 patients Derivation: 162 159 (70%): Validation: 68 705 (30%)	Median=56	2011	5–16% across surgical specialties
Wallmann *et al*[35] Spain	Unnamed	30-day readmission on cardiac-related disease	Retrospective cohort *1 tertiary centre*	35 531 admissions Derivation cohort: 24 881 Validation cohort: 10 650	Mean=67.9	2003–2009	Derivation: 4.4%; Validation: 4.7%
Wasfy *et al*[36] USA	Risk score for 30-day readmission after PCI (parsimonious)	30-day readmission after percutaneous coronary intervention	Retrospective cohort *centralised database*	36 060 surviving to discharge	Mean=68.1 (UHRs); 64.3 (no UHRs)	1 October 2005–30 September 30 2008	10.4%
Krumholz *et al*[37] USA	Claims model	30-day readmission on acute myocardial infarction (AMI)	Retrospective cohort *Medicare Claims Database*	Derivation cohort: 100 465 Validation cohort: 321 088	Mean=78.7	Half of 2006	18.9%
	Medical record model			Derivation cohort: 130 944 Validation cohort: 130 944		2005 and half of 2006	19.96%
Cardiovascular disease-related UHRs including pneumonia—heart failure only (11)							
Betihavas *et al*[38] Australia	Unnamed	28-day readmission on patients with chronic heart failure	Retrospective cohort Multicentre	280 patients 94 (no UHRs); 37 (28-D UHRs)	Mean=69 (no UHRs); 79 (UHRs)	Not reported	13%

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Table 1 Continued

Reference	Model name	Model outcome	Study design/data source	Sample size	Age group (years)	Duration of retrieved data source	Readmission rate
Di Tano *et al*[39] Italy	Unnamed	30-day readmission on acute HF	Prospective cohort *National Registry Database*	1520 patients	Mean=72	Not reported	6.25%
Huynh *et al*[40] Australia	The non-clinical model The clinical model The combined model	30-day readmission on HF	Retrospective cohort *state-wide data linkage*	Non-clinical—1537 patients Clinical—977 patients available	Mean=80	2009–2012	25.4%
Raposeiras-Roubin *et al*[41] Spain	GRACE risk score	30-day readmission on HF after acute coronary syndrome	Retrospective cohort A single centre	4429 patients	Mean=77 (UHRs); 68 (no UHRs)	2004–2010	1.3%
Sudhakar *et al*[42] USA	Readmission Risk score	30-day readmission on patients with CHF	Retrospective cohort *A tertiary hospital/ chart review*	1046 admissions from 712 patients	Mean=65.2	September 2011–August 2013	35.28%
Fleming *et al*[43] USA	Unnamed	30-day readmission on patients with HF	Retrospective cohort *1 tertiary medical centre*	3413 admissions Derivation: Validation=3:1 (2566:847)	Mean=74 (derivation cohort); validation cohort: 74.6	1 October 2007–30 August 2011	24.2% (derivation)
Wang *et al*[44] USA	LACE index (validation)	30-day readmission on patients with CHF	Retrospective cohort *An urban public hospital*	253 patients	Mean: 57.67 (no UHRs); 56.17 (UHRs)	June 2012–June 2013	24.5%
Eapen *et al*[45] USA	Unnamed	30-day readmission on heart failure	Retrospective cohort *Centers for Medicare database*	33 349 patient 70% in derivation cohort 30% in validation cohort	Median=80	1 January 2005–31 December 2009	22.8%
Zai *et al*[46] USA	The telemonitoring-based readmission model; the psychosocial readmission model (validation)	30-day readmission on heart failure	Retrospective cohort *Patients enrolled in the telemonitoring program*	100 patients	Average age of 66.8	July 2008–November 2011	38%
Au *et al*[47] Canada	Five administrative data-based models: Charlson; CMS Krumholz Keenan; LACE; LACE+	30-day readmission on HF	Retrospective cohort *4 health databases*	59 652 patients	Mean=76	April 1999 and 2009	19%
Watson *et al*[48] USA	The psychosocial readmission model	30-day readmission on HF	Retrospective cohort *1 tertiary hospital*	729	Mean=71.4	1 October 2007–30 September 2008	13.3% (all female)
Cardiovascular disease-related UHRs including pneumonia—pneumonia only (2)							
Mather *et al*[49] USA	Hartford Hospital model CMS Model (validation)	30-day readmission on pneumonia	Retrospective cohort *A tertiary hospital*	956 index admissions	≥65	January 2009–March 2012	15.5%

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6 Zhou H, *et al*. *BMJ Open* 2016;**6**:e011060. doi:10.1136/bmjopen-2016-011060

Zhou H, *et al. BMJ Open* 2016;**6**:e011060. doi:10.1136/bmjopen-2016-011060

Table 1 Continued

Reference	Model name	Model outcome	Study design/data source	Sample size	Age group (years)	Duration of retrieved data source	Readmission rate
Lindenauer *et al*[50] USA	Administrative claims model	30-day readmission on pneumonia	Retrospective cohort *Medicare enrolment database*	Derivation cohort: 226 545 Validation cohort: 762 721	Mean=80	Half of 2006	17.4%
	Medical record model			47 429 cases		Half of 2006 and 2005	17.0%
General medical condition-related UHRs (10)							
Shadmi *et al*[51] Israel	Preadmission Readmission Detection Model	30-day readmission on medical patients	Retrospective cohort *Clalit Health Services/EMR*	Total: 33 639 admissions Derivation: 22 406 Validation: 11 233	Mean=68.2; 67.5 (no UHRs); 72.5 (UHRs)	1 January 2010–31 March 2010	16.8%
Tsui *et al*[52] Hong Kong	Unnamed	28-day readmission on elderly medical patients	Retrospective cohort *41 hospitals/EMS*	Total: 327 529 episodes Derivation: 165 216 Validation: 162 313	≥65	Derivation: 2005 Validation: 2006	7.8% 7.6%
Donzé *et al*[53] USA	Unnamed	30-day readmission on medical patients due to end-of-life care	Retrospective cohort *1 tertiary medical centre including 3 hospitals*	10 275 admissions	Mean=61.5 (no UHRs); 60.8 (potentially avoidable readmissions (PARs)	1 July 2009–30 June 2010	Total:22.3%; 8%—PARs
He *et al*[54] USA	Unnamed	30-day readmission on medical patients and chronic pancreatitis (CP)	Retrospective cohort *JHH (tertiary centre) BMC (community hospital)*	Medical patients: 26 091 (JHH)+16 194 (BMC)	Mean=50.3 (JHH) 51.5 (BMC)	Medical patients: January 2012–April 2013;	11.5% (JHH) 8.7% (BMC)
				Patients with CP: 3218 (JHH)+706 (BMC)	Mean age: 51.4 (JHH) 51.4 (BMC)	CP discharged from January 2007–April 2013	15.6% (JHH) 7.8% (BMC)
Taha *et al*[55] USA	Readmission Risk Score (RRS)	30-day readmission on general internal medicine services	Retrospective cohort *4 teaching and 2 non-teaching general internal medicine services*	858 index hospitalisations Derivation cohort: 613 Validation cohort: 245	Mean=54 (derivation); validation cohort: 54	1 April 2010–30 June 2010	16%
Donzé *et al*[14] USA	HOSPITAL score	30-day readmissions on general medical patients	Retrospective cohort *Multicentre health services*	10 731 discharges	Mean=61.3	1 July 2009–30 June 2010	8.5%
Tan *et al*[56] Singapore	LACE index (validation)	30-day readmission on general medical patients	Retrospective *The largest tertiary general hospital*	127 550 patients	≥21	1 January 2006–31 December 2010	4.87–18.43%

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Table 1 Continued

Reference	Model name	Model outcome	Study design/data source	Sample size	Age group (years)	Duration of retrieved data source	Readmission rate
Billings *et al*[11] USA	PARR-30	30 days readmission on general medical patients	Retrospective cohort *centralised database*	576 868 admissions	Adult	1 April 2008 and 31 March 2009	12.2%
Zapatero *et al*[57] Spain	SEMI INDEX	30-day readmission on general medical patients	Retrospective cohort *National Health Database*	Derivation cohort: 999 089 patients; Validation cohort: 510 588 patients (internal)	Median=70 for two cohorts	January 2006–December 2007 2008	12.4% 12.5%
Gruneir *et al*[58] Canada	LACE index (validation)	30-day readmission on general medical patients	Retrospective cohort *6 hospitals*	26 045 patients	18–105	2007	12.6%
Medical condition UHRs—cirrhosis only (2)							
Singal *et al*[59] USA	Unnamed	30-day readmissions on patients with cirrhosis	Retrospective cohort *1 large safety-net hospital*	A total of 838 patients with 1291 admissions Derivation: 968 Validation: 323	Mean=52.5	January 2008–December 2009	27%
Volk *et al*[60] USA	Cirrhosis readmission prediction model	30-day readmission on cirrhosis	Retrospective cohort *1 tertiary hospital*	402 patients	≥18	1 July 2006–1 July 2009	41%, 22% of which are PARs
Medical condition UHRs—chronic kidney disease only (1)							
Perkins *et al*[61] USA	Unnamed	30-day readmission on patients with CKD second to HF	Retrospective cohort *2 inpatient facilities*	607 patients with chronic kidney disease	Mean=72.3 (UHRs); 74.1 (no UHRs)	1 July 2004–28 February 2010	19.1%
Medical condition UHRs—HIV only (1)							
Nijhawan *et al*[62] USA	Unnamed	30-day readmission on HIV-infected patients	Retrospective cohort *1 tertiary hospital*	2402 index admissions randomly split (1/2) into derivation vs validation	Mean=43	March 2006–November 2008	24.4%
Medical condition UHRs—acute pancreatitis (1)							
Whitlock *et al*[63] USA	Unnamed	30-day readmission on acute pancreatitis	Retrospective cohort *2 hospitals*	Derivation cohort: 248 Validation cohort: 198	Mean=51.6 derivation Validation: 52.3	1 June 2005–31 December 2007 1 January 2008–31 October 2009	19% 23%
Surgical condition-related UHRs (6)							
Taber *et al*[64] USA	30DRA with fixed variable vs 30DRA with fixed variables and dynamic clinical data	30-day readmission on patients following kidney transplantation	Retrospective cohort *An institution*	1147 patients Derivation; internal validation using random iteration of 50% sampling	Mean=51 (no UHRs); 52 (UHRs)	2005–2012	11%
Lawson *et al*[65] USA	Unnamed (demographic, preoperative and postoperative risk factors)	30-day readmission on patients following colectomy	Retrospective cohort *NSQIP*	12 981 patients	≥65	2005–2008	13.5%

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Zhou H, *et al. BMJ Open* 2016;6:e011060. doi:10.1136/bmjopen-2016-011060

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Table 1 Continued

Reference	Model name	Model outcome	Study design/data source	Sample size	Age group (years)	Duration of retrieved data source	Readmission rate
Iannuzzi *et al*[66] USA	Endocrine surgery Readmission Risk Score	30-day readmission on patients following cervical endocrine operations	Retrospective cohort *NSQIP—a large national clinical database*	34 046 cases Derivation and validation cohort (numbers were not specified)	Mean=54 (no UHRs); 55 (UHRs)	2011–2012	2.8%
Mesko *et al*[67] USA	Unnamed	30-day readmission on total hip and knee arthroplasty	Retrospective cohort *A readmission database*	1291 admissions/1236 patients	Mean=65.6 (UHRs); 68.3 (no UHRs)	1 May 2010–30 April 2011	3.6%
Moore *et al*[68] Canada	Unnamed (quality indicator based)	30-day readmission on trauma	Retrospective cohort *57 trauma centres*	57 524 patients	≥16	1 April 2005–28 February 2010	6.6%
Graboyes *et al*[69] USA	Unnamed	30-day readmission on otolaryngology patients	Retrospective cohort *A tertiary hospital*	1058 patients—1271 hospital admissions	Mean=52 (no UHRs); 56 (UHRs)	1 January 2011–31 December 2011	7.3%
Mental health condition-related UHRs (1)							
Vigod *et al*[70] Canada	READMIT (41 points)	30-day readmission after discharge from acute psychiatric units	Retrospective cohort *National health data*	Derivation: 32 749 patients Validation: 32 750 patients	Median=41 (UHRs); 44 (no UHRs)	1 April 2008–31 March 2011	8.42–10%

ACS, acute coronary syndrome; AMI, acute myocardial infarction; AP, acute pancreatitis, CHF, congestive heart failure; CKD, chronic kidney disease; COPD, common obstructive pulmonary disease; EMRs, electronic medical records; GRACE, global registry of acute coronary events; HF, heart failure; PCI, percutaneous coronary intervention; PREADM, preadmission readmission detection model; PNA, peptide nucleic acid.

Table 2 Performance of predictive models for 28-day or 30-day unplanned hospital readmissions (UHRs)

Reference	Model name	Discrimination (ROC)	Calibration (H&L)	Threshold (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
All-cause UHRs (14)								
Escobar *et al*[16]	ED 30	Validation: 0.739	0.40	≥20				
	Discharge 30	Validation: 0.756	0.60	≥30				
	LACE (validation)	Validation: 0.729	0.40	≥60				
Yu *et al*[17]	Institution-specific prediction model	0.74 (hospital 2) 0.64 (at admission) 0.72 (after discharge)						
	LACE (validation)	0.55 (hospital 2)						
Baillie *et al*[18]	Prediction model	Retrospective: 0.62			40	85	31	89
		Prospective: 0.61			39	84	30	89
Choudhry *et al*[12]	ACC Admission Model	Derivation data set: 0.76 Internal validation: 0.75 Average (500 simulations in derivation data set): 0.76 External validation data set with recalibration: 0.76	Derivation data set: 36.0 (p<0.001) Internal validation data set: 23.5 (p=0.0027) External validation with recalibration: 6.1 (p=0.641)	11	70	71		
	ACC Discharge Model	Derivation data set: 0.78 Internal validation: 0.77 Average: 0.78 External validation data set with recalibration: 0.78	Derivation: 31.1 (p<0.001) Internal validation: 19.9 (p=0.01) External validation with recalibration: 14.3 (p=0.074)	11	70	71		
Gildersleeve and Cooper[19]	Risk of readmission score (RRS)	Derivation cohort: 0.74	21.6 (p=0.006)	14	74.9	54.4	22.2	92.6
		Validation cohort: 0.70			79.2	55.4	22.6	94.2
Kruse *et al*[20]	Unnamed	Derivation set: 0.668 Validation set: 0.657						
Richmond[21]	Unnamed	0.60			47	78		
Shulan *et al*[22]	Unnamed	Derivation cohort: 0.80 Validation cohort: 0.70						
van Walraven *et al*[23]	LACE+ (extension of a validated index)	0.768 (1 hospitalisation per patient) 0.730 (all hospitalisations)	H–L χ^2 50.3 H–L χ^2 10 972					
Cotter *et al*[13]	LACE index (validation)	0.55						
	Regression model	0.57		47	54	47		

Continued

Zhou H, *et al. BMJ Open* 2016;6:e011060. doi:10.1136/bmjopen-2016-011060

Zhou H, et al. BMJ Open 2016;6:e011060. doi:10.1136/bmjopen-2016-011060

Table 2 Continued

Reference	Model name	Discrimination (ROC)	Calibration (H&L)	Threshold (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
All-cause UHRs (14)								
Khan *et al*[24]	Rehospitalisation risk score			19	97	28	19	98
				21	58	63	21	90
				27	42	81	27	89
Lee[25]	Unnamed	ROC was graphically illustrated, but no actual number was reported						
van Walraven *et al*[26]	CMG Score	0.637	p=0.0079					
	LACE index (validation)	0.72	P<0.0001					
	Combined CMG Score and LACE	0.743	p<0.0001					
van Walraven *et al*[27]	LACE+ (validation)	0.743						
	LACE+ with CMG score	0.753						
Cardiovascular disease-related UHRs including pneumonia (11)								
Hebert *et al*[15]	CHF model	Derivation cohort: 0.64–0.73;	p>0.05					
	PNA model	Historical validation: 0.61–0.68;						
	AMI model	Random sample combined:						
	Combined model	0.63–0.76						
Iannuzzi *et al*[28]	Vascular surgery readmission risk score	Derivation dataset: 0.67 Validation dataset: 0.64	0.09 0.66					
Keyhani *et al*[29]	CMS-based model	0.636	0.866					
	CMS-based model plus social risk factors	0.646	0.462					
	CMS-based model plus social risk and clinical factors	0.661	0.856					
Rana *et al*[30]	EMR model	0.78		5	65	78	21	83.6
	HOSPITAL score (validation)	0.60			62	50	13	78.9
	Comorbidities (validation)	0.53				65	45	
Shahian *et al*[31]	Unnamed	0.648						
Shams *et al*[32]	Potentially avoidable readmission (PAR)	Retrospective cohort: 0.836 Validation internal: 0.818/external: 0.809			91.95	97.65	86.61	98.65
	CMS endorsed model (validation)	0.63						

Continued

Table 2 Continued

Reference	Model name	Discrimination (ROC)	Calibration (H&L)	Threshold (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Cardiovascular disease-related UHRs including pneumonia (11)								
Sharif *et al*[33]	Unnamed (basic model vs final model)	Basic model (patient characteristics only): 0.677; final model (additional provider-level and system-level factors) Derivation set: 0.717 Validation set: 0.73						
Wallmann *et al*[35]	Unnamed	0.75		4	66	70	10	98
Wasfy *et al*[36]	Risk score for 30-day readmission after PCI (parsimonious)	Validation data set: 0.67		>24				
Lucas *et al*[34]	Complex all-variable model	Derivation data set: 0.721 Validation data set: 0.724						
	Parsimonious readmission score	Derivation data set: 0.696 Validation data set: 0.702		1.2	100	0	8	/
				2.4	99	6	8	99
				4.7	92	28	10	98
				8	77	52	12	97
				11.8	55	73	15	95
				14.6	37	85	17	94
				17.2	21	92	19	93
				20.3	9	97	21	93
				22.2	2	100	22	92
				40	0	100	40	92
Krumholz *et al*[37]	Claims model	Derivation cohort: 0.63 Validation cohort: 0.62–0.63						
	Medical record model	Derivation cohort: 0.58 Validation cohort: 0.59						
Cardiovascular disease-related UHRs including pneumonia—heart failure only (11)								
Betihavas *et al*[38]	Unnamed	0.8						
Di Tano *et al*[39]	Unnamed	0.695						
Huynh *et al*[40]	The non-clinical model	0.66						
	The clinical model	0.72						
	The combined model	0.76						
Raposeiras-Roubin *et al*[41]	The GRACE risk score	0.79	p=0.83	37.9	82.5	62.8	5.6	99.1

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Zhou H, et al. BMJ Open 2016;6:e011060. doi:10.1136/bmjopen-2016-011060

Table 2 Continued

Reference	Model name	Discrimination (ROC)	Calibration (H&L)	Threshold (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Sudhakar *et al*[42] USA	Readmission Risk (RR) Score	All age group—0.61 ≥65 years—0.59 Random selection—0.58		≥29	33	80	47	69
				≥24	61	52	41	71
				≥21	83	27	38	75
Fleming *et al*[43]	Unnamed	Derivation cohort: 0.69 Validation cohort: 0.66						
Wang *et al*[44]	LACE index (validation)			≥10				
Eapen *et al*[45]		Derivation cohort: 0.59 Validation cohort: 0.59						
Zai *et al*[46]	The telemonitoring-based readmission model	0.21			50	81	61	72
	The psychosocial model (validation)	0.67			87	32	44	80
Au *et al*[47]	Five administrative data-based models	0.57–0.61						
Watson *et al*[48]	The psychosocial readmission model	0.67						
Cardiovascular disease-related UHRs including pneumonia—pneumonia only (2)								
Mather *et al*[49]	Hartford Hospital model	Derivation data set: 0.71 Validation data set: 0.67	p=0.96					
Lindenauer *et al*[50]	Administrative claims model	0.63						
	CMS medical record model	0.59						
General medical condition-related UHRs (10)								
Shadmi *et al*[51]	PREADM	Derivation data set: 0.70 Validation data set: 0.69						
Tsui *et al*[52]	Unnamed	Derivation data set: 0.819 Validation data set: 0.824	p<0.05					
Donzé *et al*[53]	Unnamed	0.85						

Continued

Table 2 Continued

Reference	Model name	Discrimination (ROC)	Calibration (H&L)	Threshold (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
General medical condition-related UHRs (10)								
He *et al*[54]	Unnamed Medical patient	Validation						
		Within site CV on JHH 0.75		21	50	84	29	93
		CV on BMC 0.79		30	50	88	28	95
		Across site Test on BMC 0.81		9	47	88	27	95%
		Test on JHH 0.78		30	58	76	24	93
	CP	Within site CV on JHH 0.71		21	50	68	34	84
		CV on BMC 0.65		30	56	79	20	955
		Across site Test on BMC 0.65		9	85	41	11	97
		Test on JHH 0.73		30	60	71	27	91
Taha *et al*[55]	Readmission Risk Score			12			18	95
				16			18	90
				20			20	89
				24			21	86
				28			28	85
				32			38	84
Donzé *et al* (2013)[14]	HOSPITAL score	Derivation data set: 0.69 Validation data set: 0.71	Derivation data set: p=0.28 Validation data set: p=0.15	5.2–18.4				
Tan *et al*[56]	LACE index (validation)	0.70	13.1 (p=0.107)	16				
Billings *et al*[11]	PARR-30	0.70		50	5.4	99.5	59.2	
Zapatero *et al*[57]	SEMI INDEX	0.876	*Derivation cohort* p=0.247 (≤50 years group) p=0.1 (51–70 years group) p=0.182 (71–90 years group) p=0.227 (>90 years group) *Validation cohort* p=0.350 (≤50 years group) p=0.1 (51–70 years group) p=0.246 (71–90 years group) p=0.617 (>90 years group)	7.4–22				
Gruneir *et al*[58]	LACE index (validation)			16				

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Zhou H, *et al*. *BMJ Open* 2016;6:e011060. doi:10.1136/bmjopen-2016-011060

Zhou H, *et al*. *BMJ Open* 2016;**6**:e011060. doi:10.1136/bmjopen-2016-011060

Table 2 Continued

Reference	Model name	Discrimination (ROC)	Calibration (H&L)	Threshold (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Medical condition UHRs—cirrhosis only (2)								
Singal *et al*[59]	Unnamed	Derivation cohort: 0.68 Validation cohort: 0.66						
Volk *et al*[60]	Cirrhosis readmission prediction model	0.65						
Medical condition UHRs—chronic kidney disease only (1)								
Perkins *et al*[61]	Unnamed	0.792		20 50 80	69 28.5 1.7	73.4 97.1 99.8	38.3 70.2 66.7	90.9 85 19.1
Medical condition UHRs—HIV only (1)								
Nijhawan *et al*[62]	Unnamed	Derivation: 0.72 Validation: 0.70						
Medical condition UHRs—acute pancreatitis (1)								
Whitlock *et al*[63]	Unnamed	Derivation cohort: 0.88 Validation cohort: 0.83						
Surgical condition-related UHRs (6)								
Taber *et al*[64] USA	30DRA with fixed variable	0.63	p=0.061	10			57.7	63.8
	30DRA with fixed variable and dynamic clinical data	0.731	p=0.603	10			62.8	73.3
Lawson *et al*[65]	Unnamed	0.728						
Iannuzzi *et al*[66]	Endocrine surgery Readmission risk score	Derivation cohort: 0.676 Validation cohort: 0.646	p=0.083 p=0.592					
Mesko *et al*[67]	Unnamed	Derivation data set: 0.59 Validation data set: 0.59						
Moore *et al*[68]	Unnamed	0.651	Intercept, slope 0.000370; 1.0001					
Graboyes *et al*[69]	Unnamed	0.85						
Mental health condition-related UHRs (1)								
Vigod *et al*[70]	READMIT	Derivation data set: 0.631 Validation data set: 0.63	p=0.868					

NPV, negative predictive value; PPV, positive predictive value; ROC, receiver operating characteristic.

Table 3 Summary of significant variables included in the predictive models for unplanned hospital readmissions (UHRs)

Reference	Model name	Admitting diagnosis	Admitting ward	Blood transfusion	BMI	Comorbidities	Complications before discharge	Daily living score	Demographic/social	Discharge disposition	Discharge hour	Environment	General anaesthesia	Health insurance \hskip1ex	Index type of admission	Injury severity score	Laboratory tests	Length of stay	Physical examinations	Postoperative complications	Medications	Number of previous admission	Number of previous ED presentations	Overall prognosis	Procedures at index admission	Substances usage	Symptoms	Use of outpatient clinic	Vital signs
All-cause UHRs (14)																													
Escobar *et al*[16]	ED 30 and Discharge 30					✓				✓							✓	✓				✓							
	LACE index (validation)					✓									✓			✓					✓						
Yu *et al*[17]	Institution-specific prediction model	✓				✓			✓	✓					✓			✓				✓	✓						
	LACE index (validation)					✓									✓			✓					✓						
Baillie *et al*[18]	Prediction model																					✓							
Choudhry *et al*[12]	ACC Admission and Discharge Model					✓			✓	✓		✓					✓	✓			✓	✓			✓				
Gildersleeve and Cooper[19]	Risk of Readmission Score (RRS)					✓			✓					✓	✓			✓			✓	✓	✓						
Kruse *et al*[20]	Unnamed						✓										✓	✓				✓			✓				
Richmond[21]	Unnamed	✓				✓			✓												✓	✓		✓					
Shulan *et al*[22]	Unnamed					✓			✓									✓											
van Walraven *et al*[23]	LACE+ (validation)	✓				✓			✓						✓			✓				✓	✓		✓				
Cotter *et al*[13]	LACE index (validation)					✓									✓			✓					✓						
	Regression model																						✓						
Khan *et al*[24]	Rehospitalisation Risk Score	✓				✓		✓	✓					✓								✓							
Lee[25]	Unnamed	✓	✓												✓			✓											
All-cause UHRs (14)																													
van Walraven *et al*[26]	CMG score	✓																											
	LACE (validation)																												
	Combined CMG and LACE	✓				✓									✓			✓					✓						
van Walraven *et al*[27]	LACE+ (validation)																												
	Combined CMG and LACE+	✓				✓			✓						✓			✓				✓	✓		✓				
Cardiovascular disease-related UHRs including pneumonia (11)																													
Hebert *et al*[15]	CHF model					✓												✓			✓	✓	✓			✓			
	PNA model					✓											✓				✓	✓			✓				
	AMI model					✓			✓								✓				✓	✓							
	Combined model					✓			✓								✓	✓			✓	✓	✓						
Iannuzzi *et al*[28]	Vascular surgery readmission risk score					✓			✓	✓					✓						✓				✓				
Keyhani *et al*[29]	CMS-based Model					✓			✓																				
	CMS-based Model plus social risk factors					✓			✓																	✓			
	CMS-based model plus social risk and clinical factors	✓				✓		✓	✓																	✓			
Rana *et al*[30]	EMR Model	✓				✓			✓									✓											
Shahian *et al*[31]	Unnamed					✓			✓																				
Shams *et al*[32]	PARs					✓			✓						✓			✓				✓							
	CMS endorsed model (validation)																												
Sharif *et al*[33]	Unnamed					✓			✓									✓			✓							✓	
Lucas *et al*[34]	Complex all-variable model				✓		✓	✓	✓	✓					✓		✓	✓			✓				✓				
	Parsimonious readmission score																	✓							✓				
Wallmann *et al*[35]	Unnamed					✓			✓													✓			✓				
Wasfy *et al*[36]	Risk score after PCI (parsimonious)					✓			✓					✓	✓			✓							✓				
Krumholz *et al*[37]	Claims model (administrative)					✓			✓																				
	Medical record model					✓			✓								✓		✓								✓		✓

Continued

Zhou H, et al. BMJ Open 2016;6:e011060. doi:10.1136/bmjopen-2016-011060

Table 3 Continued

Reference	Model name	Admitting diagnosis	Admitting ward	Blood transfusion	BMI	Comorbidities	Complications before discharge	Daily living score	Demographic/social	Discharge disposition	Discharge hour	Environment	General anaesthesia	Health Insurance \hskip1ex	Index type of admission	Injury severity score	Laboratory tests	Length of stay	Physical examinations	Postoperative complications	Medications	Number of previous admission	Number of previous ED presentations	Overall prognosis	Procedures at index admission	Substances usage	Symptoms	Use of outpatient clinic	Vital signs
Cardiovascular disease-related UHRs including pneumonia—heart failure only (11)																													
Betihavas et al[38]	Unnamed					✓			✓																				
Di Tano et al[39]	Unnamed																	✓			✓						✓		
Huynh et al[40]	Non-clinical model					✓			✓		✓							✓											
	Clinical model																✓		✓		✓								✓
	Combined model								✓		✓						✓		✓		✓								✓
Raposeiras-Roubin et al[41]	The GRACE Risk Score					✓			✓								✓								✓				✓
Sudhakar et al[42] USA	Readmission Risk Score					✓			✓								✓		✓						✓				✓
Fleming et al[43]	Unnamed								✓		✓						✓					✓							
Wang et al[44]	LACE index (validation)																												
Eapen et al[45]	Unnamed					✓			✓					✓	✓			✓			✓	✓	✓						
Zai et al[46]	The telemonitoring based readmission model																				✓						✓		
	The psychosocial readmission model (validation)																												
Au et al[47]	Charlson (validation)					✓			✓																				
	CMS Krumholz (validation)																												
	Keenan (validation)					✓			✓								✓												
	LACE (validation)																												
	LACE+ (validation)																												
Watson et al[48]	The psychosocial readmission model					✓																						✓	
Cardiovascular disease-related UHRs including pneumonia—pneumonia only (2)																													
Mather et al[49]	Hartford Hospital Model					✓	✓		✓								✓					✓							
	CMS Model (validation)																												
Lindenauer et al[50]	Claims model (administrative)					✓			✓																	✓			
	Medical record model					✓			✓								✓				✓					✓			✓
General medical condition UHRs (10)																													
Shadmi et al[51]	PREADM				✓	✓			✓									✓				✓						✓	
Tsui et al[52]	Unnamed					✓			✓													✓	✓					✓	
Donzé et al (2014)[53]	Unnamed	✓				✓															✓	✓							
He et al[54]	Unnamed																✓					✓			✓				
Taha et al[55]	Readmission Risk Score (RRS)	✓				✓			✓												✓	✓							
Donzé et al (2013)[14]	HOSPITAL score														✓		✓	✓				✓			✓				
Tan et al[56]	LACE index (validation)																												
Billings et al[11]	PARR-30					✓			✓						✓								✓						
Zapatero et al[57]	SEMI INDEX					✓			✓									✓											
Gruneir et al[58]	LACE index (validation)																												
Medical condition UHRs—cirrhosis only (2)																													
Singal et al[59]	Unnamed								✓					✓			✓					✓		✓					
Volk et al[60]	Cirrhosis readmission prediction model																✓				✓			✓					
Medical condition UHRs—chronic kidney disease (1)																													
Perkins et al[61]	Unnamed					✓				✓					✓		✓	✓			✓							✓	✓

Continued

Table 3 Continued

Reference	Model name	Admitting diagnosis	Admitting ward	Blood transfusion	BMI	Comorbidities	Complications before discharge	Daily living score	Demographic/social	Discharge disposition	Discharge hour	Environment	General anaesthesia	Health insurance \hskip1ex	Index type of admission	Injury severity score	Laboratory tests	Length of stay	Physical examinations	Postoperative complications	Medications	Number of previous admission	Number of previous ED presentations	Overall prognosis	Procedures at index admission	Substances usage	Symptoms	Use of outpatient clinic	Vital signs
Medical condition UHRs—HIV (1)																													
Nijhawan *et al*[62]	Unnamed	✓													✓		✓					✓	✓						
Medical condition UHRs—acute pancreatitis (1)																													
Whitlock *et al*[63]	Unnamed					✓															✓						✓		
Surgical condition UHRs (6)																													
Taber *et al*[64]	30DRA with fixed variable					✓			✓											✓									
	30DRA with fixed variable and dynamic clinical data					✓			✓											✓									✓
Lawson *et al*[65]	Unnamed	✓			✓	✓		✓	✓											✓					✓	✓			
Iannuzzi *et al*[66]	Endocrine surgery Readmission Risk Score	✓				✓							✓				✓	✓											
Mesko *et al*[67]	Unnamed			✓		✓				✓			✓				✓	✓											
Moore *et al*[68]	Unnamed					✓			✓							✓						✓					✓		
Graboyes *et al*[69]	Unnamed					✓	✓			✓															✓	✓			
Mental health condition UHRs (1)																													
Vigod *et al*[70]	READMIT	✓				✓									✓			✓				✓	✓					✓	

BMI, body mass index; ED, emergency department.

included studies were qualitatively synthesised and presented in narrative form.

RESULTS

Literature search result

The initial electronic database search produced 7310 records. After removal of 1798 duplicates, a total of 5512 references of potential relevance to this systematic review remained. Titles and abstracts were then appraised and excluded 5333 records due to irrelevance. Of the remaining 179 relevant references, 98 were excluded as they were conference abstracts. A total of 81 references were reviewed as full text and a further 21 were excluded against selection criteria. A total of 18 of the 21 excluded studies developed and/or validated risk predictive models for the 48-hour[73] or 72-hour[74] intensive care unit readmissions or the 3-month to 1-year unplanned hospital readmissions.[75–90] One study focused on participants who were discharged to a hospital in the home–hospital programme receiving intravenous antibiotics.[91] The other study,[92] which had been included in the previous systematic review,[10] was also excluded. It was also found that the same result was published in two articles;[32] therefore, the later year article[32] was excluded. A hand search of reference list of the remaining 60 articles was also conducted and no additional studies were identified. Finally, a total of 60 studies were included in this systematic review. Figure 1 is a flow chart as per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses of the screening process of the database search results. The overall risk of bias of the 60 studies was low when evaluated against the six domains of potential bias. All studies described the population of interest adequately for key characteristics, the response rate information was clearly stated, adequate proportion of the study population had complete data on all independent variables, the outcome variable readmission was measured with sufficient accuracy and the method of statistical analysis was appropriate for the design of the study.[72]

Study characteristics

Table 1 summarises the characteristics of the final included studies of this systematic review. The 60 studies were conducted in several countries: USA (n=41), Canada (n=7), Australia (n=3), Spain (n=3), and one from Hong Kong, Korea, Israel, Italy, Singapore and the UK. Of the included studies, the majority employed retrospective data except two. One study[18] used retrospective and prospective data and the other[39] collected prospective data. Fifty-seven included studies accessed healthcare data of either tertiary hospital, centralised or national health information databases. The remaining three studies used community hospital data.[19 44 54] The duration of retrieved data source ranged from 1 single day across 10 hospitals[24] to 10 years[47] of four healthcare databases. All included studies were based on adult

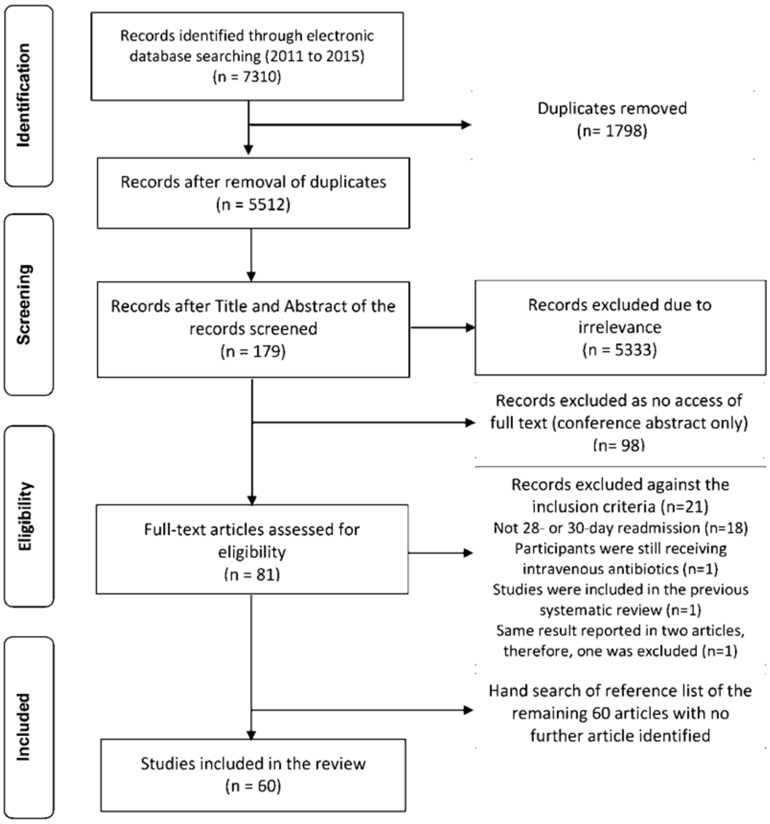

Figure 1 Flow chart for the search and study selection process (PRISMA). PRISMA, preferred reporting items for systematic reviews and meta-analyses.

patients' (aged ≥18 years) healthcare data and the mean age, if reported, ranged from 43 to 85 years.

The 60 included studies reported unique 73 predictive models for 28-day or 30-day unplanned hospital readmissions. A total of 68 of the unique 73 predictive models were developed between 2011and 2015 and 5 were existing models, which were further validated or applied to compare with other developed/existing models. The model utilisation outcome included all-cause admissions (14 studies),[12 13 16–27] cardiovascular-related disease including pneumonia (24 studies,[15 28–50] of which 11 studies focused on heart failure only), medical/internal medicine conditions (15 studies),[11 14 51–63] surgical conditions (6 studies)[64–69] and mental health conditions.[70] A total of 17 models were based on administrative data and the remaining models were derived or validated using administrative and/or clinical/medical records data. The sample size varied from 100 patients[46] to nearly a million[57] patients. The unplanned hospital readmission rate ranged from 2.8%[66] (n=34 046) to 38%[46] (n=100).

Performance of predictive models for 28-day or 30-day unplanned hospital readmissions

Table 2 displays the measures of all included predictive models. Multivariable logistic regression model was used in all included studies. In logistic regression, the outcome variable is the log of the odds of the event (probability of readmission/(1−probability of readmission)). Once the final model is determined, the multivariable logistic regression allows for the calculation of probability of readmission for cohort studies. The predicted probabilities of the final multivariable logistic model are also used for computing the receiver operating characteristic (ROC) curve and the calculation of the ROC, a measure of model discrimination.

Overall, 56 of the 60 included studies reported model discriminative ability (C-statistic), ranging from 0.21[46] to 0.88.[63] The area under curve for validation studies ranged from 0.53[30] to 0.83,[63] being slightly lower than those for the derivation study, 0.21[46] to 0.88.[63] For all-cause unplanned hospital readmission models, the C-statistic was reported by 14 studies ranging from 0.55[13] to 0.80.[22] Among 16 developed models and 2 existing models, 8 new models and 2 existing models had a C-statistic value >0.70.[12 16 17 19 22 23 26 27]

Regarding cardiovascular disease-related readmissions (24 studies), the C-statistic ranged from 0.21[46] to 0.836[32] across 32 developed models and 5 existing models. Of those, only nine developed models had a C-statistic value >0.70.[30 32 34 35 38 40 41 49 50] In particular, 13 of the 17 models (12 developed and 5 existing) from 11 studies with the special focus on heart failure-related readmissions were presented with C-statistic <0.70.[39 40 42–48] For surgical-related readmissions (6 studies), the C-statistic ranged from 0.59[67] to 0.85[69] among 7 developed models. Three of the seven models showed moderate-to-high discrimination ability.[64 65 69] Patients with heart failure in the telemonitoring program were less likely to be admitted, with the reported C-statistic being 0.21.[46] This indicates that the telemonitoring program was effective in identifying and intervening in patients who were reporting symptoms and thus reduced the likelihood of readmission.

However, 10 of 13 developed models and 1 existing model for medical condition-related readmissions (15 studies) were found to have consistent moderate discrimination ability. Four developed models also demonstrated high discrimination ability with C-statistic exceeding 0.80.[53 52 57 63]

This updated systematic review also identified one study on mental health condition-related unplanned hospital readmission. A predictive model, READMIT <(R) Repeat admissions; (E) Emergent admissions; (D) Diagnoses, and unplanned Discharge; (M) Medical comorbidity; (I) prior service use Intensity; and (T) Time in hospital>, was derived and validated using a 3-year Canadian National Health Database with a C-statistic of 0.63.

One existing predictive model, the LACE index, although validated by eight studies, demonstrated inconsistent model performance. The LACE index was first developed by van Walraven *et al*[93] in 2010 to predict the risk of unplanned readmission or death within 30 days after hospital discharge in medical and surgical patients. The model was derived and validated based on administrative data with a C-statistic of 0.684. The model includes the length of hospitalisation stay (L), acuity of the admission (A), comorbidities of patients (C) and number of emergency department visits in the 6 months before admission (E). Five studies validated the LACE index model using healthcare data of Canada, Singapore, the UK and the USA to predict all-cause readmission (4),[13 16 17 26] heart failure readmission (1)[44] and general medical condition-related readmission (2).[58 56] The discriminative ability of the model (C-statistic), reported by six studies, varied from 0.51 to 0.72.[13 16 17 26 56 58]

An extension of the LACE index to predict early death or all-cause 30-day urgent hospital readmission was further derived using administrative healthcare data and named as LACE+ index by van Walraven *et al*[27] in 2012. The LACE+ index, in addition to four predictive variables, included patient age and sex, teaching status of the discharging hospital, acute diagnoses and procedures performed during the index admission, number of days on alternative level of care during the index admission and number of elective and urgent admissions to hospital in the year before the index admission. The LACE+ index had a C-statistic of 0.771, which exceeded the performance of LACE index. The LACE+ index was further validated by two large Canadian retrospective studies. The performance of the model was 0.61[47] for patients with heart failure and 0.73[23] for patients with all-cause hospital readmissions.

A Canadian study compared the performance of different models within the same population for 30-day readmission or death due to heart failure. A total of 59 652 patients' admission information was retrieved from four health databases over a 10-year period. Five models were examined in the study,[47] namely Charlson, CMS Krumholz, Keenan, LACE index and LACE+. The five models had the C-statistic of 0.57–0.61. In terms of types of data sources used to develop or validate the 73 unique predictive models, administrative healthcare data were used for 17 models but were found/identified with inconsistent discriminative ability. A total of 13 of the 17 models reported C-statistic between 0.55 and 0.7, and the remaining four models reported C-statistic between 0.7 and 0.876. Similarly, the performance of the remaining 56 models using clinical/medical data varied between 0.21 and 0.88 (C-statistic).

Only two models[32 53] were developed targeting the potentially avoidable/preventable unplanned hospital readmissions. The outcome measure of the models focused on the end-of-life patients[53] and pneumonia, heart failure, acute myocardial infarction and chronic obstructive pulmonary disease.[32] Both models had C-statistic >0.8 (0.85 and 0.83, respectively).

Sensitivity and specificity were calculated by 16 of the 60 included studies. The sensitivity of the predictive model ranged from 5.4% (PARR-30 model, Patients at Risk of Re-admission within 30 days)[11] to 91.95% (potentially avoidable readmission (PAR) model),[32] while specificity values were between 22% (Rehospitalisation Risk Score)[24] and 99.5% (PARR-30 model).[11]

A total of 14 of the 60 included studies reported the PPV (5.6[41]–86.61%[32]) and NPV (19.1[61]–99.1%[41]) of the readmission risk predictive model. Similarly, only 17 studies calibrated the developed predictive models and mostly presented as p value, except one study[68] that reported the model calibration as the value of intercept and slope.

Predictive risk of readmission was assessed in all included studies, but only 14 of the included 60 studies specified thresholds for risk categories. Thresholds ranged from 4%[35] to 80%.[61]

Key variables included in the readmission risk predictive model

A total of 28 types of significant variables were extracted from the 73 unique predictive models for unplanned hospital readmissions as shown in table 3. Overall, the top 10 significant variables included in the 73 risk predictive models are comorbidities (n=54), demographic/social (n=45), length of stay (n=29), number of previous admissions (n=29), laboratory tests (n=25), medications (n=21), index type of admission (n=17), procedures at index admission (n=16), admitting diagnosis (n=14) and number of previous emergency department presentations (n=14) (refer to figure 2). The key demographic/social variables consisted of age (n=26), gender (n=25), living arrangement (n=12), race (n=8) and marital status (n=6).

The variables 'comorbidities', 'length of stay' and 'number of previous admissions' remained as the most frequently cited predictive risk variables against all utilisation outcomes. However, the variables 'laboratory tests' and 'medication' were more commonly included in the predictive models for cardiovascular disease-related and medical condition-related unplanned hospital readmissions compared with all-cause, mental health and surgical condition-related unplanned hospital readmissions.

DISCUSSION

A total of 60 studies with 73 unique risk predictive models for 28-day or 30-day unplanned hospital readmissions were included in this systematic review. The discrimination ability (C-statistic) of the 73 models varied largely from 0.21 to 0.88. Inconsistent performances were found among models for all-cause readmission, cardiovascular disease-related readmission and surgical-related readmission. However, most of the predictive models for the general medical condition-related readmission exceeded C-statistic of 0.7. In comparison, Kansagara *et al*[10] included 26 models with the focus of adult medical patients only. A total of 13 predictive models measured 30-day readmissions; of these, 10 models performed poorly and only 3 models reported C-statistic >0.70. The outcome measures of the other 13 models ranged from 41-day to 4-year unplanned hospital readmission; as a result of the vast difference in the time frame, the C-statistic also varied from 0.53 to 0.75.

This updated systematic review has certain limitations. The studies included in this systematic review were limited compared with studies that were published in English with full-text access. The outcomes of the predictive models included in this systematic review were also restricted to 28-day or 30-day unplanned hospital readmission. A meta-analysis is not permitted in this systematic review as the included studies were heterogeneous due to diversity of cohort of population, duration of retrieved data source, sample sizes and geographical locations. It was noted that the sample size was reported in different units, that is, (index) admission/hospitalisation, cases, patients or discharges, as shown in table 1. The lack of standardised calculation could also

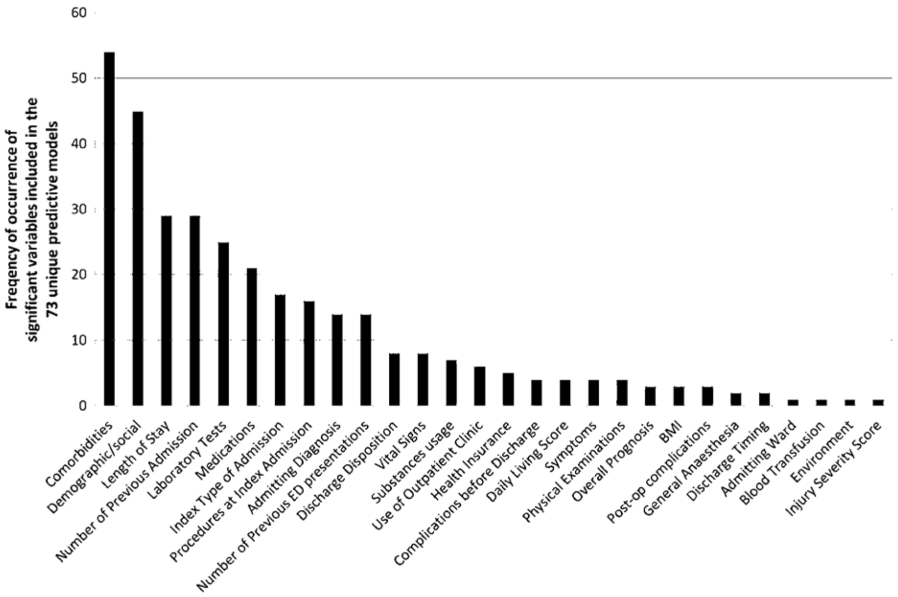

Figure 2 Pareto chart of significant variables included in the predictive models. BMI, body mass index; ED, emergency department.

contribute to the broad range of readmission rates (2.8–38%); thus, the results were not comparable. This systematic review also found the sample size is not associated with the model predictive ability. Of the included 73 unique models, Zai *et al*[46] derived a model based on the selected 100 readmitted patients with heart failure and scored the lowest C-statistic of 0.21. In contrast, Whitlock *et al*[63] retrieved around 200 readmitted patients with acute pancreatitis and developed a model with the highest discrimination ability (C-statistic=0.88).

There has been increased recognition that some unplanned hospital readmissions are associated with the diagnosis of the initial hospitalisation and could be potentially prevented or avoided through systematic discharge process. In 2006, a Swiss study[94] compared three models (non-clinical model, Charlson-based model and SQLape model, A patient classification system, also designed to adjust for costs and other outcomes) to identify potentially preventable readmission risk on over 60 000 medical patients. The C-statistics of the three models were 0.67, 0.69 and 0.72, respectively, which indicated poor-to-reasonable discrimination ability. In contrast, this systematic review identified two high-performance models[32 53] for potentially avoidable/preventable readmissions with C-statistic >0.8. The PAR model[32] was also high in other predictive model performance indicators, such as sensitivity (91.95%), specificity (97.65%), PPV (86.61%) and NPV (98.65%). However, the two models were developed based on comparatively smaller sample size of 5600[32] and 10 275[53] using American healthcare data collected over a 12-month period. Overall, the number of potentially preventable readmissions remains unclear due to lack of standardised identification process.[95–98]

Compared with the previous systematic review,[10] there were more studies in this review using clinical medical record data to develop disease-specific predictive models. However, the debate whether a predictive model should be developed using administrative data or clinical/medical records data remains inconclusive. Three key variables extracted from the 73 unique models, 'comorbidity', 'length of stay' and 'previous admissions', were based on administrative data and were consistent with the findings of a previous systematic review.[10] The latest evidence has shown that variables based on clinical medical data, that is, 'laboratory tests' and 'medications', were also valued in models for predicting cardiovascular-related and medical condition-related readmissions. Of note, ineffective communication in transitions of care is reported as a major contributing factor to adverse events that directly risk patient safety.[99 100] Poor communication at discharge also leads to preventable unplanned readmissions and frequent problems with the continuity of medication management.[101–103] None of the examined 73 models cited the comprehensiveness of discharge information as a predictor to unplanned hospital readmissions.

All included studies in this systematic review were based on adult population. To date, only two paediatric predictive models were identified and both were based on American paediatric populations. One retrospective multicentre study[104] retrieved 12-month administrative data from 38 children's hospitals. A model was developed and internally validated with a high discrimination ability (C-statistic=0.81). However, the model outcome measure was 12-month all-cause readmissions. In comparison, a 30-day hospital readmission model[105] was developed based on 5376 paediatric patients following plastic surgery procedures. The study accessed prospective medical records, and the model had moderate discrimination ability of C-statistic 0.784.

The performance of the 73 unique predictive models in this review was assessed using a variety of statistical measures. Inconsistency of reported statistical measures was noted in the included 60 studies, of which 2 studies[44 58] reported threshold as the only model performance measurement. A US framework for assessing the performance of predictive models[106] argued the importance of reporting discrimination and calibration for a risk predictive model. In all included 60 studies, the most reported measure of the risk predictive model is the ROC (C-statistic). The interpretation of the risk predictive model discriminative ability (C-statistic) was inconsistent. For instance, a study[47] examined five predictive models and concluded that the models had moderate discrimination ability based on the C-statistic of 0.57–0.6; whereas models are typically considered reasonable when the C-statistic is higher than 0.7 by Hosmer and Lemeshow.[71]

CONCLUSION

The risk predictive models which focused on general medical conditions in relation to unplanned hospital readmissions reported moderate discriminative ability. Two models[32 53] for potentially preventable/avoidable readmissions showed high discriminative ability. This systematic review, however, found inconsistent performance across the included unique 73 risk predictive models for unplanned hospital readmissions.

The variables 'comorbidities', 'length of stay' and 'previous admissions' were frequently cited across the examined unique 73 models, and 'laboratory tests' and 'medication' variables had more weight in the models for cardiovascular disease and medical conditions in relation to readmissions. However, comprehensiveness of discharge information was not included in any of the examined models.

This review highlighted the need for rigorous validation of the risk predictive models with moderate-to-high discriminative ability be undertaken, especially the two models[32 53] for the potentially avoidable hospital readmissions. There is a need to review and update predictive models. Specifically this is essential for paediatric 28-day all-cause unplanned hospital readmissions as limited evidence was found.

Findings from this updated systematic review revealed an increasing number of developed risk predictive models for specific disease-related unplanned hospital readmission using clinical/medical records data. Findings from this systematic review also confirm the limited applicability of hospital readmission risk predictive models. The performance of the applied existing models was inconsistent. It is, therefore, essential to clearly define utilisation outcomes and the type of accessible data sources prior to determining which risk predictive model to use. For example, most of the models were developed based on healthcare data from the USA, which might not be applicable to patients from other settings.

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2.5 Publication 3

Zhou, H., Roberts, P.A., Dhaliwal, S.S., & Della, P.R. (2019). Risk factors associated with paediatric unplanned hospital readmissions: a systematic review. *BMJ Open*, *9*(9:e020554). http://doi:10.1136/bmjopen-2017-020554

The *BMJ Open* was selected for this publication as it is a well recognised and cited journal with impact factor of 2.496 in 2019. It is a fully online, open access journal, publishes medical research studies from all disciplines and therapeutic areas. Confirmation of adherence to copyright requirements is evidenced in Appendix A.2. This publication has been cited six times by 2 August 2021 as per Scopus (Appendix D.1).

Specific objectives of Publication 3 were:

- To systematically review the current literature on risk factors of paediatric all-cause, surgical procedure and general medical condition related UHRs.
- To synthesise the identified risk factors associated with paediatric UHRs.

Main findings of Publication 3 were:

- A total 44 included studies with 36 significant risk factors were extracted.
- For all-cause UHRs, ethnicity, comorbidity and type of health insurance were the most frequently cited factors.
- For surgical procedure related UHRs, specific surgical procedures, comorbidity, length of stay (LOS), age, the American Society of Anaesthesiologists class, postoperative complications, duration of procedure, type of health insurance and illness severity were cited more frequently.
- The four most cited risk factors associated with General medical condition related UHRs were comorbidity, age, health service usage prior to the index admission and LOS.

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Risk factors associated with paediatric unplanned hospital readmissions: a systematic review

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ABSTRACT

Objective To synthesise evidence on risk factors associated with paediatric unplanned hospital readmissions (UHRs).

Design Systematic review.

Data source CINAHL, EMBASE (Ovid) and MEDLINE from 2000 to 2017.

Eligibility criteria Studies published in English with full-text access and focused on paediatric All-cause, Surgical procedure and General medical condition related UHRs were included.

Data extraction and synthesis Characteristics of the included studies, examined variables and the statistically significant risk factors were extracted. Two reviewers independently assessed study quality based on six domains of potential bias. Pooling of extracted risk factors was not permitted due to heterogeneity of the included studies. Data were synthesised using content analysis and presented in narrative form.

Results Thirty-six significant risk factors were extracted from the 44 included studies and presented under three health condition groupings. For All-cause UHRs, ethnicity, comorbidity and type of health insurance were the most frequently cited factors. For Surgical procedure related UHRs, specific surgical procedures, comorbidity, length of stay (LOS), age, the American Society of Anaesthesiologists class, postoperative complications, duration of procedure, type of health insurance and illness severity were cited more frequently. The four most cited risk factors associated with General medical condition related UHRs were comorbidity, age, health service usage prior to the index admission and LOS.

Conclusions This systematic review acknowledges the complexity of readmission risk prediction in paediatric populations. This review identified four risk factors across all three health condition groupings, namely comorbidity; public health insurance; longer LOS and patients<12 months or between 13–18 years. The identification of risk factors, however, depended on the variables examined by each of the included studies. Consideration should be taken into account when generalising reported risk factors to other institutions. This review highlights the need to develop a standardised set of measures to capture key hospital discharge variables that predict unplanned readmission among paediatric patients.

Strengths and limitations of this study

- This is the first systematic review of the literature from 2000 to 2017 on risk factors associated with paediatric unplanned hospital readmissions.
- The rigorous methodology applied to this systematic review used a comprehensive electronic databases search strategy, strict inclusion, exclusion and quality assessment criteria to synthesise characteristics of the included studies, examined variables and the statistically significant risk factors.
- Pooling of extracted significant risk factors was not possible because the included studies were not homogeneous due to the different diagnoses, examined variables and follow-up time frames to identify readmissions. Therefore, data extracted from the included studies were synthesised using content analysis and presented in narrative form.

INTRODUCTION

Unplanned hospital readmission (UHR) rate has been recognised as a key performance indicator for measuring the quality of care in paediatric healthcare services.[1] Hospital readmission is defined as subsequent admissions within a specified period after the initial/index hospitalisation.[2 3] Paediatric UHRs rates range from 3.4% to 28.6% and cost healthcare systems such as UK, USA and Canada up to $1 billion per annum.[4–9]

Identification of risk factors associated with UHRs is increasingly being examined as a strategy to assist in reducing these rates. A systematic review[10] conducted in 2011, identified 26 risk predictive models from 30 examined studies focused on adult general medical condition related UHRs. Readmission length of time measures used ranged from 30 days to 12 months. Overall, the performance of the 26 models was poor. The most commonly identified risk factors were *medical comorbidity* and *use of medical services before the index admission*. In a 2016 systematic review,[11] limited to 28-day or 30-day readmissions and focused on adult health conditions, a total of 60 studies and 73 risk predictive models with inconsistent performance was noted. The predictive models focusing on general medical conditions showed moderate discriminative ability. Risk factors cited most frequently for all UHRs were *comorbidities, length of stay (LOS)* and *previous hospital admissions*. For condition-specific readmissions, such as cardiovascular and general medical diseases *laboratory tests* and *medication* were more associated with readmissions.[11]

There is only one review[12] within the paediatric literature examining UHRs. This review focused on asthma-related UHRs and included 29 studies. Five significant predictive factors, including *age <5 years old or adolescent; being African American; public or no insurers; previous hospitalisations prior to the index admission; underlying chronic complex conditions* were identified. To date, there is no published review paper on risk factors associated with UHRs for general paediatric patients. This paper aimed to systematically review the current literature on risk factors of paediatric All-cause, Surgical procedure and General medical condition related UHRs. The objectives were to assess characteristics of included studies and to synthesise the identified risk factors.

METHODS

A systematic review was performed and reported according to the 2009 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) Statement.[13]

Data sources and search strategy

An electronic database search was carried out using the CINAHL, EMBASE(Ovid), MEDLINE to identify studies published from 2000 to 2017. The key search terms included ('Readmission' or rehospitali* or readmission* or readmit* or re-admission*) AND (child* or infant* or toddler* or bab* or newborn* or neonat* or school age* or preschool or paediatric* or pediatric* or kid* or boy* or girl*) OR (adolescen* or teen* or youth or juvenile* or young person* or young people*) (see online supplementary appendix for full search strategy).

Inclusion/exclusion criteria

Articles eligible for inclusion were those published in English with full-text access. The focus of the included studies was paediatric patients with UHRs. Eligible studies were published in peer-reviewed journals with details of study design clearly stated and reported statistical analysis procedure/s. Abstract only references were excluded. Studies that included patients discharged from rehabilitation health services but readmitted to acute hospitals were excluded from this systematic review as it only focused on hospital readmission following discharge from acute healthcare services. Newborn or preterm newborn studies related UHRs were excluded as the index admission was the birth hospitalisation. In addition, studies focused on mental health condition related UHRs were also excluded due to the specialised nature of the discipline.

Study selection

After the initial literature searches, two authors independently screened titles, abstracts and appraised full papers against the inclusion and exclusion criteria. The process of exclusion was relatively straightforward and only a handful of studies warranted discussion between authors, to reach consensus as to whether they met the inclusion criteria. Moreover, the reference list of all identified relevant records were searched for additional studies.

Data extraction

Data were extracted from the 44 included studies. The data extraction comprised study characteristics, examined variables and statistically significant risk factors. Study characteristics included study setting, population, data source, timing of data collection, sample size, study design, model utilisation outcome, readmission rate and statistical analysis test/s used to identify risk factors (table 1). All examined variables or confounding factors and the significant risk factors were extracted into table 2 and detailed information was included in the online supplementary table. Studies were grouped based on the health conditions in both tables. Disagreements between two reviewers about the extracted data were resolved through group discussion.

Quality assessment

Two independent reviewers completed the assessment of study quality. Six domains of potential bias[14] were used to assess the 44 included primary research studies. The six domains are: 1. Study participation: 'Was source population clearly defined?' 2. Study attrition: 'Was completeness of follow-up described and adequate?' 3. Prognostic factor measurement: 'Did prognostic factors measure appropriately?' 4. Outcome measurement: 'Was outcome defined and measured appropriately?' 5. Confounding measurement and account: 'Was confounders defined and measured?' 6. Analysis: 'Was analysis described and appropriate?' The ratings of 'Yes', 'Partly', 'No' or 'Unsure' was given to each domain and then an overall risk of 'low' or 'high' was assigned to each study.

Data synthesis

Pooling of extracted significant risk factors was not possible because the included studies were not homogeneous due to the different diagnoses, examined variables and follow-up time frames to identify readmissions. Therefore, data extracted from the included studies were synthesised using content analysis and presented in narrative form.[11]

Patient and public involvement

Patients and or public were not involved in this systematic review.

RESULTS

The initial electronic database search produced 11 859 records. After removal of 4145 duplicates, a total of 7714 records remained. Titles and abstracts were then appraised and 7579 records were excluded due to irrelevance. Of the remaining 135 relevant references, a further

Table 1 Characteristics of the 44 included studies

Reference	Medical condition	Outcome measures	Study design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data analysis
All-cause related UHRs (8)									
Toomey *et al*, 2016[70] USA	All-cause	30-day Potentially preventable UHRs	Prospective	A freestanding children's hospital Interviews and medical records	305 patients	<18 years	December 2012 to February 2013	Overall UHR 6.5%, 29.5% potentially Preventable UHR	Multivariable logistic regression
Wijlaars *et al*, 2016[4] UK	All-cause	≤30-day and 31-day to 2-year UHRs	Retrospective	National administrative hospital data	866 221 patients	0–24 years	2009 to 2010	8.8% (30 days) 22.4% (31 days to 2 years)	Multivariable logistic regression
Khan *et al*, 2015[69] USA	All-cause	30-day UHRs	Retrospective	State inpatient database— 177 acute hospitals (12 children's hospital)	701 263 discharges	0–17 years	1 January 2005 to 30 Nov ember2009	4.5% (AHR) 3.8% (SHR) 0.6% (DHR)	Multivariable logistic regression
Auger and Davis, 2015[68] USA	All-cause	30-day UHRs	Retrospective	A tertiary children's hospital Administrative data	55 383 hospitalisations/ 32 112 patients	Not specified	2006 to 2012	10.3%	Logistic regression
Coller *et al*, 2013[5] USA	All-cause	30-day UHRs	Retrospective	A tertiary children's hospital Administrative data and Medical records	7794 index discharges/5056 patients	<2 to 18 years	July 2008 to July 2010	18.7%	Logistic regression
Berry *et al*, 2011[6] USA	All-cause	365-day UHRs	Retrospective	PHIS of 37 children's hospital	317 643 patients/ 579,504 admissions	0 to >18 years	2003 to 2008	21.8%	χ^2 and multivariate analysis
Feudtner *et al*, 2009[7] USA	All-cause	365-day UHRs	Retrospective	PHIS of 38 children's hospital	186 856 patients	2 to 18 years (Mean=9.2)	2004	16.7%	C-statistics=0.81
Beck *et al*, 2006[8] Canada	All-cause	30 day UHRs	Retrospective	The Canadian Institute—Discharge Database	506 035 hospitalisations/334 959 children	29 days–8 years	1996 to 2000	3.4%	Multivariate modelling
Surgical conditions related UHRs (20)									
Brown *et al*, 2017[81] USA	General surgical admissions	7-day, 14-day and 30-day UHRs	Retrospective	University HealthSystem Consortium database— 258 hospitals	260 042 patients	0–17 years	1 September2011 to 31 March 2015	2.1% (7 days), 3.1% (14 days) and 4.4% (30 days)	Multivariate logistic regression
Vo *et al*, 2017[83] USA	All Surgeries	30-day UHRs	Retrospective	National surgical QI programme—Paediatric	182 589 patients	<18 years	2012 to 2014	4.8%	C-statistics=0.747
Richards *et al*, 2016[80] USA	All Surgeries	30-day UHRs	Retrospective	A children's hospital—Seattle children's hospital enterprise data warehouse	20 785 patients with 26 978 encounters	0 to≥18 years	1 October 2008 to 28 July 2014	11.5%	Multivariate logistic regression
Elias *et al*, 2017[85] USA	Cardiac surgery	1-year UHRs with plural effusion	Retrospective	PHIS database	142 633 admissions	Median=6.4 months (1.1–46.5 months)	1 January 2003 to 30 September 2014	1.1%	Multivariate logistic regression

Continued

Table 1 Continued

Reference	Medical condition	Outcome measures	Study design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data analysis
Polites *et al*, 2017[86] USA	General & Thoracic surgery	30-day UHRs	Retrospective	National surgical QI programme—Paediatric	48 870 patients	Mean=8.1±5.8 years	2012 to 2014	3.6%	C-Statistics=0.710
Yu *et al*, 2017 [90] USA	Tracheostomy	30-day UHRs	Retrospective	An urban tertiary children's hospital—Medical charts	237 patients	<18 years	2005 to 2013	22%	Multivariate logistic regression
Murray *et al*, 2016[72] USA	ENT surgeries	30-day UHRs	Retrospective	PHIS database	493 507 procedures	0–18 years	1 January 2009 to 31 December 2011	2.3%	Multivariate logistic regression
Roxbury *et al*, 2015[77] USA	Surgical (Otologic)	30-day UHRs	Retrospective	National NSQIP-P data (50 institutions)	2556 procedures	Only reported as<3 or >3 years	2012	1.3%	Multivariate logistic regression
Roddy and Diab, 2017[87] USA	Spinal fusion	30-day and 90-day UHRs	Retrospective	The state Inpatient Database	13 287 patients	<21 years	2006 to 2010/2011	38% (30 days) 33% (90 days)	Multivariate logistic regression
Vedantam *et al*, 2017[88] USA	Epilepsy surgery	30-day UHRs	Retrospective	2015 NSQIP-P database	208 patients	0–18 years	2015	7.1%	Multivariate logistic regression
Chern *et al*, 2014[74] USA	Shunt surgery	30-day UHRs	Retrospective	1 institution-Administrative and clinical databases	1755 procedures	Mean = 7.15 Years	1 May 2009 to 30 April 2013	16.5%	Multivariate logistic regression
Sarda *et al*, 2014[79] USA	Non-shunt surgery	30-day UHRs	Retrospective	1 institution-Administrative and clinical databases	2924 Index admissions	Mean = 7.17 Years	1 May 2009 to 30 April 2013	10.4%	Multivariate logistic regression
Minhas *et al*, 2016[71] USA	Spinal surgeries (Scoliosis)	30-day UHRs	Retrospective	American College of Surgeons NSQI-Pediatric database	3482 patients	0–18 Years	2012 to 2013	3.4%	C-statistics=0.76–0.769
Buicko *et al*, 2017[82] USA	Appendectomy (Laparo-scopic)	30-day UHRs	Retrospective	The Nationwide Readmission Database	12 730	<18 Years	2013	3.4%	Multivariate logistic regression
Cairo *et al*, 2017[83] USA	Appendectomy	30-day UHRs	Retrospective	American College of Surgeons NSQI-Paediatric database	22 771 patients	0–17 Years Mean=11±3.56	2012 to 2015	1.89% same-day discharge 2.33% 2-3 day discharge	Multivariate logistic regression
Cairo *et al*, 2017[84] USA	Cholecystectomy (Laparoscopic)	30-day UHRs	Retrospective	The NSQI-Paediatric database	5046	2–17 Years	2012 to 2015	3.6%	Multivariate logistic regression
Roth *et al*, 2016[73] USA	Circumcision	7-day UHRs	Retrospective	PHIS database	95 046 procedures	0–18 Years	2013 to 2014	0.3%	Logistic regression analysis
McNamara *et al*, 2015[76] USA	Surgical (Urology)	30-day UHRs	Retrospective	National NSQIP-P database (50 institutions)	461 patients	Median=9.4 Years	2012 to 2013	27.8%	logistic regression
Vemulakonda *et al*, 2015[78] USA	Surgical (Urology)	12-month UHRs	Retrospective	PHIS database Administrative Health-Information data	4499 patients	0–18 years (Median=10 months)	1 January 1999 to 30 September 2009	4.9%	Logistic regression Cox PH

Continued

Table 1 Continued

Reference	Medical condition	Outcome measures	Study design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data analysis
Tahiri *et al*, 2015[75] USA	Plastic surgeries[86]	30-day UHRs	Retrospective	National surgical QI programme database	5376 patients	Mean = 5.47 years	2012	2.4%	C-statistics=0.784
General medical conditions related UHRs (16)									
Sacks *et al*, 2017[101] USA	Cardiac conditions	30-day UHRs	Retrospective	A large urban tertiary children's hospital—Medical charts	1,124 patients/ 1993 hospitalisations	0–12.9 years	2012 to 2014	20.5%	C-statistics=0.75
Chave *et al*, 2017[93] Switzerland	Congenital heart disease	30-day UHRs	Retrospective	A tertiary general hospital -Medical charts	996 patients	<18 years Mean=2.7 years	2002 to 2014	9.6%	Multivariable logistic regression
Mackie *et al*, 2008[97] Canada	Congenital heart disease	31-day UHRs	Retrospective	All hospitals of Quebec, Canada	3675 hospitalisations	0–17 years	1 April 1990 to 31 March 2005	15%	Cox proportional hazards analysis
Nakamura *et al*, 2017[99] USA	Lower respiratory infections	30-day UHRs	Retrospective	Medicaid Analytic eXtract data—26 states	150 590 hospitalisations	<18 years	2008 to 2009	5.5%	A 2-level mixed-effects logistic regression
Veeranki *et al*, 2017[104] USA	Asthma	30-day UHRs	Retrospective	2013 National Readmission Database—21 states	12 842 Index hospitalisations	6–18 years	2013	2.5%	Cox proportional hazards analysis
Vicendese *et al*, 2015[105] Australia	Asthma	28-day UHRs	Retrospective and case control	A children's hospital Medical records and Indoor sampling and Survey	Selected 22/96 Patients URHs vs 22 without URHS	2–17 years	September 2009 to December 2011	38%	Logistic regression
Neuman *et al*, 2014[100] USA	Pneumonia	30-day UHRs	Retrospective	PHIS of 45 hospital	82 566 patients	0 to >18 years	2008 to 2011	7.7% (All-cause); 1% (Pneumonia-specific)	Multivariate logistic regression
Vicendese *et al*, 2014[106] Australia	Asthma	28-day and 1-year UHRs	Retrospective	Victorian Admitted Episodes Dataset	53 156 admissions/33 559 patients	2–18 years	1997 to 2009	4.5% vs 19.3%	Logistic regression
Kun *et al*, 2012 *et al*[96] USA	Chronic respiratory failure	1-year UHRs	Retrospective	A tertiary children's hospital—Medical charts	109 patients	0–21 years	1 January 2003 to 31 October 2009	40%	Generalised estimating equations (GEE)
McNally *et al*, 2005[98] UK	Preschool viral-wheeze	6-month UHRs	Prospective	Quantitative—Medical records extraction	208 patients 192 patients	15 to 40 months	May to October 1999; November 1999 to April 2000	22% 25%	Mann-Whitney U test or χ^2 test
Cohen *et al*, 2000[94] USA	Asthma	30-day UHRs	Retrospective	Administrative and Billing record data; Medical records	37 patients selected from 700 admissions	0–18 years	12 months	*Not reported*	Standard algebraic formula
Sobota *et al*, 2012[103] USA	Sickle cell disease	30-day UHRs	Retrospective	PHIS of 33 children's hospitals	12 104 Hospitalisations/ 4762 patients	<18 years	1 July 2006 to 31 December 2008	17%	Generalised estimating equations (GEE)
Frei-Jones *et al*, 2009[95] USA	Sickle cell disease	30-day UHRs	Retrospective	A children's hospital	100 admissions	8 months to 21 years	12 months	30%	Multivariate analysis

Continued

Table 1 Continued

Reference	Medical condition	Outcome measures	Study design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data analysis
Slone *et al*, 2008[102] USA	ALL	28-day UHRs	Retrospective	A children's medical centre; Medical records	129 patients	1–19 years	1 January 2001 to 31 May 2005	28%	Multivariate logistic regression
Braddock *et al*, 2015[92] USA	Complex chronic/medical	7-day, 30-day and 90-day UHRs	Retrospective	A specialty children's hospital Administrative database+Medical records	1229 patients with 2295 admissions	0 to >18 years (not clearly specified)	2006 to 2011	38%	Logistic regression analysis with GEE
Attard *et al*, 2017[91] UK	Gastrointestinal bleeding	30-day UHRs	Retrospective	PHIS (49 not-for-profit, tertiary children's hospital)	99 902 patients	1–21 years	1 January 2007 to 30 September 2015	9%	Multivariate logistic regression

AHR, all hospitals readmissions; ALL, acute lymphoblastic leukaemia; DHR, Different hospitals readmissions; ENT, ear, nose and throat; GEE, generalised estimating equations; PHIS, Paediatric Health Information Systems; SHR, same hospital readmissions; UHR, unplanned hospital readmission.

22 were excluded as they were conference abstracts only. A total of 113 references were reviewed as full-text and a further 75 were excluded against selection criteria. Four studies were excluded as they were published in Chinese,[15] Korean,[16] Portugese[17] and Spanish.[18] Studies that mixed paediatric and adult patients[19–21] or mixed planned and unplanned readmissions[22] or mixed Emergency Department presentations and hospital readmissions[23–25] were excluded. Three studies[26–28] that included patients initially discharged from rehabilitation health service but then admitted to an acute hospital were excluded. An integrative review[12] on paediatric asthma related UHRs was excluded. As mentioned previously, studies[29–53] examined newborn/preterm newborn-related UHRs and mental health condition related UHRs[54–67] were excluded. A hand search reference list of the remaining 38 studies was conducted and six additional studies were identified. Finally, a total of 44 studies were included in this systematic review. Figure 1 is a flowchart as per PRISMA of the screening process of the database search results.

Study quality appraisal

The overall risk of bias of the 44 included studies was low when evaluated against the six domains of potential bias. The studies described the population of interest for key characteristics, the response rate information was clearly stated, an adequate proportion of the study population had complete data for all independent variables, the outcome variable readmission was measured with sufficient accuracy and the method of statistical analysis was appropriate for the design of the study.[14]

Characteristics of the included studies

Table 1 displays the characteristics of the final included studies of this systematic review. The 44 studies were conducted in several countries: USA (n=36), UK (n=3), Australia (n=2), Canada (n=2) and Switzerland (n=1). Thirty of the included studies retrieved data from multiple sites and the other 14 accessed single healthcare service. A total of 33 included studies examined a combination of health database and medical records and the remaining 11 accessed database only. The included studies are grouped as per health conditions namely (1) All-cause related UHRs (n=8);[4–8 68–70] (2) surgical procedure related UHRs (n=20),[71–90] including all surgical admissions (n=3), cardiothoracic surgeries (n=3), ear, nose and throat (ENT) surgeries (n=2), neurosurgeries (n=5), abdominal surgeries (n=3), urological surgeries (n=3) and plastic surgeries (n=1) and (3) General medical condition related UHRs (n=16)[91–106] including cardiac conditions (n=3), respiratory conditions (n=8), blood disorders (n=3), complex chronic conditions (CCC) (n=1) and gastrointestinal conditions (n=1).

All included studies used retrospective health data except Toomey[70] who employed a prospective research design including structured interview and reviewing medical records. Of the included studies, outcome measures of length of time from discharge to readmission

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Table 2 Thirty-six differing significant risk factors associated with three paediatric health condition groups related UHRs

Health condition group	All-cause (n=8)								Surgical procedures (n=20)																				General medical conditions (n=16)															
Reference number	70	4	69	68	5	6	7	8	81	89	80	85	86	90	72	77	87	88	74	79	71	82	83	84	73	76	78	75	101	93	97	99	104	105	100	106	96	98	94	103	95	102	92	91
Examined variables (n=)	11	2	13	10	7	5	11	7	10	8	33	7	8	5	10	4	15	9	17	13	44	9	6	9	3	9	8	12	10	8	11	4	13	4	14	4	8	12	11	17	9	3	11	13
Significant risk factors (n=)	3	1	3	1	5	4	7	3	3	4	7	4	7	4	7	2	9	1	1	4	3	5	1	2	1	3	1	5	2	1	6	2	6	1	5	2	0	0	2	3	4	1	3	4
Age at admission/operation					X		X					X		X	X	X						X					X		X		X		X		X					X				
Gender		X					X										X															X				X								
Race/Ethnicity					X	X	X				X																																	
Location of residence												X			X															X			X											
Health Insurance			X		X	X	X								X		X								X																			
Living environment									X																									X		X								
Type of index hospital			X							X							X					X											X											
Health service usage prior to index admission							X	X			X																				X				X				X		X			
Time since last admission							X																																					
Comorbidity		X	X			X		X		X		X	X		X		X				X	X		X		X			X		X	X	X		X				X		X			X
Illness severity					X								X	X	X					X											X				X									
LOS/Postop LOS							X		X				X	X	X		X			X		X									X		X		X									X
Principal diagnoses																	X					X																		X			X	X
Principal procedures									X			X	X		X	X	X	X		X	X																							
Inpatient complications								X		X			X				X											X																
Specific medication at index admission						X																						X												X			X	
Devices at index admission																																									X			X
Length of operation													X													X		X																
Time between scheduled start and actual																																												
Wound contamination before operation													X															X																
After hour's operations																			X	X																								
The ASA class										X											X		X	X		X		X																
Specific laboratory results																																										X		
Discharge on Friday or Weekend											X																				X													
Admission on weekends				X																																								
Afterhours discharge											X																																	
Follow-up after discharge					X																																				X			
Discharge disposition																	X																X											
Discharge with special treatment														X																														
Discharge with increased medication/further treatment																																											X	
Index admission and readmission causally related	X																																											
Hospital contributing factors	X																																											
Patient contributing factors	X																																											

Continued

Table 2 Continued

Health condition group	All-cause (n=8)								Surgical procedures (n=20)																				General medical conditions (n=16)															
Reference number	70	4	69	68	5	6	7	8	81	89	80	85	86	90	72	77	87	88	74	79	71	82	83	84	73	76	78	75	101	93	97	99	104	105	100	106	98	96	94	103	95	102	92	91
Hospital service (specialties)											X																																	
Surgical division											X																																	
Surgical locations											X																																	

ASA, the American Society of Anaesthesiologists; UHR, unplanned hospital readmission.

varied from 7 days for CCC,[92] all surgical admissions,[81] or circumcision[73] to 1 year for All-cause,[6 7] asthma[106] and chronic respiratory failure[96] related UHRs. Thirty-one of the 44 included studies adopted 28-day or 30-day UHRs measurement. The duration of time for the retrieved data used in the studies ranged from 3 months[70] to 10 years[78].[106] The majority of included studies involved patients younger than 18 years. Five studies included patients older than 18 years with either blood disorder disease,[102] CCC,[4] gastric bleed,[91] spinal fusion[87] or all surgeries.[80]

Of included studies, the sample size was recorded in various units, such as *Patients, Admissions, Index admissions, Hospitalisations, Index discharges, Discharges* or *Procedures.* The sample size ranged from 100 admissions[57 63 95] to 866 221 patients.[4] UHR rates, if reported, varied from <1% following postcircumcision[73] to 40% in patients with chronic respiratory failure.[96]

All included studies employed logistic regression or equivalent to analyse the data. Most studies reported OR with 95% CI and the result is considered as statistically significant when the p value is less than 0.05. Six included studies also reported risk predictive model performance. One model[7] demonstrated high discriminative ability (C-statistic=0.81) for 12-month All-cause UHRs. The other models had moderate discrimination ability to predict 30 day UHRs following cardiac conditions,[101] plastic,[12] thoracic surgeries,[86] scoliosis surgeries,[13] or all surgical admissions[89] (C-statistic of 0.75, 0.784, 0.71, 0.769 and 0.74, respectively).

Examined variables/Confounding factors and Significant risk factors

The variables or confounding factors examined varied across the 44 included studies. The number of examined variables of each included study ranging from 24 to 44.[71] Two of the included studies, after applying statistical analysis tests to the examined variables, yielded inconclusive findings.[96 98] Thirty-six differing but significant risk factors were extracted and presented under the three health condition groupings (All-cause, Surgical procedure and General medical condition).

Risk factors associated with All-cause UHRs

The least number of studies (n=8) in the systematic review related to All-cause UHRs. Risk factors associated with All-cause UHRs and cited more frequently are comorbidity, ethnicity and health insurance. Patients' comorbidity was identified by four studies[4 6 8 69] with OR ranging from 1.2 to 5.61. Of these, chronic conditions (n=3) was more frequently cited as a risk for readmission. Three studies cited race/ethnicity as a risk factor. Compared with other race/ethnicities, patients of Black race[6 7] or Asian[5] had 50% more likelihood of being readmitted. Patients from families with only public health insurance were identified at risk for readmission by three studies (OR=1.31 to 1.48).[5–7] One study by Khan 2005,[69] however, identified patients with private health insurance were 1.14

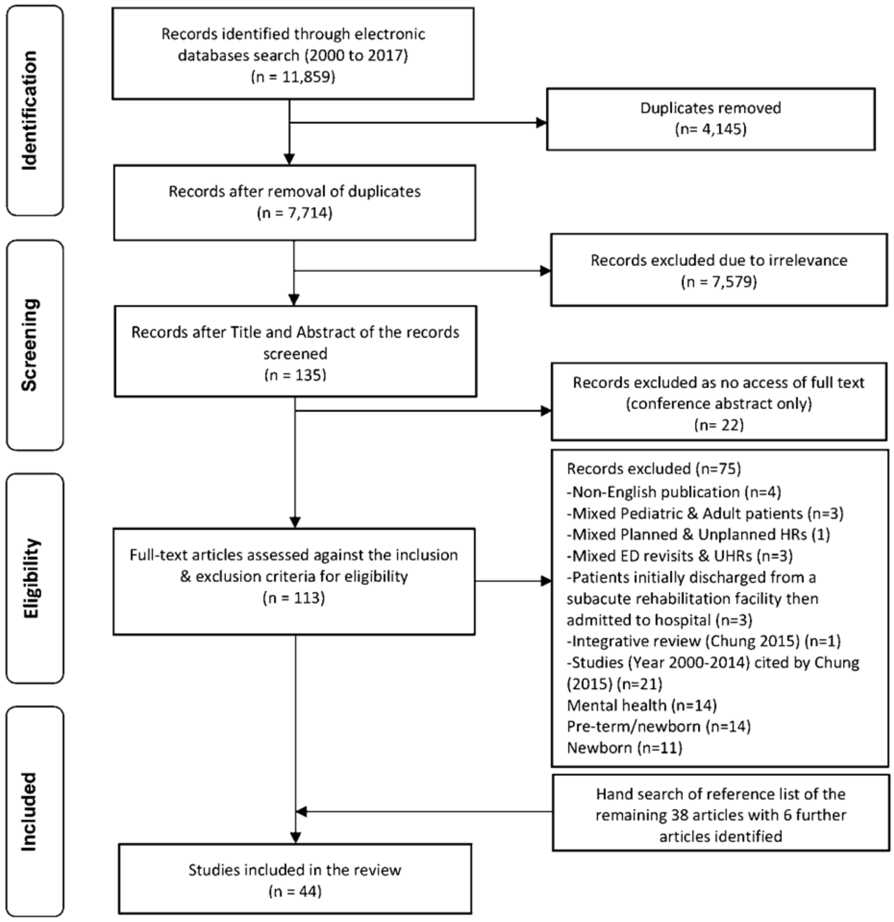

Figure 1 Flowchart for the search and study selection process (PRISMA).

times more likely to be readmitted to a different hospital. Other significant risk factors related to All-cause UHRs are displayed in table 2.

Risk factors associated with surgical procedure related UHRs

The greatest number of risk factors contributing to UHRs were found in the grouping of studies Surgical Procedure. Within the 20 included studies, the most frequently cited risk factors are comorbidity, specific surgeries, LOS, age, the American Society of Anaesthesiologists (ASA) class, development of complications during index admission, duration of surgery, type of health insurance and illness severity. Patients' comorbidity[71 72 76 82 84–87 89] and specific surgical procedures[71 72 77 79 81 85–88] were each cited in nine differing studies. The type of comorbidities were not consistent among the studies (OR=1.12 to 10.08).

In general, patients with longer LOS at index admission were found in seven studies to be at greater risk of readmission following surgical procedures (OR=1.01 to 13.96)[72 79 81 82 86 90] although one study[87] found shorter than 3 days of hospitalisation at the index admission was a risk factor for patients who underwent spinal fusion (OR=1.89).

Age at index admission or surgery[72 77 78 82 85 90] and the ASA class[71 75 80 83 84 89] were cited in six differing studies. Age, however, was inconsistent across the studies. For example, patients either younger than 1 year[78] with urological surgeries or older than 13 years[72] with ENT surgeries were more likely to be readmitted. The ASA class of 3 and above was associated with higher risk of UHRs (OR=1.78 to 7.62). In four studies, patients who developed medical or postoperative complications at the index admission were at risk of readmission with OR ranging from 1.34 to 11.92.[75 86 87 89]

Public insurance,[72 73 87] longer operating time,[75 76 86] and severe health conditions prior to surgeries[72 79 86] were all cited three times in different studies as increasing the risk of patients UHRs. Other significant risk factors related to surgical procedure related UHRs are displayed in table 2.

Risk factors associated with general medical condition related UHRs

Sixteen studies were reviewed that examined General medical condition related UHRs. Four most frequently cited risk factors are comorbidity, age, health service usage prior to the index admission and LOS. A total of eight studies identified patients' comorbidity as a risk factor (OR=1.1 to 3.61).[91 94 95 97 99–101 104] The most frequently cited comorbidity was chronic conditions (n=5).

Age of patients at index admission was cited as a risk factor by five studies[97 100 101 103 104] with OR ranging from 1.1 to 4.11. In particular, patients younger than 1 month[100 101] or patients between 12 and 18 years[100 104] were more likely to be readmitted. Three studies[94 95 100] reported patients with previous hospitalisation prior to the index admission were at higher risk of readmissions (OR=4.7 to 7.3). A further three studies[91 100 104] cited LOS as a risk factor with OR ranging from 1.13 to 1.56. Patient stays >4 days for Asthma[104] or >7 days for Pneumonia[100] are more like to be readmitted. Other significant risk factors related to General medical condition related UHRs are displayed in table 2.

DISCUSSION

This systematic review identifies risk factors associated with paediatric UHRs. A total of 44 studies were reviewed and 36 differing significant risk factors were extracted. There are only four consistently cited paediatric readmission risk factors across all included studies, namely comorbidity, public health insurance, longer LOS at the index admission and patients either younger than 12 months or those 13–18 years of age. The results demonstrate a shift in focus from All-cause UHRs to condition specific related UHRs, especially those involving surgical procedures. Overall, the 36 significant risk factors varied among studies focused on condition-specific related readmissions and some risk factors were not reported consistently across studies.

This systematic review has certain limitations. The database search was restricted to English publication only and full-text access was also required to allow comprehensive data extraction. Meta-analysis was not performed on the extracted significant risk factors as the included studies were not homogeneous due to the different diagnoses, examined variables and follow-up time frames to identify readmissions. This systematic review did not establish a definite cut-off age during the literature search although 0–18 years is a widely accepted definition for paediatric patients. Consequently, five included studies had patients in their late teens or young adulthood (19–24 years).[4 80 87 91 102] The inclusion of late adolescent and young adult under paediatric health services care is consistent with the finding of delayed transitions from paediatric to adult healthcare services.[107] This systematic review did not restrict the follow-up time frame used by studies to identify UHRs, which resulted in data collection spanning 7 days to 21 years. This in turn contributed to a vast range of paediatric UHRs rates of <1% to >40%. Nineteen included studies in this review investigated 28-day, 30-day or 31-day paediatric UHR rates, ranging from 1.3%[77] to 38%.[72 92] The number of predictive models with performance reported for paediatric UHRs (n=6) is very limited compared with the adult population (n=94).[10 11] This systematic review did not identify any paediatric based studies examining potentially preventable UHRs reported risk prediction model performance. In comparison, there are two developed models[108 109] with high discriminative ability for adult patients.

CONCLUSION

This systematic review acknowledges the complexity of UHRs risk prediction in paediatric populations. The evidence on the utility of developed predictive models for paediatric UHRs, comparison to adult population literature, is very limited as no existing models have been validated externally. This review identified four consistently cited risk factors associated with paediatric UHRs. These include comorbidity, public health insurance, longer LOS at the index admission and patients either younger than 12 months or 13–18 years old. The identified risk factors depended on what variables were examined in each of the included studies. Therefore, consideration should be taken into account when generalising reported significant risk factors to other institutions.

This review concludes that a focus on the development of potentially preventable/avoidable UHRs risk predictive models for paediatric patients is required as some unplanned readmissions might be unavoidable due to medical complexity.[110] Future studies should use a combined approach of administrative and clinical medical data. Also, there is a need to examine if paediatric potentially/avoidable UHRs are associated with patients' social complexity (ie, language proficiency) and comprehensiveness of discharge information (written and verbal communication).

The utmost priority is to develop a standardised set of measures to capture key hospital discharge variables that predict unplanned readmission among paediatric patients. Key challenges include time frame used to measure readmissions, unit of measure on which to record/calculate readmission and variables to be examined. Establishing the most appropriate length of time (being discharge to readmission) to measure UHRs is the first challenge. The second is to standardise the unit of measure that should be used to calculate the readmission rate, while the final challenge is to determine what variables should be extracted and examined to identify risk factors associated with UHRs. Once these challenges have been addressed, a parsimonious predictive model, with high sensitivity and specificity, can be developed for use in all healthcare settings, to identify and implement quality improvement plans for patients with high risk of UHRs.

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2.6 Updated Literature Review on Risk Factors Associated with Paediatric Unplanned Hospital Readmissions

The systematic review (Zhou, Roberts, et al., 2019) presented in Section 2.5 critically analyses research evidence from years 2000 to 2017 pertaining to risk factors associated with paediatric UHRs. Following publication, an updated literature search was undertaken to identify new information, which had emerged since the initial publication. This was important to ensure the latest research evidence on the identification of paediatric readmission risk factors was included.

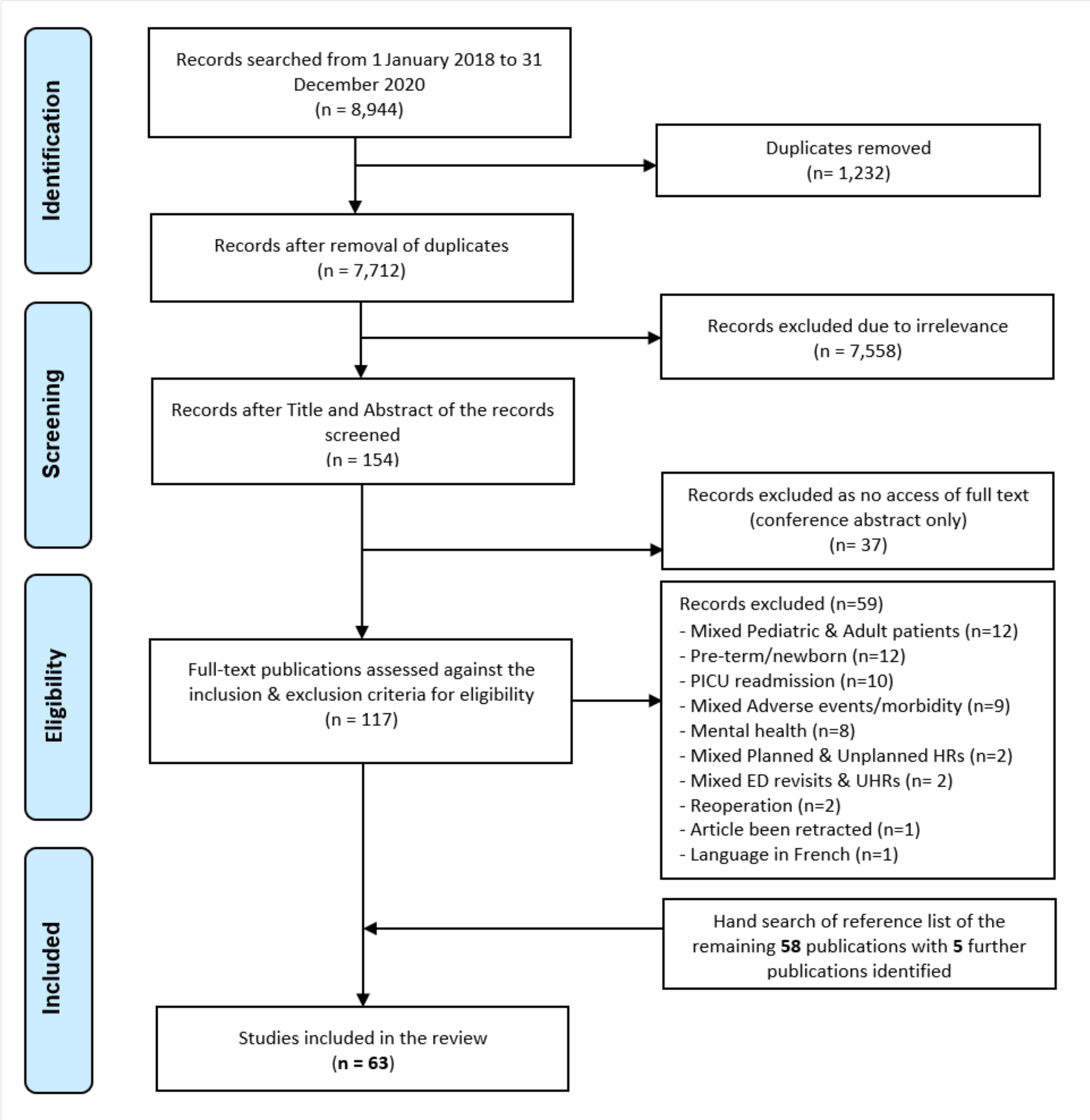
2.6.1 Search strategy

Three electronic databases, CINAHL, EMBASE(Ovid) and MEDLINE, were searched in August 2019 and January 2021 using the same search strategies as the previous systematic review. A total of 8,944 records were generated from three electronic databases from 1st January 2018 till 31st December 2020. After removal of 1,232 duplicates, a total of 7,712 records remained. Titles and abstracts were then screened, and 7,558 irrelevant records were excluded. Of the remaining 154 records, a further 37 conference abstracts were excluded.

A total of 117 records were reviewed as full-text, and a further 59 were excluded against inclusion and exclusion criteria. Excluded studies included mixed paediatric and adult patients (n = 12), newborn/pre-term newborn related UHRs (n = 12), unplanned intensive care unit readmissions (n = 10), mixed adverse events/morbidities (n = 9), and mental health condition related UHRs (n = 8). Studies examining mixed unplanned Emergency Department visits and UHRs (n = 2), mixed planned hospital readmission and UHRs (n = 2), or reoperation (n = 2) were excluded. A study published in French (n = 1) was also excluded as well as a publication which was retracted. A hand search of reference lists of the remaining 58 studies identified five additional studies. A final total of 63 studies were included in this updated literature review. Figure 2.2 is a PRISMA flowchart to display the screening process of the updated database search results.

Figure 2.2

PRISMA Flowchart of the Screening process of the updated database search results



Assessment of the quality of the included 63 studies were carried out using the six domains of potential bias and overall risk of bias was low. The studies provided clear and adequate descriptions on characteristics of population, response rate, independent variables, the outcome variable measurement, and statistical analysis method (Zhou, Roberts, et al., 2019). No further studies were excluded based on the assessment outcomes.

2.6.2 Characteristics of the included studies

Characteristics of the final included studies are summarised and displayed in Table 2.2. The majority, almost 80% of the 63 included studies, were conducted in USA (n = 50). The others were undertaken in China (n = 2), UK (n = 2), and one each in Australia, Canada, Chile, Lebanon, India, South Africa, Spain, Sweden and Taiwan. Sixty percent of the included studies (n = 27) accessed data from multiple sites and the others retrieved data from a single site healthcare service. Three quarters of the included studies (n = 47) were based on health administrative databases, 15 studies reviewed patients' medical records, and one study used survey to collect data. The data retrieval period ranged from one year (Bavishi et al., 2018; Chew et al., 2020; Hong et al., 2019; Johnson et al., 2018; Mears et al., 2019; Parikh et al., 2018; Vedantam et al., 2018; Veeranki et al., 2018) to 14 years (Wong et al., 2020).

The included studies are grouped and presented according to the three health condition groupings used in the previous systematic review (Zhou, Roberts, et al., 2019), all-cause related UHRs (n = 11), general medical conditions related UHRs (n = 14), and surgical procedure related UHRs (n = 38). General medical conditions consisted of respiratory conditions (n = 7), complex chronic conditions (n = 2), neurology (n = 2), febrile seizure (n = 1), diabetic ketoacidosis (n = 1), and pulmonary hypertension (n = 1). Surgical procedures included all surgical admissions (n = 3), cardiothoracic surgeries (n = 8), Ear, Nose and Throat (ENT) surgeries (n = 6), abdominal surgeries (n = 6), neurosurgeries (n = 5), trauma (n = 3), urological surgeries (n = 3), plastic surgeries (n = 2), ophthalmology surgery (n = 1), and orthopaedic surgeries (n = 1).

The majority of included studies (n = 47) employed retrospective study designs and the remaining 16 studies prospective data collection methods including structured interview, survey, and review of medical records. Forty-two included studies used 30-day unplanned hospital readmission as the measure, others varied from 3–7 days for all-cause, neurology UHRs. Follow up periods of data retrieval ranged from six months (Rodriguez et al., 2019) to 11 years (Milford et al., 2019; Roth et al., 2018).

Most of the included studies involved patients younger than 18 years, but three involved patients older than 18 years with all-cause readmission (Ehwerhemuepha et al., 2020), congenital heart surgery (Benavidez et al., 2019), or spinal cord tumour surgery (Janjua et al., 2019). The sample size of included studies ranged from 125 admissions (Rodriguez et al., 2019) to 390,745 patients (Markham et al., 2019). The reported UHR rates varied from <1% following general surgeries (Evans et al., 2019; Mears et al., 2019) to 48% for all-cause UHRs (Rodriguez et al., 2019). "Patients" or "Admissions" were the commonly used measurement units for sample size, but some studies reported "Hospitalisations", "Discharges", "Cases" or "Procedures".

Apart from generally used logistic regression analysis, four studies applied machine learning data analysis methods in the identification of unplanned hospital readmission predictors. In particular, two studies used the Least Absolute Shrinkage and Selection Operator (LASSO) (Ehwerhemuepha et al., 2020; Janjua et al., 2019), Gradient booting trees (XGBoost) (Taylor et al., 2020), or Naïve Bayes, Support Vector Machines (SVM), and Multilayer Perception methods (Wolff et al., 2019). Eight included studies reported predictive model performance. Four models for surgical procedure related UHRs had c-statistics of 0.54 (Jiang et al., 2018) to 0.802 (Brown et al., 2019). Five models for all-cause UHRs had c-statistics of 0.645 (Zhou, Della, et al., 2019) to 0.86 (Ehwerhemuepha, Finn, et al., 2018). One model for medical condition related UHRs had c-statistics of 0.67 (Leary et al., 2019).

2.6.3 Examined variables/confounding factors and significant risk factors

The number of examined variables or confounding factors of the included studies ranged from 1 (Mears et al., 2019) to 35 (Ehwerhemuepha et al., 2020). Two included studies had inconclusive findings (Evans et al., 2019; Parikh et al., 2018). A total of 25 types of significant paediatric UHRs risk factors were extracted and presented as per the three health condition groupings in Table 2.3.

2.6.4 Risk factors associated with all-cause UHRs

A total of 12 types of significant risk factors were extracted from 11 studies, including socio-demographic and clinical factors. The most frequently cited risk factors were comorbidity (n = 8), LOS (n = 6), type of index admission (n = 6), age (n = 5), and socio-economic status (n = 3).

2.6.4.1 Socio-demographic factors

Four socio-demographic factors were identified as significantly associated with All-cause UHRs. These included age, socio-economic status, race/ethnicity, and type of insurance. Age was cited by five studies, but results were inconsistent. Three studies cited patients under 1-year-old were more likely to be readmitted (Kumar et al., 2019; Markham et al., 2019; Pershad et al., 2020), while the other two found teenage patients were at greater risk of UHRs (Ehwerhemuepha, Bendig, et al., 2018; Zhou, Della, et al., 2019). Patients of a family with lower socio-economic status were cited by two studies as a predictors of UHRs (Ehwerhemuepha, Bendig, et al., 2018; Kumar et al., 2019). In comparison, one study found patients with advantaged socio-economic status had 20% more chance to be readmitted in Western Australia (Zhou, Della, et al., 2019).

Patients of Native American or Hispanic ethnicity were also significantly associated with UHRs (Markham et al., 2019; Rodriguez et al., 2019). One Australian single site study reported patients who were admitted and used private health insurance as more likely to be readmitted (Zhou, Della, et al., 2019); while two American studies identified users of the government payer health insurance system as the predictor of UHRs (Markham et al., 2019; Pershad et al., 2020).

2.6.4.2 Clinical factors

Nine clinical factors were identified as risk factors of All-cause UHRs. The factors included comorbidities, previous usage of health services prior to index admission, date of index admission, type of index admission, LOS, principal diagnosis of index admission, date of index discharge, type of medication during index admission, and clinical decision making.

Patients with comorbidities, especially complex chronic conditions, were consistently cited by eight studies with odds ratio from 1.31 to 2.67 as more likely to be readmitted (Ehwerhemuepha, Finn, et al., 2018; Ehwerhemuepha et al., 2020; Kumar et al., 2019; Markham et al., 2019; Pérez-Moreno et al., 2019; Pershad et al., 2020; Taylor et al., 2020; Zhou, Della, et al., 2019). Emergency index admissions were cited as a readmission predictor by five studies (Ehwerhemuepha, Bendig, et al., 2018; Ehwerhemuepha, Finn, et al., 2018; Pérez-Moreno et al., 2019; Rodriguez et al., 2019; Taylor et al., 2020), but one study found elective index admission is associated with increased risk of readmission (Ehwerhemuepha et al., 2020).

Six studies identified patients with longer LOS at the index admission as more likely to be readmitted (Ehwerhemuepha, Bendig, et al., 2018; Ehwerhemuepha, Finn, et al., 2018; Ehwerhemuepha et al., 2020; Pershad et al., 2020; Taylor et al., 2020; Zhou, Della, et al., 2019). Patients discharged on Friday (Zhou, Della, et al., 2019) and weekend (Markham et al., 2019; Zhou, Della, et al., 2019) or in autumn (Ehwerhemuepha et al., 2020) were cited as a risk factors of 30-day UHRs.

Patients with ED visits, hospitalisation, and a 30-day readmission in the six months prior to the index admission were likely to be readmitted (Ehwerhemuepha, Finn, et al., 2018; Ehwerhemuepha et al., 2020; Taylor et al., 2020). Patients admitted on Friday were more likely to experience 30-day UHRs (Zhou, Della, et al., 2019). Patients with a specific principal diagnosis at the index admission had more chance of readmission, especially neoplasms (OR = 2.17; 95% CI [1.85–2.55]) (Ehwerhemuepha, Finn, et al., 2018; Ehwerhemuepha et al., 2020).

Type of medication (intrathecal or adrenergic agonist), rout of medication (intravenously), and at least one oral medication during index admission were also identified as risk factors of UHRs (Ehwerhemuepha et al., 2020). In addition, an American study reviewed 26 medical records of patients who were readmitted within 3 days of discharge. The doctors involved in readmitting the patients were interviewed. The study found doctors, who were unsure in decision making about the need for readmission, increase the patients' likelihood of experiencing UHR (Rodriguez et al., 2019).

2.6.5 Risk factors associated with surgical procedure related UHRs

A total of 18 types of significant risk factors were extracted from 38 studies. The four most frequently cited risk factors were complications during index admission (n = 13), comorbidity (n = 12), age (n = 11), and severity of illness (n = 9).

2.6.5.1 Socio-demographic factors

Six socio-demographic factors were significantly associated with surgical procedure related UHRs. Factors included age, gender, race/ethnicity, socio-economic status, type of insurance, and location of residence. Eleven studies cited age as a risk factors of UHRs following index surgical procedures. Of the eleven studies, ten studies identified patients younger than five years were more likely to be readmitted (Barakat et al., 2020; Bavishi et al., 2018; Benavidez et al., 2019; Hsueh et al., 2018; Janjua et al., 2019; Mahle et al., 2019; Marston et al., 2019; Roth et al., 2018; Russell et al., 2018; Valero et al., 2020). One study found patients younger than 13 years had 18% more chance of UHRs related to assault-related injury (Cortolillo et al., 2020).

Ethnicity were cited as a readmission predictor by six studies. Patients of Hispanic or African race had 2.5 more times to be readmitted (Benavidez et al., 2019; Cashen et al., 2020; Kogon et al., 2019; Mahle et al., 2019; Roth et al., 2018; Russell et al., 2018). From an insurance perspective five studies cited type of insurance as a risk factor of UHRs. Four studies identified either patients using government insurance or Medicaid were associated with increased (30% to 129%) risk of readmission (Benavidez et al., 2019; Janjua et al., 2019; Roth et al., 2018; Russell et al., 2018). One study, however, found patients using private insurance were likely to be readmitted (Cortolillo et al., 2020).

Patients of families earning median household income or living in medium metro country or small country were significantly associated with UHRs (Chew et al., 2020; Cortolillo et al., 2020; Wheeler et al., 2018). In addition, female patients were more likely to be readmitted than males for patients following trauma or appendectomy (Cortolillo et al., 2020; Valero et al., 2020), but one study found male patients experienced a greater chance of readmission following endoscopic retrograde cholangiopancreatography (Barakat et al., 2020).

2.6.5.2 Clinical factors

Twelve clinical factors were identified as risk factors of surgical procedure related UHRs and included comorbidities, previous usage of health services prior to index admission, hospital characteristics, type of index admission/surgical procedure, principal diagnosis/surgical procedure of index admission, surgical risk assessment, severity of illness, laboratory results, and complications during index admission, LOS, date of index discharge, and discharge disposition.

A total of thirteen studies found that patients, who developed complications during the index admission, had up to 163 times more chance of being readmitted (Benavidez et al., 2019; Blough et al., 2019; Cheon et al., 2019; Garcia et al., 2018; Hsueh et al., 2018; Janjua et al., 2019; Johnson et al., 2018; Kogon et al., 2019; Kulaylat et al., 2018; Lee, Fields, Boddapati, et al., 2020; Lee, Fields, McCormick, et al., 2020; Maddux et al., 2018; Zheng et al., 2019). The commonly reported inpatient complications were post-operative pulmonary complications, wound complications, or seizure.

Patients in nine studies with high severity of illness scores at index admission was cited as at risk of experiencing UHRs (Benavidez et al., 2019; Blough et al., 2019; Cortolillo et al., 2020; Janjua et al., 2019; Johnson et al., 2018; Kogon et al., 2019; Maddux et al., 2018; Mahle et al., 2019; Marston et al., 2019). Comorbidities, especially CCC, were also cited as risk factor of UHRs by twelve studies (Barakat et al., 2020; Berry et al., 2020; Chew et al., 2020; Cortolillo et al., 2020; Garcia et al., 2018; Kogon et al., 2019; Kulaylat et al., 2018; Lee, Fields, Boddapati, et al., 2020; Lee, Fields, McCormick, et al., 2020; Maldonado et al., 2018; Milford et al., 2019; Russell et al., 2018). The reported comorbidities included cardiac, endocrine, renal, haematology, and genetic syndromes. Prolonged LOS of index admission was also cited as a predictor of UHRs by nine studies (Cashen et al., 2020; Johnson et al., 2018; Kogon et al., 2019; Lee, Fields, Boddapati, et al., 2020; Maddux et al., 2018; Mahle et al., 2019; Valero et al., 2020; Wheeler et al., 2018; Zheng et al., 2019).

Ten studies identified patients, who underwent specific surgical procedures, are more likely to be readmitted. The procedures include ENT, Renal, 3rd degree burn, neurosurgical, trauma related procedures, or complicated abdominal surgeries (Delaplain et al., 2020; Egberg et al., 2020; Hsueh et al., 2018; Kulaylat et al., 2018; Maddux et al., 2018; Omling et al., 2020; Valero et al., 2020; Vedantam et al., 2018; Vivas et al., 2020; Wheeler et al., 2018). Patients assessed as high surgical risk had a four times greater likelihood to be readmitted (Benavidez et al., 2019; Cortolillo et al., 2020; Kogon et al., 2019; Kulaylat et al., 2018; Maddux et al., 2018; Vivas et al., 2020). The commonly used risk assessments were the American Society of Anaesthesiologists (ASA) class, Risk Adjustment for Congenital Heart Surgery (RACH), and wound classification.

An emergency admission requiring surgical intervention procedure was consistently cited by four studies as a risk factor of readmission (Benavidez et al., 2019; Kulaylat et al., 2018; Mears et al., 2019; Zheng et al., 2019) as did patients who had been discharged to care facilities or to home with/without services (Maddux et al., 2018; Russell et al., 2018). In addition, patients who left hospital against medical advice were 147% more likely to be readmitted (Cortolillo et al., 2020).

Patients with specific laboratory results, such as Galectin-3, tumorgenicity 2, N-terminal prohormone for congenital heart surgeries were associated with higher risks of readmission (Brown et al., 2019; Parker et al., 2019) as were patients who underwent cardiac surgery prior to the index admission (Kogon et al., 2019), were admitted to a medium beds hospital with approximate 2,000 hospitalisations annually (Cortolillo et al., 2020) or were discharged on a weekday following congenital heart operation (Kogon et al., 2019).

2.6.6 Risk factors associated with general medical conditions related UHRs

A total of 14 types of significant risk factors were extracted from ten studies. The most frequently cited risk factors were comorbidity (n = 7), age (n = 6), lower socio-economic status (n = 4), and higher levels severity of illness at the index admission (n = 3).

2.6.6.1 Socio-demographic factors

Five socio-demographic factors were significantly associated with general medical condition related UHRs. Identified factors included age, gender, race/ethnicity, socio-economic status, and environmental factors. Patients younger than three years had up to five times more likelihood of be readmitted (Ardura-Garcia et al., 2018; Burns et al., 2018; Okubo et al., 2018). One study found patients 12–18 years were significantly associated with

UHRs (Veeranki et al., 2018). Female gender was found by two studies associated with readmission for patients with asthma (Ardura-Garcia et al., 2018; Bhatt et al., 2020), but male patients with febrile seizure experienced higher rate of readmission (Okubo et al., 2018). Patients of African-American ethnicity were significantly associated with UHRs (Ardura-Garcia et al., 2018).

Low to median socio-economic status was identified as a predictor of UHRs by five studies (Ardura-Garcia et al., 2018; Awerbach et al., 2018; Bhatt et al., 2020; Okubo et al., 2018; Veeranki et al., 2018). In addition, two studies reported patients who utilised Medicare/government payer health insurance systems had a more than 4.79 greater chance of being readmitted.

Air quality was identified by two studies as a readmission predictor for patients with respiratory diagnoses. A recent study found elevated level of ozone and $PM_{2.5}$ concentration contributed 2% – 8% more likelihood of being readmitted (Beck et al., 2006). In addition, patients with passive smoke exposure had more than 4.55 times the chance of bronchiolitis related UHRs (Burns et al., 2018).

2.6.6.2 Clinical factors

Nine clinical factors were identified as risk factors of general medical condition related UHRs. The factors included, previous usage of health services prior to index admission, comorbidities, type of index admission, hospital characteristics, principal diagnosis of index admission, severity of illness, LOS, date of index discharge, and discharge disposition (the final place or setting to which the patient was discharged, i.e., home or community healthcare facilities).

Patients with pre-existing health conditions, especially chronic lung disease, had up to 12 times more likelihood of UHRs (Ardura-Garcia et al., 2018; Bhatt et al., 2020; Burns et al., 2018; Kessler et al., 2020; Leary et al., 2019; Wang et al., 2019; Wong et al., 2020). Patients with higher severity of illness were consistently cited by three studies as a risk factors of UHRs (Auger et al., 2019; Hong et al., 2019; Veeranki et al., 2018).

Emergency Department visits or hospitalisation in the six months prior to the index admission doubled the likelihood of readmission (Ardura-Garcia et al., 2018; Leary et al., 2019). Patients who take regular medications prior to the index admission were also four and half times more likely to be readmitted (Hong et al., 2019).

Readmission risk was doubled when their index admission was to either tertiary hospitals or urban hospitals (Bhatt et al., 2020; Veeranki et al., 2018). In addition, patients with hypertension or viral pneumonia who were admitted to a hospital were also significantly associated with UHRs (Awerbach et al., 2018; Wong et al., 2020). Patients with longer than two days of hospital stay at the index admission were 26–195% more likely to be readmitted (Kessler et al., 2020; Leary et al., 2019; Veeranki et al., 2018).

Patients discharged to community healthcare facilities (Leary et al., 2019; Veeranki et al., 2018) or sent home with arranged hospital in the home health care services (Kessler et al., 2020) were significantly associated with UHRs. In addition, patients whose caregiver discharged them against medical advice doubled the chance of readmission (Bhatt et al., 2020). Patients with medical admissions or discharged on a weekday were also more likely to be readmitted (Leary et al., 2019).

2.6.7 Summary

An updated electronic databases search was conducted examining risk factors associated with paediatric unplanned hospital readmission from 2018 to 2020 using the same search strategy as the published systematic review (Publication 3) in section 2.5. A total of 63 studies met the selection criteria, compared to 44 studies from 2000 to 2017, illustrating the rapid growing importance of this area in identifying paediatric patients at high risk of being readmitted following an initial index admission.

The additional included studies were reviewed and grouped into three health condition groups used in the previous systematic review of All-cause UHRs, Surgical procedure related UHRs, and General Medical Conditions related UHRs. Of the 63 included studies, 38 (60%) were pertinent to surgical procedure related UHRs, which is similar to the initial systematic review (20/44 studies). Nine studies reported model performance, compared to six in the published systematic review. Additionally, four studies from this updated literature review utilised machining learning analysis methods in the identification of risk factors.

A total of 25 different types of risk factors were extracted from the 63 included studies and reviewed as per health condition groupings. Overall, the top four frequently cited risk factors associated with paediatric UHRs across three groups are comorbidity (n = 27), age of patient at index admission/procedure (n = 22), complications during the index admission (n = 13), and severity of illness (n = 12), which differed from the previous systematic review results of comorbidity, public health insurance; longer LOS, and age of patients as the top four risk factors (Zhou, Roberts, et al., 2019).

In terms of variables impacting hospital-to-home transition process, two of the 63 included studies examined follow up planning (Kumar et al., 2019), transition of care information (Kumar et al., 2019; Rodriguez et al., 2019), readiness for discharge (Rodriguez et al., 2019), however, none of these variables were significantly associated with UHRs. Additionally, two studies examined the impact of parental health-literacy (Rodriguez et al., 2019) and English proficiency (Leary et al., 2019) on their child's UHRs, but the results were inconclusive.

Table 2.2

Characteristics of the 63 Included Studies Published in 2018 to 2020 on Risk Factors related to Paediatric UHRs

Reference	Medical Condition	Outcome measures	Study Design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data Analysis
				All-Cause Related (11)					
Ehwerhemuepha 2020 USA	All-cause	7-Day UHRs	Retrospective	A tertiary paediatric hospital Electronic medical records	50,241 patients	29 Days – 21 Years	2013–2017	4.46%	Least absolute shrinkage and selection operator (LASSO) regression AUC = 0.778
Pershad 2020 USA	All-cause	7-Day UHRs	Retrospective	An urban tertiary paediatric hospital & Pediatric Health Information System (PHIS) & Hospital's electronic medical record	17,707 admissions 13,642 patients	0–>18 Young adults	Oct 2012 – Sept 2015	2.3%	Generalised estimating equation (GEE)
Taylor 2020 USA	All-cause	3, 7, and 30-Day UHRs	Retrospective	Children's hospital association pediatric Health Information System (CHAPHIS) database	1,111,323 children 1,321,376 admissions	0–18 Years	2016–2017	1.6% (3-Day) 2.4% (7-Day) 4.4% (30-Day)	Gradient boosting tress (XGBoost) 30-Day AUC = 0.811 3-Day AUC = 0.771 7-Day AUC = 0.778
Pérez-Moreno 2019 Spain	All-cause Identification of early UHRs	30-day UHRs	Retrospective	Paediatric ward of a tertiary hospital Medical records	5,459 Patients	<16 Years	Jun 2012 – Nov 2015	4.1%	Cox regression model
Kumar 2019 India	All-cause	<15-; 15–30; 31–60 Day UHRs	Prospective	Paediatric department of a tertiary general hospital	6,179 Admissions	1 Months to 15 Years	Feb 2016 - Jan 2017	Overall 3.0%	t-Test Chi-Square Test

Reference	Medical Condition	Outcome measures	Study Design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data Analysis
				Medical records					
Markham 2019 USA	All-cause	30-Day UHRs	Retrospective	43 paediatric hospitals Administrative database	390,745 Hospitalisations	0–17 Years	Oct 2014 - Sep 2015	8.2%	Generalised linear mixed modelling
Rodriguez 2019 USA	All-cause	3-Day Preventable UHRs	Prospective	A tertiary children's hospital; Medical records & interview	121 Patients & 125 Readmission Cases	Not specified	20 July 2016 – 3 Feb 2017	48% preventable UHRs	t-Test Chi-Square Test Content analysis
Wolff 2019 Chile	All-cause	30-Day UHRs	Retrospective	A paediatric hospital Administrative cost coding system	56,558 Admissions	Mean = 5.78 ± 5.04	July 2011 – Oct 2017	3.72%	Support Vector Machines (SVM); Multilayer perception (MLP); Naıve Bayes Method (NB)
Zhou 2019 Australia	All-cause	30-Day UHRs	Retrospective	A tertiary paediatric hospital Inpatient electronic dataset	73,132 Patients	Mean = 6.3 ± 5.37 vs. 5.71±4.95 Years	2010–2014	4.55%	c-statistic = 0.645
Ehwerhemuepha 2018 USA	All-cause	30-Day UHRs	Retrospective	A tertiary paediatric hospital Medical records	38,143 Patients	29 Days to 18 Years	July 2013 – June 2017	10.4%	c-statistic = 0.86
Ehwerhemuepha 2018 USA	All-cause	7-Day UHRs	Retrospective	A tertiary paediatric hospital Medical records	19,702 Admissions	29 Days to 21 Years	Sept 2014 -Aug 2016	3.85%	Multivariable logistic regression

Reference	Medical Condition	Outcome measures	Study Design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data Analysis
Surgical Related (38)									
Barakat 2020 USA	Endoscopic retrograde cholangiopancreatography (ERCP)	30-Day UHRs	Retrospective	The National Inpatient Sample (NIS) and the National Readmission Database (NRD)	11,060 Patients	<20 Years	2005–2014	13.3%	Multivariable logistic regression
Berry 2002 USA	Hip reconstruction	30-Day UHRs	Retrospective	49 children's hospitals	3,753 Children with neurological CCC 4,058 Surgeries	4–19 Years	2015–2018	8.9%	Univariable analysis
Cashen 2020 USA	Fontan circulation/Cardiac surgery	1-Year UHRs	Retrospective	3 Institutions Chart review	297 Children	<15 Years	2009–2014	15%	Multivariable logistic regression
Chew 2002 USA	Airway surgery	30-Day UHRs	Retrospective	The NRD 22 states	10,289 Procedures over 7,210 Admissions	4.96±5.84 Years	2014	8.6%	Multivariable logistic regression
Cortolillo 2020 USA	Assault/ Trauma	1-Year UHRs	Retrospective	The NRD	46,294 Patients	<18 Years	2010–2014	11.4%	Multivariable logistic regression
Egberg 2020 USA	Total Abdominal Colectomy (TAC)	30-Day UHRs	Retrospective	The NSQIP-P	489 Hospitalisations of Children with ulcerative colitis	13–17 Years	2012–2017	19.4%	Multivariable logistic regression
Delaplian 2020 USA	Trauma	7-Day & 30-Day UHRs	Retrospective	28 Hospitals The Cerner Health Facts database	82,532 Patients 95,158 Admissions	<18 Years	2000–2017	21.14%	Mixed-effects regression 7- Day AUC = 0.737 30-Day AUC = 0.799
Lee 2020a USA	Spinal deformity surgery	90-Day UHRs	Retrospective	The NRD	2,856 Patients	<18 Years	2012–2017	17.6%	Multivariable logistic regression

Reference	Medical Condition	Outcome measures	Study Design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data Analysis
Lee 2020b USA	Fusion surgery for idiopathic scoliosis	30-Day & 90-Day UHRs	Retrospective	The NRD	30,677 Patients	10–18 Years	2012–2015	30-Day (2.9%) 90-Day (1.4%)	Multivariable logistic regression
Omling 2020 Sweden	Appendectomy	30-Day UHRs	Retrospective	The National Patient Register	38,939 Patients	<18 Years	2001–2014	1.9%	Multivariable logistic regression
Valero 2020 USA	Appendectomy	30-Day UHRs	Retrospective	The Colombia's Contributory Health System	21,674 Children	12.15±3.93 Years	July 2013-Sept 2015	1.5%	Generalised multilevel mixed model
Vivas 2020 USA	Spine deformity surgery	90-Day & 2-Year UHRs	Retrospective	A multicentre Database	218 Children	Mean = 14.2 Years	2008–2014	90-Day (8.7%) 2-Year (7.3%)	Multivariable logistic regression
Mahle 2019 USA	Heart transplantation	30-Day & 1-Year UHRs	Retrospective	Clinical Trials in Organ Transplantation Multi-institutions	227 Discharges	<14 Years	2 Jan 2011 – 31 Dec 2013	29.5%	Multivariable logistic regression
Marston 2019 USA	Choanal Atresia Repair	30-Day UHRs	Retrospective	The NSQIP-P database Multi-institutions	178 Children	Median Age 135 to 466 Days	2012–2015	15%	Univariate analysis
Mears 2019 UK	General Surgeries	30-Day UHRs	Prospective	A large general tertiary hospital Hospital Episode Statistics Software	2,616 Children 1,398 Elective 1,218 Emergency	<18 Years	2016	0.9%	t-test
Maldonado 2018 USA	Augmentation Cystoplasty	30-Day UHRs	Retrospective	The NRD (22 states /50% of all US hospitalisations)	1,873 Cases	≤ 18 Years	2010–2014	19.6%	Multivariable logistic regression
Zheng 2019 China	General Surgeries	30-Day UHRs	Retrospective	Paediatric general surgical department of a tertiary hospital Medical records	3,263 Patients	Mean UHR = 3.56± 3.73 Mean Control = 3.5 8±3.63 Years	July 2010 – June 2017	9%	Multivariable logistic regression
Evans 2019 USA	Tonsillectomy	30-Day UHRs	Retrospective	A tertiary children's hospital Medical records	427 Patients	24–42 Months	July 2014 – July 2017	0.94%	Chi-Square test Wilcoxon test

Reference	Medical Condition	Outcome measures	Study Design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data Analysis
Brown 2019 USA	Congenital Heart Surgery	30-Day UHRs	Prospective	A tertiary hospital via The society of Throacic Surgeons Congenital Heart Surgery Database	162 Patients	1–18 Years	2010–2014	13%	c-statistics = 0.802
Blough 2019 USA	Palatoplasty	30-Day UHRs	Retrospective	The Pediatric National Surgical Quality Improvement Program Database	3,616 Patients	Mean = 12.2 Months	2012–2015	2.4%	Multivariable logistic regression
Benavidez 2019 USA	Congenital Heart Surgery	30-Day UHRs	Retrospective	State Inpatient Databases (Washington, New York, Florida, and California)	8,585 Patients	<19 Years	2009–2011	11.3%	Generalised estimating equation
Kogon 2019 USA	Congenital Heart Surgery	30-day UHRs	Retrospective	The Society of Thoracic Surgeon Congenital Heart Surgery Database 100 centres	56,429 Patients	<18 Years	2014–2016	11%	Multivariable logistic regression
Parker 2019 Lebanon	Congenital Heart Surgery	30-day UHRs	Prospective	A tertiary children's hospital Medical records review	162 Patients	2 Years to 17.3 Years	2010–2014	12.9%	Multivariable logistic regression
Cheon 2018 USA	Low –risk skin and soft tissue surgery	30-Day UHRs	Retrospective	The American College of Surgeon's (ACS-NSQIP-P).	6,730 Patients	Mean = 6.70 ± 5.14 Years	2012–2014	0.61%	Multivariable logistic regression
Janjua 2019 USA	Spinal Cord Tumour Surgery	30- & 90-Day UHRs	Retrospective	The Nationwide Readmission Database	397 Patients	≤ 20 Years	2010–2015	10.8% (30-Day); 16.0% (90-Day)	LASSO analysis
Milford 2019 South Africa	Nissen fundoplication	1-Year UHRs	Retrospective	A children's hospital Medical records review	187 Patients	Mean = 28 Months	2004–2015	29%	Mann-Whitney U Test Chi-Square Test
Bavishi 2018 USA	Dilation of laryngotracheal stenosis	30-Day UHRs	Retrospective	The ACS-NSQIP-P	171 Endoscopic Vs 116 Open Procedures	0 – 17.6 Years	2015	Endo-7.6% Open-9.5%	Univariate logistic regression

Reference	Medical Condition	Outcome measures	Study Design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data Analysis
Garcia 2018 USA	Kasai procedure for biliary atresia	30-Day UHRs	Retrospective	The ACS-NSQIP-P	190 Patients	Mean = 62 Days	2010–2015	15.3%	Multivariable logistic regression
Hsueh 2018 Taiwan	Tonsillectomy	30-Day UHRs	Retrospective	The National Health Insurance Research Database	17,326 Patients	<18 Years	1997–2012	1.81%	Multivariable logistic regression
Johnson 2018 USA	Tonsillectomy/ Adenoidectomy	30-Day UHRs	Retrospective	The Nationwide Readmission Database (NDR)	9,079 Patients	<18 Years	2013	3.6%	Univariate logistic regression
Jiang 2018 USA	Urology surgery	30-Day UHRs	Not Defined	The NDR; The state Inpatient Database & The State Emergency Department Databased	8,006 – NDR 6,236 – SID/SEDD	<18 Years	Not Defined	Not Defined	AUC CCS – 0.63 VWI – 0.54 Rhee – 0.56
Kulaylat 2018 USA	All Surgery	30-Day UHRs	Retrospective	The NSQIP-P	130,274 Patients	<5 months till >12 Years	2013–2014	3.9%	Multivariable logistic regression
Maddux 2018 USA	Trauma	1-Year UHRs	Retrospective	The National Trauma Data Bank & The NSQIP	51,591 Patients	<18 Years	2007–2012	5.4%	Multivariable logistic regression
Markham 2018 USA	Orbital cellulitis	30-Day UHRs	Retrospective	The Pediatric Health Information System (PHIS)	1,828 Patients	2–18 Years	2007–2014	Not Defined	Chi-Square test
Russell 2018 USA	Tracheotomy	Not Defined	Retrospective	The PHIS – 48 hospitals	8,009 Patients	0–17 Years	2007–2013	36%	Cox-proportional hazard model
Roth 2018 USA	Hypospadias repair	30-Day UHRs	Retrospective	43 hospitals	45,264 Patients	Mean = 1.8 Years	2004–2015	1.2%	Logistic regression with fixed and random effects
Vedantam 2018 USA	Epilepsy surgery	30-Day UHRs	Retrospective	The NSQIP-P	280 Surgeries	0–18 Years	2015	7.1%	c-statistic = 0.71
Wheeler 2018 USA	Burn	30-Day UHRs	Retrospective	The NRD	11,940 Patients	1–17 Years	2013–2014	2.7%	Multivariable logistic regression

Reference	Medical Condition	Outcome measures	Study Design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data Analysis
Medical Related (14)									
Baek 2020 USA	Asthma	30-Day URHs	Retrospective	A children's hospital Hospital database	111 patients	5–18 Years	2010–2014	NA	Conditional logistic regression
Bhatt 2020 USA	Diabetic Ketoacidosis	30-Day URHs	Retrospective	The Nationwide Readmissions Database	87,815 Hospitalisations	2–18 Years	2010–2014	4.6%	Multivariable logistic regression
Kessler 2020 USA	Epilepsy	30-Day URHs	Retrospective	The Nationwide Readmissions Database	42,873 Admissions	1–17 Years	2013–2014	10.4%	Multivariable logistic regression
Wong 2020 Canada	RSV	30-Day URHs	Retrospective	The Alberta Health Services Discharge Abstract Database (Province Database)	10,212 Children with 10,967 Admissions	<5 Years	July 2004 – June 2017	4.2%	Cox proportional hazard model
Ardura-Garcia 2019 UK	Asthma	15-Day to 3-Year UHRs	Systematic Review	3 RCTs; 33 Observational studies; 5 Databases searched on 9th January 2017	44–37,267 Patients	0–20 Years	15Day to 3 Years Follow Up Period	Not specified	Not specified
Auger 2019 USA	Complex Medical Conditions	30-Day URHs	Retrospective	A tertiary children's hospital Medical records	Of 41,422 index hospitalisations – 595 pairs matched	<18 Years	2008–2012	9.4%	Multivariable logistic regression
Wang 2019 China	Mycoplasma Pneumoniae Pneumonia	90-day UHRs	Retrospective	Paediatric wards of a tertiary hospital Medical records	424 Hospitalisations	<14 Years	Jan 2016 - Feb 2017	11.3%	Multivariable logistic regression
Parikh 2018 USA	Asthma	30-Day UHRs	Prospective	Survey on 13 asthma-specific discharge components Multi-institutions	45 of 49 hospitals responded (92%)	5–17 Years	2015	5.7%	Chi-square test
Leary 2019 USA	Complex chronic conditions	30-Day UHRs	Retrospective	An academic medical centre Electronic health records	2,296 Index admissions	6 Months to 18 Years	Oct 2010 -July 2016	8.2%	c-statistic = 0.67

Reference	Medical Condition	Outcome measures	Study Design	Data source	Sample size	Age	Follow-up period	Proportion readmitted	Data Analysis
Hong 2019 USA	Neurology 44% UHRs<7days	7- & 30-Day UHRs	Retrospective	A large freestanding children's hospital Electronic medical records	923 Admissions	≤18 Years	2017	3.0% (7-Day); 6.9% (30-Day)	Multivariable logistic regression
Awerbach 2018 USA	Pulmonary hypertension	30-Day UHRs	Retrospective	The PHIS – 49 tertiary paediatric hospitals	13,580 Patients	<18 Years	2005–2014	26.3%	Multivariable logistic regression
Burns 2018 USA	Bronchiolitis	30-Day UHRs	Retrospective	A children's hospital Medical records review	299 Patients	<2 Years	Jan 2010 – May 2015	9.0%	Multivariable logistic regression
Okubo 2018 USA	Febrile seizure	Not Clearly Defined	Retrospective	The Nationwide Readmission Database (NRD) – 12 states	40,956 Patients	<6 Years	2010–2014	3.45 cases per 1000 person-months	Multivariable logistic regression; Cox proportional hazard model
Veeranki 2018 USA	Asthma	30-Day UHRs	Retrospective	The NRD	12,842 Patients	6–18 Years	2013	2.5%	Cox's proportional hazards model

Table 2.3

Examined Variables of Included 63 Studies and Significant Risk Factors Associated with Paediatric UHRs

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Ehwerhemuepha 2020 USA	All-cause	7-Day UHRs	Demographic (Sex, Race/Ethnicity, Age) Social determinants of health (Medical insurance type, Proportion of single parents by zip code, Proportion of vacant houses by zip code, Median income by zip code) Health care resource use (LOS/Index admission, Cumulative LOS/Previous 6Months, Previous UHR/6Months, Previous planned readmission/6Months, Previous hospitalisations/6Months, Types of index admission, Outpatient encounters/6Months, Previous ED visits/6Months, Catherisation, CT scans, and MRIs/Previous 6Months, Procedures/Previous 6Months, Devices or implants (Previous 6Moths) Diagnoses (ICD-10-CM code_22 listed) Severity of illness and acuity (ED index admission, CCI, Discharged from ICU, ICU Stay during index admission, No. of CCC, Average PEWS score, Pediatric Rothman Index scores (5 Criteria), Index visit catherisation, CT scans, and MRIs, Index visit procedures, Current or index visit devices or implants, Encounter type (inpatient versus observation), Average pain score) Medication classes (10 Listed) Medication route (6 listed) Other variables (Season of discharge, Day of week of discharge, Primary care no shows/Previous year), Primary care visit cancellation/Previous year)	LASSO regression model consists of: **Severity of illness** (Charlson comorbidities ≥ 2, CCC ≥ 1, No. Catheters, CT, MRI in previous 6Months, Surgical procedures previous 6Months, Rothman Index scores) **Health care resources use** (Previous hospitalisations ≥ 1), History of UHRs ≥ 1, History of planned readmission ≥ 1, LOS ≥ 3days, ED visits ≥ 2, Previous visits, Primary care no shows, Season of discharge_Fall, Planned admission_Yes, Cumulative LOS) **Diagnosis x 8** [Neoplasms (C00–D49), Conditions affecting ears and eyes (H00–H95), Health services (Z00–Z99), Heart diseases (I05–I09, I20–I52), Conditions from perinatal period (P00–P96), Blood and immune conditions (D50–D89), Malnutrition (E40–E46), Injury and poison (S00–T88)] **Medication** (No. Intrathecal medications, No. Adrenegic agonists) **Medication taken** via intravenous **No. Oral medications**
Pershad 2020 USA	All-cause	7-Day UHRs	Demographic (Age, Sex, Race/Ethnicity, Insurance payer, clinical (heart rate at discharge, the Paediatric Medical Complexity Algorithm (PMCA)Medical Complexity Algorithm, and hospital characteristics (length of stay (LOS) in days, surgical indicator, ICU flag, weekday versus weekend discharge)	LOS (OR = 1.03; 95%CI 1.01–1.04) Government insurance (OR = 1.35; 1.10–1.66) Complex Chronic (OR = 2.67; 95% CI 2.15–3.32) Neonatal (OR = 3.72; 95% CI 2.21–6.27) Infant (OR = 1.95; 95% CI 1.53–2.49) Toddler (OR = 1.29; 95% CI 1.01–1.64) Teenager (OR = 1.45; 95% CI 1.12–1.89)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Taylor 2020 USA	All-cause	3-, 7-, and 30-day UHRs	Demographic (Age, Sex, Ethnicity, Race, Insurance payer), Previous UHR prior to the index admission, Admission type, LOS, Had an infection, Had a surgical complication, Had a medical complication, PMCA, CCCs	Previous unplanned hospital readmission, ED Admission type at index admission, Medical complexity/CCC, LOS
Pérez-Moreno 2019 Spain	All-cause Preventable/ Eearly UHRs	<15-day UHRs	Age, Severity based on high-flow oxygen therapy or admission to the intensive care unit (ICU) during stay, Underlying disease, Emergency visits, Mean LOS, Respiratory admission, Gastrointestinal admission	Underlying disease (HR = 1.51; 95% CI 1.07–2.27) Emergency visits (HR = 1.66; 95% CI 1.11–2.48)
Kumar 2019 India	All-cause	<15- & 15–30 & 31–60 Day UHRs	Age, Sex, Kuppuswami scale, Local/migrant, Religion, Source of health information, Primary health care giver, Educational status of the mother, Birth order, Adequate breastfeeding, Length of stay (LOS), Comorbidities, PICU admission, Procedure during PICU admission, Follow-up planned, Follow-up in OPD or Special clinic OPD, follow-up explained to attendants in their own language, Danger signs explained	Lack of health information like television, Lower socio-economic status, Inadequate breastfeeding, Younger age, Migrants, Comorbidities (cardiac disease, anaemia, malnutrition, and global developmental delay)
Markham 2019 USA	All-cause	30-Day UHRs	Day of discharge, Age, Gender, Race/Ethnicity, Payer, Median household income quantile, Any CCC, Any Technology Dependence, Number of Chronic Conditions, Admitted through ED, ICU Stay	Weekend Discharge (OR = 1.12; 95% CI 1.09–1.14) Age 0–30days (OR = 1.21; 95% CI 1.13–1.30) Age 31–365days (OR = 1.39; 95% CI 1.33–1.45) Native American (OR = 1.18; 95% CI 0.93–1.50) Government Payer (OR = 1.04; 95% CI 1.01–1.07) Any CCC (OR = 1.26; 95% CI 1.22–1.30) Technology dependency (OR = 1.15; 95% CI 1.11–1.20) ≥ 1 to 5+ Chronic conditions (OR = 1.71 to 5.93; 95% CI 5.62–6.27) **Protective factors:** Age 5–9years (OR = 0.85; 95% CI 0.81–0.89) Age 10–14years (OR = 0.97; 95% CI 0.93–1.02) Admitted through ED (OR = 0.93; 95% CI 0.91–0.99)
Rodriguez 2019 USA	All-cause	3-Day Preventable UHRs	**Quantitative variables** LOS of index admission, Time between discharge and readmission, LOS of UHR; Date of initial discharge Age, Sex, Medical complexity (Previously healthy, simple past medical history, complex past medical history), Number of admissions in a year prior to study (0 to 4+), Health-literacy problem;	**Preventability:** Problems with clinical decision-making readmissions (P<0.001), Issues with the discharge process in readmissions (p=0.01), Clinically related admission and readmission (p=0.004) Weekday of initial discharge (p=0.02).

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
			Race/Ethnicity, COI – childhood opportunity index (a measure of education, health, environment, and economy based socio-economic status), Insurance; **Qualitative content analysis themes from physician responses** *Clinical factors:* Unclear diagnosis at the time of discharge, Discharging patient before clinically back to baseline, Unexplained changes in the patients clinical course after discharge, Unless patients are kept in the hospital unnecessarily, some readmissions will occur; *Factors related to a lack of consensus on discharge or readmission:* Family preference to be discharged influenced the primary team, Discharge based on subspecialty recommendations instead of primary-team opinion, Discharge between primary team and the ED providers on the necessity of readmission, Family preference to be readmitted influenced the primary team and ED providers **Qualitative content analysis themes from family responses** *Clinical factors:* Inadequate medical workup, Unclear diagnosis at the time of discharge, Clinical condition worsened at home, Discharge instruction *Factors related to a lack of consensus on discharge or communication:* Disagreement on readiness for discharge between the family and primary team, Poor communication	**Clinically unnecessary readmissions**: Hispanic ethnicity (p=0.02), Outside-hospital transfer (p=0.05) Problems with clinical decision-making (p=0.01). **Qualitative data highlighted:** Disagreement on readiness for discharge and the necessity of readmission among various providers and family
Wolff 2019 Chile	All-cause	30-Day UHRs	Administrative cost coding system (Age, Sex, Ethnic group, Anonymized geographical information/postal code, Public insurance plan, Principal diagnosis, Secondary diagnosis, Tertiary diagnosis, and Main procedure performed); Patient's admission (Date of admission, The service in which he/she was admitted, and His/her origin); Internal transfers (Date/hour, Service of origin and internal destination); Patient's discharge (Discharge date, Service that performs the discharge, Patient's destination)	Area Under the Curve: The NB: 0.654 The SVM: 0.597 The MLP1: 0.643 The MLP2: 0.539 NO SIGNIFICANT FACTOR is reported

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Zhou 2019 Australia	All-cause	30-Day UHRs	Age, Gender, Index admission status, Funding source for inpatients, Type of insurance, Source of referral transport, State/Territory of residence, Care type provided, economical social status, Interpreter service requirement, General anaesthetics (GA) at index admission, PICU at index admission, LOS, Day of index admission date, Day of discharge from index admission, Number of co-diagnoses	>16 years (OR = 1.46; 95% CI 1.07–1.98) Utilising private insurance as an inpatient (OR = 1.16; 95% CI 1.00–1.34) With greater socio-economic advantage (OR = 1.20; 95% CI 1.02–1.41) Admitted on Friday (OR = 1.21; 95% CI 1.05–1.39) Discharged on Friday (OR = 1.26, 95% CI 1.10–1.44) Discharged on Saturday (OR = 1.34, 95% CI 1.15–1.57) Discharged on Sunday (OR = 1.24, 95% CI 1.05–1.47) ≥ 4 Co-diagnoses (OR = 2.41; 95% CI 2.08–2.80) LOS ≥ 15 days (OR = 2.39; 95% CI 1.88–2.98) **Protective factors:** Aeromedical service (OR = 0.47; 95% CI 0.31–0.71) Had a procedure under GA during the index admission (OR = 0.67; 95% CI 0.64–0.76)
Ehwerhemuepha 2018 USA	All-cause	30-Day UHRs	Demographics/Socio-economic data (Sex, Race/ethnicity, LOS, Age, Median income by zip code/$10,000, Percent vacant houses by zip code, Percent single parent by zip code, Low income primary medical insurance); Resource use (Planned admission/Admitted through ED, ED visits within last 6 months, Previous inpatient visits within the last 6 months, History of 30-day readmission within last 6 months, Ambulatory resource use within last 6 months); Severity of illness/medical complexities (Charlson's comorbidities, Complex chronic conditions/CCC, ICU stay at the index admission); The paediatric Rothman Index -pRI (Vital signs, Laboratory results, Nursing assessment results that may be direct or proxy risk factors of readmission); 18 ICD-10-CM diagnosis Chapters	LOS 2–3 days (OR = 1.23; 95% CI 1.07–1.42) LOS 4–6 days (OR = 1.42; 95% CI 1.20–1.67) LOS>7 days (OR = 1.80; 95% CI 1.51–2.14) 1 ED visits in last 6 month (OR = 1.27; 95% CI 1.11–1.45) ≥ 2 ED visits in last 6 month (OR = 1.30; 95% CI 1.12–1.50) 1 Previous admission in last 6 month (OR = 1.86; 95% CI 1.59–2.17) ≥ 2 Previous admission in last 6 month (OR = 2.39; 95% CI 1.94–2.94) 1 History of 30-day readmission in last 6 month (OR = 1.27; 95% CI 1.06–1.53) ≥ 2 History of 30-day readmission in last 6 month (OR = 2.75; 2.19–3.44) Admitted through ED (OR = 1.15; 95% CI 1.02–1.29) 1 CCC (OR = 1.63; 95% CI 1.42–1.87) ≥ 2 CCC (OR = 1.66; 95% CI 1.43–1.92)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
				18 ICD-10-CM diagnosis Chapters Neoplasms (OR = 2.17; 95% CI 1.85–2.55) Blood and/or immune (OR = 1.30; 95% CI 1.14–1.48) Nervous, eye, ear, and/or mastoid (OR = 1.21; 1.08–1.37) Circulatory disease (OR = 1.33; 95% CI 1.14–1.56) Health status and/or services factor (OR = 1.20; 1.06–1.35) **Protective factors** Planned index admission (OR = 0.65; 95% CI 0.52–0.82) pRI of 10 percent increment (OR = 0.86; 95% CI 0.81–0.90) Maximum pRI occurred last 24 hours of hospitalisation (OR = 0.85; 95% CI 0.75–0.95) Diagnosis Chapter of Respiratory disease (OR = 0.75; 95% CI 0.66–0.85) Diagnosis Chapter of External morbidity causes (OR = 0.64; 95% CI 0.45–0.89)
Ehwerhemuepha 2018 USA	All-cause	7-Day UHRs	Demographic (Sex, Age, Race/Ethnicity), Type of health insurance as payer, Acute/emergent admission, Number of previous emergency department (ED) visits within the last 6 months, LOS, Preregistration status, Registered dietitian (RD) diagnosis of malnutrition; LACE Readmission model variables (LOS, Acute and/or emergent admission, The Charlson's Comorbidity Index Score, and Number of ED visits in the previous 6 months (excluding visits that resulted in hospitalisation)	Older age (OR = 1.03; 95% CI 1.02–1.04) Malnutrition (OR = 1.84; 95% CI 1.39–2.39) **LACE variables** Longer LOS (OR = 1.33; 95% CI 1.28–1.37) Acute/Emergent admission (OR = 1.10; 95% CI 1.05–1.16) Comorbidity (OR = 1.31; 95% CI 1.25–1.37) ED visit in the previous 6 month (OR = 1.23; 95% CI 1.15–1.32)
		Surgical Related		
Barakat 2020 USA	Endoscopic retrograde cholangiopancreatography (ERCP)	30-Day UHRs	Age, Sex, Race/ethnicity, Hospital region, Teaching status, Elective procedure status, LOS, Comorbidities (obesity, diabetes) and history of liver transplantation, Type of ERCP procedure, Primary cause for hospitalisation	Male (OR = 1.17; 95% CI 1.16–1.18) Age/0–4 years (OR = 1.95; 95% CI 1.93–1.97) Age/5–9 years (OR = 1.13; 95% CI 1.10–1.15) Comorbidity/Obesity (OR = 1.10; 95% CI 1.07–1.14) History of liver transplant (OR = 2.01; 95% CI 1.79–2.25)
Berry 2002 USA	Hip reconstruction	30-Day UHRs	Underlying neurological CCCs, No. Co-occurring chronic conditions; Demographic characteristics (Sex, Age at admission, Payer, Ethnicity); Clinical characteristics (Side of surgery, Site of surgery)	≥4 co-existing chronic conditions (Increased by 250%, p<0.001)

Reference	Medical Condition	Outcome measures	Examined Variables	**Significant Risk Factors** **All-Cause Related**
Cashen 2020 USA	Fontan circulation/Cardiac surgery	1-Year UHRs	Age, Weight, Sex, Race/Ethnicity, Institution/Centre site, Cardiac lesion, Comorbidities, Operative procedures prior to the completion Fontan procedure, Operative details (Type of Fontan procedure, Presence of fenestration, Additional surgical procedures during the Fontan operation including Pulmonary arterioplasty, Atrial septectomy, Tricuspid valvuloplasty, Repair of superior vena cava stenosis, Aneurysm repair, Aortic valve repair, Maze procedure); post-operative complications, durations of ICU and hospital stay, Discharge medications, Discharge echocardiogram findings; ED visits post-discharge (Chief complaint, <= Admitting diagnosis, treatment, and disposition)	Centre B (OR = 6.1; 95% CI 2.3–16.3) Centre C (OR = 2.3; 95% CI 0.7–7.0) African-American/Black (OR = 2.5; 95% CI 1.0–6.0) Post-operative LOS ≥ 14 days (OR = 3.3; 95% CI 1.5–6.9)
Chew 2020 USA	Airway Surgery	30-Day UHRs	Age, Gender, Patient residency location, Type of insurance, Median household income of patient zip code, Teaching hospital status, No. Comorbid diagnoses, No. CCC, No. procedures,	No. Diagnosis (OR = 1.02; 95% CI 1.00–1.03) No. CCC (OR = 1.13; 95% CI 1.09–1.16) Quartile 1 median household income per zip code (OR = 1.2; 95% CI 1.02–1.41)
Cortolillo 2020 USA	Assault/Trauma	1-Year UHRs	Ownership of hospital, Age, Injury mechanism, Injury servery (ISS), Hospital characteristics (Bed size, Teaching), Median household income, Payer, Discharge disposition, CCCs	<13 Years (OR = 1.18; 95% CI 1.10–1.28) Females (OR = 1.43; 95% CI 1.34–1.52) Firearm injury (OR = 2.5; 95% CI 2.10–2.97) ISS>15 (OR = 1.29; 95% CI 1.20–1.38) Medium beds hospital (OR = 1.61; 95% CI 1.43–1.82) Median household income $64K (OR = 1.85; 95% CI 1.70–2.03) Private insurance (OR = 1.12; 95% CI 1.13–1.3) Left hospital against medical advice (OR = 2.47; 95% CI 1.66–3.68) CCC>1 (OR = 1.14; 95% CI 1.03–1.27) **Protective factors** Investor-owned hospital (OR = 0.79; 95%CI 0.67–0.93) Penetrating (OR = 0.38; 95& CI 0.32–0.44) Large bed size hospital (OR = 0.84; 95% CI 0.75–0.94) Metropolitan teaching hospital (OR = 0.64; 95% CI 0.58–0.7) Non-metropolitan hospital (OR = 0.54; 95% CI 0.41–0.72) $48,000–$63,999 household income (OR = 0.89; 95% CI 0.81–0.97)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Egberg 2020 USA	Total Abdominal Colectomy (TAC)	30-Day UHRs	**Patient-related variables (**Age at index surgery, Sex, Weight, Race, Ethnicity); **Surgery-related variables** (Duration of operation (hours), Time under anaesthesia (hours), Paediatric-trained surgeon (Y/N), Procedural approach, Case/admission type, Procedure type (TAC vs TAC + proctocolectomy); **Patient variables associated with the surgical hospitalisation** (Prior steroid exposure within 30 days of the index procedure, Blood transfusion within 48 hours of surgery, Preoperative laboratory values/albumin, hematocrit, and platelets, LOS of index surgical admission	TAC + Proctectomy (AOR = 2.4; 95% CI 1.1–5.2)
Delaplian 2020 USA	Trauma	7-Day & 30-Day UHRs	**Demographics** (Age, Sex, Race/Ethnicity); **Proxy of social determinants of health** (Health insurance/payer); Source of admission, and resource utilisation (LOS, History of ED use, History of hospitalisations, History of the past readmissions within the preceding 6 months); **Surgical procedures** (Auditory, Cardiovascular, Digestive, Haematologic, Lymphatic, Integumentary, Musculoskeletal, Nervous, Respiratory, Urinary/reproductive systems); **No. medications administered during the Hospitalisation**	LOS>4 days (OR = 1.25–1.51) No. Previous visits ≥ 1 (OR = 1.94–2.44) Previous ED visits ≥ 3 (OR = 1.33) No. Previous readmission ≥ 1 (OR = 1.46–2.54) Type of index admission/Elective readmission from a prior visit (OR = 1.474) Traumatic injury/Poisoning (OR = 1.242) Traumatic injury/Complications of surgical/medical care (OR = 1.20) **Protective factors** Traumatic injuries (Thorax, Knee, Lower leg, Hip/thigh, Elbow/forearm, Shoulder/upper arm)
Lee 2020a USA	Spinal deformity surgery	90-Day UHRs	Age, Sex, Comorbidities (15 CCC listed), Insurance, Income percentile, Surgical factors, Hospital ownership, Hospital teaching status	Pre-existing pulmonary disease (OR = 1.5) Obesity (OR = 3.4) Cachexia (OR = 27) Non- teaching hospital (OR = 3.5) inpatient return to operating room (OR = 1.9) LO S>8 days (OR = 1.5);

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Lee 2020b USA	Fusion surgery	30-Day & 90-Day UHR	Demographics (Age, Sex, Income percentile, Primary payer); Comorbidities 17 CCC listed); Surgical characteristics (Blood transfusion, Autograft, BMP use, Osteotomy, Fusion levels); Hospital characteristics (Teaching status/location)	**30-Day UHR** LOS>5 days (OR = 1.8; 95% CI 1.6–2.2) Anaemia (OR = 2.0; 95% CI 1.6–2.5) Hypothyroidism (OR = 3.0; 95%CI 2.0–4.5) Fluid & electrolyte disorders (OR = 1.8; 1.5–2.3) Obesity (OR = 2.9; 95% CI 2.2–4.0) Chronic use of anticoagulants (OR = 7.0; 95% CI 3.0–16.4) Intraop dural tear (OR = 2.7; 95%CI 1.6–4.7) Index stay complication: SIADH (OR = 4.7; 95% CI 2.6–8.4) **31–90Day Readmission** LOS>5 days (OR = 2.8; 95% CI 2.2–3.6) Obesity (OR = 3.6; 95% CI 2.3–5.6) Chronic use of anticoagulants (OR = 29.7; 95% CI 12.8–66.7) Index stay complication: SMA (OR = 24.7; 95% CI 9.4–25.3)
Omling 2020 Sweden	Appendectomy	30-Day UHRs	Type of appendicitis, Type of treatment/procedure, Gender, Age, Year of diagnosis	Complicated appendicitis (AOR = 5.5; 95% CI 4.08–5.53)
Valero 2020 USA	Appendectomy	30-Day UHRs	Age, Sex, Type of surgery, Comorbidities (11 listed), Geographic region/Place of procedure, Insurer.	Age younger than 1 year (Other categories OR<1.0) Female (OR = 1.53; 95% CI 1.22–1.91) Laparoscopic surgery (OR = 1.80; 95% CI 1.21–2.69) Appendectomy with peritoneal drainage (OR = 1.69; 95% CI 1.30–2.19) Surgeries performed in the Atlantic, Pacific and ‘‘other departments’’ (OR = 2.07–3.00)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Vivas 2020 USA	Spine deformity surgery	90-Day & 2-Year UHRs	Demographic information (Age, BMI, Gender) Comorbidities (Intellectual disability, Verbal communication, Cross motor function classification, Institutionalised, Epilepsy, Feeding status, Activity level) Surgical procedure (Surgical time, Estimated blood loss, EBL per blood volume, levels fused, Pre-op Halo, Intra-op Halo, Fusion to pelvis, Surgical approach/instrumentation, Staged procedure, Rod type) Hospitalisation characteristics (LOS, Length of ICU, Intubation); Radiographic characteristics (Pre-op curve type, Risser score, Triradiate cartilage, Preop imaging/7 listed, Postop imaging) CP CHILD questionnaire data (Actiniteis of daily living/personal care, Positioning, transferring and mobility, Comfort and emotions, Communication and social interaction, Health, Overall QOL, Total score) Surgical and nonsurgical indications (Infection, Gastrointestinal issues, Instrumentation failure, Medical causes, Neurological complaints, Pain, Pulmonary complications, Need for reoperation)	$p<0.10$ for 90-Day UHR Operative time/Minute increases 0.7% readmission Decreased lumbar lordosis/Degree increases 2% readmission **Protective factor** Tolerating Oral feeds
Mahle 2019 USA	Heart transplantation	30-Day & 1-Year UHRs	Age at transplant, LOS, the United Network for Organ Sharing (UNOS) status code (UNOS status), Sex, Ethnicity	Infant (OR = 1.61; 95% CI 1.26–2.07) LOS/30day (OR = 1.30; 95% CI 1.16–1.44) UNOS Status 1B/2 (OR = 1.67; 95% CI 1.21–2.3) Hispanic or Latino (OR = 1.45; 95% Ci 1.06–1.24)
Marston 2019 USA	Choanal atresia repaired	30-Day UHRs	Age, Ventilator dependency, Oxygen support, Cardiac risk factors, Esophagus/GI disease, Development delay, Steroid use, Nutritional support	Age $\leq$ 10 days (OR = 3.1; 95% CI 1.1–9.1) Ventilator dependence among the non-syndromic cohort (OR = 5.46; 95% CI 1.9–15.6)
Mears 2019 UK	General Surgeries	30-Day UHRs	Elective admission vs. Emergency admission	The emergency cohort UHRs was 1.5% compared to 0.4% in the elective cohort, 4times higher (p = 0.002)
Maldonado 2018 USA	Augmentation Cystoplasty	30-Day UHRs	Age, Sex, Primary Diagnosis, Payer, Median household income quartile for zip code, Number of CCCs, Elective index admission, LOS, Discharge destination, Hospital characteristics (Bed size, Ownership, Annual case volume, Safety-net hospital)	Indication of neurogenic bladder (OR = 3.82; 95% CI 1.03–14.20)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Zheng 2019 China	General Surgeries	30-Day UHRs	Age, Sex, Operative time (minutes), Operative blood loss (ml), Emergency surgery, Initial surgery-related risk level, ASA classification, Surgeon level, Operation on weekend, Time of case start, Contaminated or dirty wound, Major complications, The initial hospital LOS	Emergency surgery (OR = 2.73; 95% CI 1.35–6.19) Major complications (OR = 2.43; 95% CI 1.12–4.71) The initial hospital LOS (OR = 3.46; 95% 1.67–7.53)
Evans 2019 USA	Tonsillectomy	30-Day UHRs	Demographics (Gender, Age); Body habitus (Height, Weight); Comorbidities; Oral intake; Medication usage (IV steroids, IV narcotics, Oxygen therapy); Attending physician, Distance from the hospital, Payer	Inconclusive
Brown 2019 USA	Congenital heart surgery	30-Day UHRs	Age, gender, Weight, prematurity, Mortality category (STAT level), Prior cardiothoracic operation, Non-cardiac congenital anatomic abnormality, Chromosomal abnormality or syndrome, Pre-operative factors; Pre & Post-operative biomarkers	Clinical model alone ROC of 0.617 Pre-operative biomarkers ROC of 0.754 Pre- & post-operative biomarkers ROC of 0.802 Prior cardiothoracic operation (p=0.031) Pre-operative factor (p=0.001) Higher STAT category (p=0.003) **Pre-OP Soluble suppression of tumorgenicity 2** OR = 1.66; 95% CI 1.16–2.37 vs. Clinical model + biomarker OR = 1.85; 95% CI 1.02–3.36 **Post-OP Soluble suppression of tumorgenicity 2** OR = 2.26; 95% CI 1.36–3.75 vs. Clinical model + biomarker OR = 1.74; 95% CI 1.63–4.76 **Post-OP Galectin-3** OR = 2.12; 95% CI 1.02–4.37 vs. Clinical model + biomarker OR = 1.72; 95% CI 0.67–4.38 **Post-OP N-terminal prohormone of brain natriuretic peptide** OR = 1.19; 95% CI 0.94–1.51 vs. Clinical model + biomarker OR = 1.07; 95% CI 0.72–1.59
Blough 2019 USA	Palatoplasty	30-Day UHRs	Age, Weight, Total procedural relative value unit, Operation time, ASA classification, Ventilator dependence, Other airway problem, Tracheotomy, Oesophageal, gastric, intestinal disease, Bronchopulmonary dysplasia/CLD, Cardiac risk factors, Previous cardiac surgery, Cognitive issue, CVA/TBI, Neuromuscular disorder, Steroid dependence, Hematologic disorder, Failure to thrive/weight loss, Nutritional support, Additional ventilation requirement, Wound heading complication, LOS	Requiring nutritional support (OR = 2.6) Unplanned reoperation (OR = 63.6)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Benavidez 2019 USA	Congenital Heart Surgery	30-Day UHRs	Patient-level characteristics (age, sex, race, household income, insurance status, genetic syndromes, co-morbidities, RACHS (1–4+) Surgical risk category, and complication) and admission characteristics (weekend admission, urgent/emergent admission, and high resource use – HRU)	Age ≤ 1 year (AOR = 1.4; 95% CI 1.1–1.9) Hispanic (AOR = 1.2; 95% CI 1.01–1.4) Government insurance (AOR = 1.3; 95% CI 1.1–1.7) Emergent admission (AOR = 2.0; 95% CI 1.6–2.3) RACHS 3 (AOR = 2.4; 95% CI 1.7–3.3) RACHS 4+ (AOR = 2.0; 95% CI 1.3–2.9) Complication during index admission (AOR = 1.3; 95% CI 1.1–1.5) High resource use during index admission (AOR = 1.4; 95% CI 1.0–1.9)
Kogon 2019 USA	Congenital Heart Surgery	30-Day UHRs	**Preoperative characteristics** Age, Age at surgery, Sex, Race, Hispanic ethnicity (Y/N), Weight at surgery (kg), Prematurity, Any Chromosomal abnormalities or genetic syndromes (Y/N), Any preoperative risk factors, Mechanical ventilator support, Mechanical circulatory support, Any form of insurance. **Operative Characteristics** Operation type (Cardiopulmonary bypass – CPB vs. No CPB), CPB time, STAT mortality score/procedural complexity (Society of Thoracic Surgeons/European Association for Cardio-Thoracic Surgery), Postoperative LOS, Any postoperative complication, Major morbidity Date of discharge	Non-cardiac abnormalities (AOR = 1.24) Chromosomal abnormalities or genetic syndromes (AOR = 1.24) Preoperative mechanical circulatory support (AOR = 1.36) Other preoperative factors (AOR = 1.21) Prior cardiac surgery (AOR = 1.31), Hispanic ethnicity (AOR = 1.13), Higher STAT level 3–5 (AOR = 1.22 to 2.62) Prolonged postoperative LOS (AOR = 1.07 per day from 0 to 14 days; AOR = 1.01 per week>14 days), Major complication (AOR = 1.27), Other postoperative complications (AOR = 2.00) Discharge on a weekday (AOR = 1.07) **Protective factors** Premature Neonates (AOR = 0.79; 95% CI 0.68–0.93) Weight among non-premature neonates (AOR = 0.86; 95% CI 0.77–0.93)
Parker 2019 Lebanon	Congenital Heart Surgery	30-Day UHRs	Biomarkers: Galectin-3 & ST2; Age, Gender, Weight, Prematurity, the Society of Thoracic Surgeons (STAT) level, Comorbidities, Prior cardiac surgery, Persistent shock at the operation, mechanical ventilation usage	Galectin-3 Postoperative mid-tercile (AOR = 6.17; 95% CI 1.50–25.43) ST2 Post-operative Highest tercile (AOR = 4.98; 95% CI 1.06–23.32)
Cheon 2018 USA	Low –risk skin and soft tissue surgery	30-Day UHRs	Age, Sex, Race/ethnicity, Surgical specialty, ASA (American Society of Anaesthesiologists physical status classification), Gestational age, Nutritional status, Co-morbidities, Postoperative complications	Postoperative pulmonary complication (OR = 22.52; 95% CI 2.82–57.44) Postoperative wound complication (OR = 163.56; 95% CI 27.62->999.99)

Reference	Medical Condition	Outcome measures	Examined Variables	**Significant Risk Factors** **All-Cause Related**
Janjua 2019 USA	Spinal Cord Tumour Surgery	30-Day UHRs & 90-Day UHRs	Patient demographic data including Age, Gender, Payer status, and Median household income quartile – zip code; The admission and hospital characteristics included Admission type (non-elective vs. elective), Hospital bed size (small or medium vs. large), Total annual hospitalisations per hospital, Hospital type (metropolitan non-teaching vs. metropolitan teaching), and Hospital location (large metropolis with >1 million residents vs. small metropolis with <1 million residents). Tumour location, and tumour characteristics (malignant vs. benign) were determined using the ICD diagnosis and procedure codes. Complications; The all patient refined DRG (APR-DRG) severity of illness score	**30-Day UHRs** Age<5 years (OR = 2.97) Medicaid (OR = 3.30) Malignant tumour (OR = 2.78) APR-DRG severity of illness score of 3 or 4 (OR = 5.79) APR-DRG risk of mortality score>1 (OR = 3.87) **90-Day UHRs** Age<5 years (OR = 2.21) Medicaid (OR = 2.29) Malignant tumour (OR = 1.92) APR-DRG severity of illness score of 3 or 4 (OR = 4.18) APR-DRG risk of mortality score>1 (OR = 2.76) Any complication during index admission (OR = 1.88) Major complication during index admission (OR = 2.55)
Milford 2019 South Africa	Nissen fundoplication	1-Year UHRs	Underlying medical conditions, Age, Weight, Presence of malnutrition, Length of hospital, Type of Surgery	Comorbidity of Cardiac disease and Oesophageal atresia
Bavishi 2018 USA	Dilation of laryngotracheal stenosis	30-Day UHRs	Age, Tracheostomy status, Prematurity, Sex, Race, Congenital malformations, Prior cardiac surgery, Underlying pulmonary disease, Immune disease, Brain disease, GI disease, Cardiac disease	Endoscopic procedure: Age<1 Year (OR = 4.21) – 95% CI is not reported
Garcia 2018 USA	Kasai procedure for biliary atresia	30-Day UHRs	Age, Gender, Race/Ethnicity, Prematurity, Preoperative comorbidities from the NSQIP-P were grouped t by systems, Preoperative laboratory values, Operative factors (Operative time, ASA class, Perioperative blood transfusion, Postoperative LOS, 30-day postoperative complication	Prematurity (OR 3.88; 95% CI 1.08–13.95) 30-day complication event (OR 4.09; 95% CI 1.41–11.87)
Hsueh 2018 Taiwan	Tonsillectomy	30-Day UHRs	Gender, Age, Hospital level, Indication of procedure (infection, OSA, tumour), Comorbidity, other ENT procedures, Usage of NSAIDs, Usage of steroid	Age 0–2.9 Years (OR = 2.70; 95% CI 1.60–4.54) Age 3–5.9 Years (OR = 1.61; 95% 1.23–2.10) Indication of procedure-OSA (OR = 1.36; 95% CI 1.08–1.73) Indication of procedure-Tumour (OR = 11.73; 95% CI 4.93–27.91) NSAIDs use (OR = 1.61; 95% CI 1.26–2.07)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Johnson 2018 USA	Tonsillectomy ± Adenoidectomy	30-Day UHRs	Age, Gender, Primary payer, Median income by zip code, Indications for surgery (OSA, tonsillitis), Haemorrhage complicating the procedure, Respiratory complications, any complication of medical or surgical care, respiratory intubation and mechanical ventilation	Postop complication of care (OR = 3.3; 95% CI 1.5–7.3) Intubation & mechanical ventilation (OR = 4.0; 95% CI 1.30–12.4) LOS (OR = 1.03; 95% CI 1.00–1,06)
Jiang 2018 USA	Urology surgery	30-Day UHRs	Age, Gender, Primary payer, WWI, CCI, Rhee, Specific procedure	NO SIGNIFICANT FACTOR is reported Focus is on the model performance
Kulaylat 2018 USA	All Surgeries	30-Day UHRs	Age, Sex, Race, Comorbidities, ASA, Wound classification, Operative details, Specialty, Pre-op or Post-op complications	ASA-Server (OR = 1.63; 95% CI 1.5–1.77) ASA-Life threatening (OR = 1.29; 95% CI 1.07–1.54) Wound classification-Clean-contaminated (OR = 1.37; 95% CI 1.24–1.51) Wound classification-Dirty (OR = 1.95; 95% CI 1.68–2.26) Urgent/Emergent operation (OR = 1.37; 95% CI 1.26–1.48) Preoperative complication (OR = 1.24%; 95% CI 1.12–1.38) Postoperative complication (OR = 22.87; 95% CI 20.87–25.06) Comorbidity: Endocrine, Cardiac, GI, CNS, Renal, Haematology, Immunosuppressive, Nutritional (OR = 1.17 – 1.86) Neurosurgery (OR = 2.05; 95% CI 1.8–2.32) **Protective factors** Age<5 months (OR = 0.76; 95% CI 0.67–0.85) Age 6–12 Years (OR = 0.86; 95% CI 0.78–0.94) Specialty of Orthopaedics, Urology, ENT, Plastic surgery (OR = 0.38–0.69)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Maddux 2018 USA	Trauma	1-Year UHRs	Demographics (Age, Gender); Injury group (Non-traumatic brain injury/TBI, TBI, TBI + other); Injury mechanism, Any burn, Injury severity, Index hospitalisation stay (ICU, LOS); Index hospitalisation events (Intracranial pressure-ICP monitor, craniotomy, seizure, cardiac arrest); Index hospitalisation treatment (RBC transfusion, Benzodiazepine, Narcotics, Neuromuscular blockade, Vasoactive); Disposition	Inflicted injury (OR = 1.37; 95% CI 1.22–1.53) Injury severity-Head/neck Abbreviated Injury Scale, per point (OR = 1.09; 95% CI 1.03–1.15) Admitted to ICU during index admission (OR = 1.19; 95% CI 1.07–1.33) LOS, per day (OR = 1.03; 95% CI 1.03–1.03) Seizure during index admission (OR = 2.35; 95% CI 2.03–2.74) Had RBC transfusion (OR = 1.72; 95% CI 1.48–2.01) Discharged to Home with services (OR = 1.74; 95% CI 1.21–2.49) Discharged to care facility (OR = 1.62; 1.21–2.16) **Protective factors** Age, per year (OR = 0.98; 0.97–0.99) Only TBI (OR = 0.82; 95% CI 0.69–0.98) Motor vehicle injury (OR = 0.83; 95% CI 0.73–0.94) With Burn (OR = 0.80; 95% CI 0.64–1.00)
Markham 2018 USA	Orbital cellulitis	30-Day UHRs	Age, Sex, Race/ethnicity, Primary payer, Season, Region, Surgical intervention, PICC stay, ICU stay, CMI (relative weight assigned to each discharge on the basis of the ARP-DRG SOI)	No significant statistical findings
Russell 2018 USA	Tracheotomy	Not defined	Age, Gender, Race/ethnicity, Primary payer, Disposition, Discharge season, Number of CCC, Specific CCC, Risk adjustment for congenital heart surgery (RACHS) score, Underlying medical conditions associated with tracheostomy, Other underlying medical conditions	Age<30 days (AHR = 1.32; 95%CI 1.11–1.58) Hispanic race/ ethnicity (AHR = 1.34; 95%CI 1.20–1.50) Government insurance (AHR = 1.21; 95%CI 1.10–1.33) >2 CCC (AHR = 1.96; 95%CI 1.34–2.86) Discharge to home (AHR = 1.19; 95%CI 1.08–1.32 **Protective factors** Trauma diagnosis at tracheotomy (AHR = 0.83; 95%CI 0.69–1) Ventilator dependency (AHR = 0.88; 95%CI 0.81–0.97)
Roth 2018 USA	Hypospadias repair	30-Day UHRs	Age at initial operation, Insurance status, Race/ethnicity, Presence or absence of readmission or reoperation within 30 days, Presence of repeat hypospadias repair (same ICD-9 code), and presence or absence of another urethral operation	Age of 1–2 Years (OR = 1.46; 95%CI 1.21–1.76) Age of 3–5 Years (OR = 1.69; 95%CI 1.24–2.29) Black race (OR = 1.34; 95%CI 1.04–1.71) Hispanic (OR = 1.41; 95%CI 1.07–1.86) Medicaid (OR = 1.24; 95%CI 1.02–1.50)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Vedantam 2018 USA	Epilepsy surgery	30-Day UHRs	Age at surgery, Gender, Race, ASA classification, LOS, Weight category, Comorbidities, Procedures, Disposition	Hemi-spherectomy (OR = 4.11; 95% CI 1.48–11.42) **Protective factors** Female (OR = 0.34; 95% CI 0.12–0.99)
Wheeler 2018 USA	Burn	30-Day UHRs	Age, Gender, Household income by zip code, Primary payer, Patient location/residence, Number of CCC, The total body surface area (TBSA) %, Burn degree, Burn site/s, Severity of illness based on DRG, Burn mechanism, LOS, Major surgical procedure	TBSA ≥ 10% (AOR = 1.81; 95% CI 1.18–2.79) 3rd degree burn (AOR = 2.68; 95% CI 1.69–4.24) Index LOS of 2–3 days (AOR = 1.72; 95% CI 1.72; 95% CI 1.14–2.70) Residence of medium metro county (AOR = 1.93; 95% CI 1.14–3.29) Residence of small county (AOR = 2.04; 95% CI 1.06–3.92)
Medical Related				
Baek 2020 USA	Asthma	30-Day & ≥31 Day URHs	Age, Gender, Ethnicity, Type of insurance, Days to readmission, Season, $PM_{2.5}$, Ozone, Temperature	Elevated ozone (OR = 1.02; 95% CI 1.001–1.045) $PM_{2.5}$ concentrations (OR = 1.080; 95% CI 1.01–1.16). The effects of ambient air pollutants on hospital readmissions Varied by age and season.
Bhatt 2020 USA	Diabetic Ketoacidosis	30-Day URHs	Age, Gender, Female, APRDRG risk mortality, Severity of illness, Median household income category as per zip code, Primary payer, Admission type, Hospital bed size, Hospital location & teaching status, Location of hospital (Metropolitan/Non), Admission day	Age/5–11Years (OR = 2.73; 95% CI 1.34–5.58) Age/12–18Years (OR = 4.93; 95% CI 2.46–9.88) Female (OR = 1.56; 95% CI 1.34–1.82) Risk mortality/2 (OR = 1.36; 95% CI 1.03–1.80) Comorbidity/Depression (OR = 1.88; 95% CI 1.03–1.80) Comorbidity/Psychosis (OR = 1.94; 95% CI 1.35–2.79) Discharge against medical advice (OR = 2.15; 95% CI 1.36–3.39) **Protective factors** Median household income for zip code/51–75 percentile (OR = 0.75) Median household income for zip code/76–100 percentile (OR = 0.73) Private payer (OR = 0.50) Self-pay/others (OR = 0.73) Admitted to metropolitan teaching hospital (OR = 0.57)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Kessler 2020 USA	Epilepsy	30-Day URHs	Age, Sex, Primary payer, Zip code quartile, Control/Ownership of hospital, Hospital bed size, Hospital teaching status, LOS, Index hospitalisation disposition, Co-diagnosis/hospital events, Adverse events	Medicare/Primary Payer (AOR = 4.79; 95% CI 1.05–21.93) Index LOS = 2days (AOR = 1.26; 95% CI 1.07–1.49) Index LOS ≥ 3days (AOR = 1.95; 95% CI 1.68–2.26) Index disposition/Home with home health care (AOR = 1.67; 95% CI 1.25–2.23) **Chronic condition/Index admission characteristics** Tracheostomy (AOR = 2.04; 95% CI 1.58–2.65) Gastrostomy (AOR = 1.90; 95% CI 1.62–2.23) Intellectual disability (AOR = 1.46; 95% CI 1.13–1.89) Developmental delay (AOR = 1.17; 95% CI 1.01–1.35) Cerebral palsy (AOR = 1.29; 95% CI 1.11–1.50) Intractable epilepsy (AOR = 1.53; 95% CI 1.28–1.82) **Protective factors** Age ≥ 3Years (OR = 0.84–0.75)
Wong 2020 Canada	RSV	30-Day URHs	Demographics (Age, Sex, Gestational age) Comorbidity (Congenital heart disease/CHD, Chronic lung disease, Trisomy 21) Past medical history (Previous intubation, Previous non-invasive ventilation, Previous cardiopulmonary bypass) Clinical diagnosis (Bronchiolitis, Pneumonia, URTI) Markers of RSV severity (PICU admission, Intubation, Non-invasive ventilation, Cardiopulmonary bypass, LOS)	Comorbidity_CHD (OR = 2.93; 95% CI 1.08–6.79) RSV admission clinical diagnosis_Pnemonia (OR = 2.57; 95% CI 1.07–5.61)
Ardura-Garcia 2019 UK	Asthma	15-Day to 3-Year UHRs	NA as Systematic Review	Previous history of emergency for asthma Previous hospital admissions for asthma Younger age African-American ethnicity Low socio-economic status Female Concomitant allergic diseases
Auger 2019 USA	Complex Medical Conditions	30-Day URHs	Patient hospitalisation characteristics (Age, Race/Ethnicity, Gender, Insurance, LOS) Medical complexity at index discharge (Number of scheduled medications, Number of as-needed/PRN medications, Number of scheduled doses per 24hours, Medical technology, Specific types of medical technology, Home healthcare after discharge) Change in Medical State Complexity (Any new CCC, Any new technology)	**Change in complexity**: when adjusting for patient characteristics New diagnosis of a CCC (AOR = 1.75; 95% CI 1.11–2.75) New technology (AOR = 1.84; 95% CI 1.09–3.10)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Parikh 2018 USA	Asthma	30-Day UHRs	Asthma-specific discharge components: Hospital education (Content of education, Format of education, Dedicated individual); Medications and devices in-hand (Spacer, Beta-agonist, Controller medication, Steroids for current exacerbation, Steroids for future exacerbation); Contact with Primary Medical Doctor (Communication with PMD at discharge, Scheduled PMD appointment), Post discharge (Environment mitigation, Home visits, Post-discharge phone call)	**Risk Factors: Inconclusive** **Protective factors** Having comprehensive content of education ($p<0.029$)
Wang 2019 China	Mycoplasma Pneumoniae Pneumonia	90-day UHRs	Socio-demographic: Sex, Age Before and after admission: Days before admission, Febrile day before admission, Body temperature on admission, LOS Clinical manifestation at presentation: Wheezing day, Cough day, Diarrheal Radiographic finding: Normal, Light diffuse shadowing, Consolidation, Pleural effusion Severity on admission: ICU admission, Mechanical ventilation Laboratory results: WCB, Neutroophil, Lymphocyte, Monocyte, CRP, LDH, LBDH	Influenza A co-infection (OR = 4.746; 95% CI 1.19–1.89) **Protective factors** Age (OR = 0.82; 95% CI 0.71–0.94) Body temperature (OR = 0.65; 95% CI 0.52–0.84)
Leary 2019 USA	Complex chronic conditions (CCCs)	30-Day UHRs	Socio-demographic factors: Age, Race/Ethnicity, Sex, Non-English primary language, Insurance, Neighbourhood per capita income Measures of hospital use: Any admissions & emergency department (ED)] visits in the 6 months leading up to index admission Clinical measures: CCC category, Number of CCC categories, Technology assistance, Number of home medications at admission, Admission type (Surgical/Medical) Hospitalisation and Discharge characteristics: Any ICU use, Discharge disposition, LOS, Weekday versus weekend discharge during index admission	Previous admissions (AOR = 1.70; 95% CI 1.16–2.46) Previous ED visits (AOR = 2.04; 95% CI 1.31–3.11) Number of CCC categories of 2 (AOR = 1.56; 95% CI 1.06–2.26) Number of CCC categories of 3 (AOR = 1.72; 95% CI 1.06–2.26) Medical admission (AOR = 1.75; 95% CI 1.23–2.49) Discharge disposition with service (AOR = 1.69; 95% CI 1.17–2.44) Discharge disposition to other facilities (AOR = 1.15; 95% CI 0.58–2.13) LOS 2–5days (AOR = 1.15; 95% CI 0.78–1.72) LOS ≥ 6days (AOR = 1.45; 95% CI 0.90–2.33) Weekday discharge (AOR = 1.23; 95% CI 0.84–1.85)
Hong 2019 USA	Neurology	7-Day UHRS & 30-Day UHRs	Age, Income, discharge occurring on a weekend, admission to the paediatric intensive care unit (PICU), use of multiple antiepileptic drugs (AEDs), and involvement of multiple subspecialties	**30-Day UHRs** Multiple AEDs (OR = 4.5; 95% CI 2.1–9.7) Multispecialty care (OR = 2.6; 95% 1.0–6.9) **7-Day UHRs** PICU admission (OR = 2.1; 95% CI 1.0–5.3)

Reference	Medical Condition	Outcome measures	Examined Variables	Significant Risk Factors All-Cause Related
Awerbach 2018 USA	Pulmonary hypertension	30-Day UHRs	Age, Bronchopulmonary dysplasia (BPD), Congenital heart disease (CHD), ICU during index admission, Type of insurance, LOS, Gender, Pulmonary hypertension pharmacotherapy, Race, Respiratory infection during hospitalisation, Volume of patients with pulmonary hypertension admitted to hospital	Lower hospital volume of pulmonary hypertension admissions (OR = 1.14; 95% CI 1.23–1.57) Public insurance (OR = 1.26; 95% CI 1.16–1.38) **Protective factors** 1 to <7 Years old (OR = 0.85; 95% CI 0.78–0.94) 7–13 Years old (OR = 0.77; 95% CI 0.66–0.89) ≥ 13 Years (OR = 0.89; 95% CI 0.77–0.91) CHD (OR = 0.84; 95% CI 0.77–0.99)
Burns 2018 USA	Bronchiolitis	30-Day UHRs	Demographic variables (Age, Sex, Race, Insurance type); Clinical factors (Breastfeeding status, Gestational age, LOS during index admission, Family history of asthma, chronic lung disease, asthma, acute otitis media on examination, respiratory syncytial virus positive, and Down's syndrome). Environmental factors (Day care exposure, presence of siblings, and passive smoke exposure; Interventions included palivizumab, and the following treatments of suction, neo-synephrine, albuterol, epinephrine, hypertonic saline, antibiotics, steroids, intubation/mechanical ventilation, intravenous fluids, oxygen – high-flow nasal cannula)	Age<2 months (OR = 3.9; 95% CI 1.62–9.18) Passive smoke exposure (OR = 4.55; 95% CI 1.86–11.06) Chronic lung disease (OR = 12.9; 95% CI 1.99–84.87)
Okubo 2018 USA	Febrile seizure	Not Clearly Defined	Patient characteristics (Age, Sex), Date of admission (weekend/weekday), Utilisation of ED services, Primary payer information (private, Medicare/Medicaid, other types/self-pay including no insurance, or no information), Median household income quartiles for counties of residence, Patient county location of residence; Patient chronic medical conditions – Pediatric complex chronic conditions classification system version 2 (CHD, kidney, pulmonary, endocrine, hematologic, gastrointestinal, and neurologic diseases; cancer or leukaemia; and autoimmune disease); Hospital characteristics (Government, not-for-profit or private hospital), Bed size (small, medium, or large), and teaching status (teaching or non-teaching) of the hospital.	**Multivariable regression model:** Age of 1 Year (AOR = 3.26; 95% CI 1.51–7.02) Age of 2 Year (AOR = **5.09**; 95% CI 2.25–11.5) Age of 3 Year (AOR = 3.17; 95% CI 1.13–8.95) Male (AOR = 1.75; 95% CI 1.13–2.70) Very low income (AOR = 2.57; 95% CI 1.39–4.76) **Cox proportional hazard model – Hazard Ration (HR):** Age of 1 Year (HR = 2.27; 95% CI 1.30–3.93) Age of 2 Year (HR = **3.10**; 95% CI 1.72–5.59) Age of 3 Year (HR = 2.08; 95% CI 1.02–4.23) Male (HR = 1.5; 95% CI 1.13–1.98) Very low income (HR = 1.61; 95% CI 1.05–2.47)

Reference	Medical Condition	Outcome measures	Examined Variables	**Significant Risk Factors** **All-Cause Related**
Veeranki 2018 UkogSA	Asthma	30-Day UHRs	Patient Characteristics: Age (6–11 vs. 12–18 years), Sex, Median household income, Primary insurance type, patient county location (“Central” counties of metro areas of ≥1 million population, “Fringe” counties of metro areas of ≥1 million population, Counties in metro areas of 250,000–999,999 population, Counties in metro areas of 50,000–249,999 population, and Micropolitan/10,000–49,999), and paediatric complex chronic condition (PCCC) status; Admission Characteristics: Type of admission (**weekend/weekday**), Utilisation of ED, LOS (<2, 2–4 and >4 days), and discharge disposition (**routine or unfavourable discharge**); and Hospital characteristics: Ownership (government, not-for- profit or private hospital), Bed size (small, medium, or large), and Teaching status (urban non-teaching, urban teaching, or rural) of the hospital.	Aged 12–18 years (HR = 1.59; 95% CI 1.22–2.07) Resided in center counties (HR = 1.50;95% CI 1.00–2.24 Resided in Micropolitan counties (HR = 2.46; 95% CI 1.36–4.45) >4-days LOS at index admission (HR 1.56; 95% CI 1.02–2.38) Urban hospital (HR = 2.11; 95% CI 1.03–4.32) Teaching hospital (HR = 2.25; 95% CI 1.16–4.39) (Disposition)-Unfavorable discharge (HR = 2.53; 95% CI 1.33–4.79) Diagnosed with a PCCC (HR = 3.21; 95% CI 2.31–4.47) **Protective factors** Private insurance (HR = 0.69, 95% CI 0.51–0.95)

2.7 Chapter Summary

Chapter Two has presented extensive research literature analysis and has comprehensively met Study Objectives 1 and 2. This chapter consisted of three peer-reviewed journal publications and two sections of systematic review updates.

2.7.1 Study Objective 1

Study Objective 1 was met through an exploration of literature examining transitions of care process at discharge for paediatric patients. This initially resulted in a published integrative review (Publication 1) of 61 studies (2010 to October 2014) on transitioning adolescent and young adult with chronic disease and/or disabilities from paediatric to adult healthcare services. In general, patients' outcomes both physically and psychosocially following the transition were poor. However, implementation of a structured transition program involving multiply stakeholders and patients with specific diagnoses, such as cystic fibrosis and diabetes, did improve health outcomes. The three main recommendations from the review were (1) early preparation for transition is essential for patients, caregivers and healthcare providers from both paediatric and adult healthcare services; (2) accurate and regular assessment of patients and caregivers' readiness for transition; (3) communication and sharing of patients' information between healthcare providers and healthcare services prior to transition is essential.

A systematic review of literature was conducted and presented as chapter section 2.3. Sixty-seven studies from years (2009 to 2020) focusing on the transition of paediatric patients from acute hospital to home was undertaken. The literature analysis revealed discharging a paediatric patient is a complex and challenging process. The evidence suggests both caregivers and patients, who experienced adverse events post-discharge, such as an unplanned ED visit and readmission, had one or more of the following risk factors; insufficient or inconsistent delivery of hospital-to-home transition of care information, caregiver with limited language proficiency, lower level of readiness for discharge, and/or limited hospital to home transition planning and preparation. Congruent with recommendations made by Publication 1, this review highlights the importance of early commencement of the hospital-to-home transition process, readiness for discharge assessment, tailored transition information to meet patient's individual/family needs, and use of interpreter services for families with limited language proficiency.

2.7.2 Study Objective 2

Study Objective 2 was achieved via two published systematic reviews (Publication 2 and 3) and an updated systematic/literature review presented as chapter section 2.6. These publications and the review were conducted to examine risk factors and predictive models for UHRs. Publication 2, an updated systematic review extracted 73 unique predictive models from 60 studies (2011 to 2015). Inconsistent predictive model performance were revealed, except in models which predict general medical conditions, readmissions with consistent moderate discriminative ability. The most frequently cited risk factors associated with UHRs for adult population were ‘comorbidities’, ‘length of stay’ and ‘previous admissions’.

Publication 3, a systematic review focused on risk factors associated with paediatric UHR. Thirty six significant risk factors were extracted from 44 included studies (2010 to 2017). An updated literature review using the same search strategy from 2018 to 2020 found a further 63 studies, which reinforces the increasing importance within the healthcare system in identifying paediatric patients at greater risk of experiencing an unplanned hospital readmission. The updated literature review extracted a total of 24 different types of significant risk factors. After combining the findings of Publication 3 and the updated literature review, the most frequently cited risk factors across all studies included ‘comorbidity’; ‘type of health insurance’; ‘LOS’, ‘age’, ‘severity of illness’, and ‘complication during the initial index admission’.

2.7.3 Recommendation for future research

Literature analysis related to Study Objective1 found that the quality of hospital-to-home transition processes impacts on the experience for caregivers and paediatric patients. The majority of studies to date have been conducted in USA healthcare settings using either survey or interview study design. There is a need to directly observe the transition process, especially the delivery of hospital-to-home transition information from healthcare providers to caregivers at the bedside of a hospital.

The findings from the systematic reviews pertaining to Study Objective 2 acknowledges the complexity of unplanned hospital readmission risk prediction in paediatric populations. Predictive model performance and validation for paediatric readmissions, compared to adult population literature, is limited. The review also emphasises that identification of risk factors largely depends on the examined variables by each study. Most of the studies were based on administrative data and conducted in the USA. There is a dearth of published Australian studies, especially from Western Australia, on paediatric all-cause unplanned hospital readmission. The need to develop a predictive model using not only administrative data, but also clinical data and written discharge documentation data on hospital-to-home transition information is imperative to enable more precise and reliable identification of paediatric patients at risk of an unplanned readmission.

Chapter 3

Methodology

3.1 Chapter Overview

Chapter Three provides a comprehensive description of the overarching study design. Study methods utilised within the research are presented including data sources, collection methods and analysis plan. Ethical considerations of each stage of the research are also discussed. Study Objectives 3 to 6 are addressed by applying a mixed method sequential explanatory research design. A detailed description of each method used in the sequential process has been published in the following four peer-reviewed journal publications which form part of the thesis.

Zhou, H., Della, P.R., Roberts, P.A., Porter, P., & Dhaliwal, S.S. (2018). A 5-year retrospective cohort study of unplanned readmissions in an Australian tertiary paediatric hospital. *Australian Health Review*. https://doi.org/10.1071/AH18123

Zhou, H., Della, Della, P.R., P. Porter, P., & Roberts, P.A. (2019). Risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in Western Australia. *Journal of Paediatrics and Child Health*. https://doi.org/10.1111/jpc.14492

Zhou, H., Albrecht, M.A., Roberts, P.A., P. Porter, P., & Della, P.R. (2021). Using machine learning to predict paediatric 30-day unplanned hospital readmissions: A case-control retrospective analysis of medical records, including written discharge documentation. *Australian Health Review*. https://doi.org/10.1071/AH20062

Zhou, H., Roberts, P.A. & Della, P.R. (2021). Nurse-Caregiver communication of hospital-to-home transition information at a tertiary pediatric hospital in Western Australia: A multi-stage qualitative descriptive study. *Journal of Pediatric Nursing*, *60*, 83–9. https://doi.org/10.1016/j.pedn.2021.02.017

3.2 Study Design

The extensive analysis of literature in Chapter Two highlights the limited research evidence and the complex nature of transitioning paediatric patients from the acute hospital setting to home. The development and use of reliable predictive models to identify paediatric patients at high risk of unplanned readmission is also limited. At the time of thesis submission there is no published research evidence examining paediatric all-cause UHRs in Western Australia.

A mixed-methods sequential explanatory research design was selected to address the study objectives. This design involves two-phases of sequential data collection commencing initially with a quantitative phase followed by a qualitative phase. Results from Phase 1 are used to inform the sampling process for the subsequent qualitative phase. The qualitative Phase 2 supports the explanation of significant quantitative results (Cameron, 2009; Creswell, 2003). The selection of this study design facilitates a comprehensive understanding of the identification of predictive factors for UHRs, nurse-caregiver communication of hospital-to-home transition information at discharge for paediatric patients and subsequent unplanned ED presentations and UHRs.

When quantitative and qualitative methods are integrated, information is drawn from a wide range of sources including an electronic administrative inpatient dataset, medical records, nurses and caregivers within a two-phase process (Creswell, 2003). The data which emerged from the two phases addresses Study Objectives 3 – 6 (Ivankova et al., 2006). An overview of study design, data sources, data collection methods, and data analysis of each stage in both phases of the study is presented in a flow chart (Figure 3.1).

3.2.1 Phase 1 of study

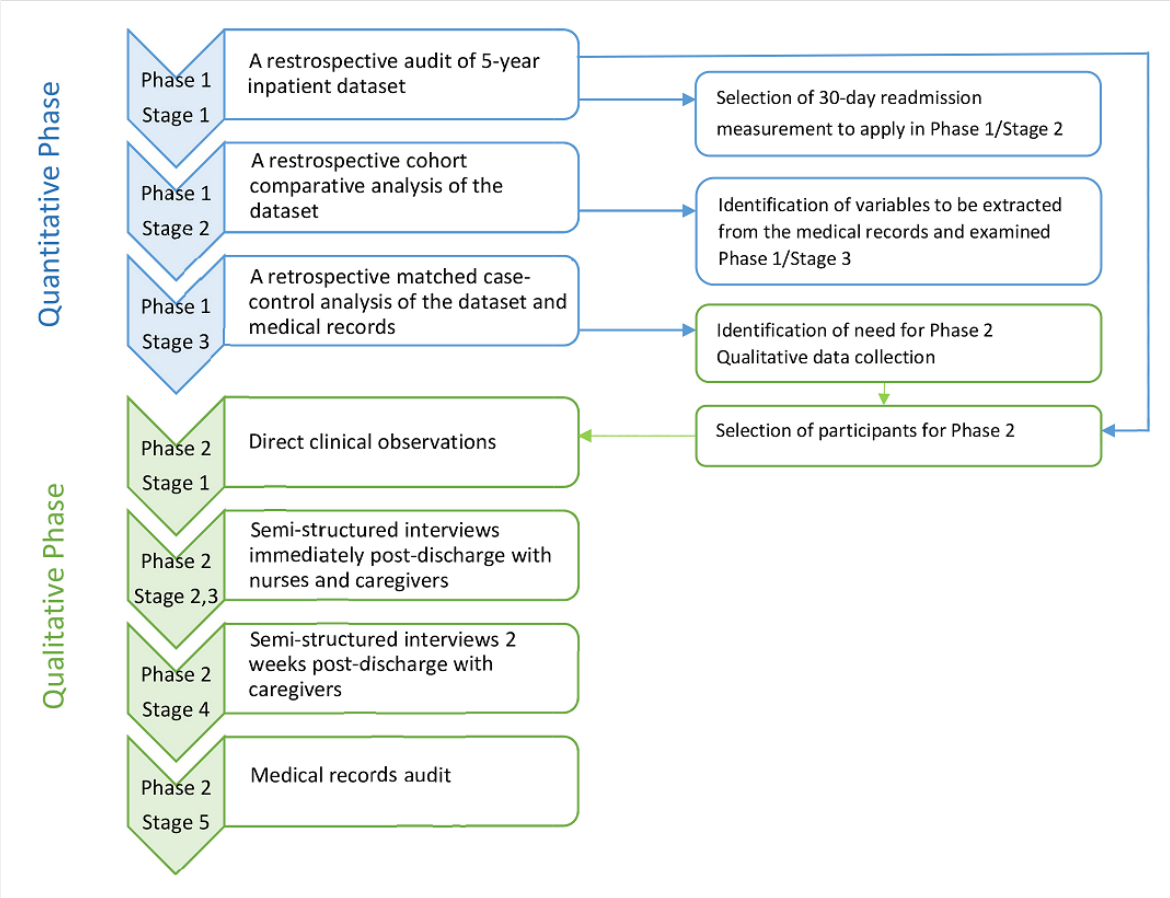
Phase 1 of the study involved a 3-stage retrospective audit of an inpatient dataset. Stage 1 of this phase examined the prevalence and characteristics of paediatric UHRs. Results of Stage 1 informed the decision to select 30-day all-cause readmissions as measurement of unplanned hospital readmission in Stage 2 and identified the selection criteria for participants in Phase 2.

Stage 2 identified readmission risk factors via a retrospective cohort analysis of the administrative dataset. Results of Stage 2 informed which additional variables would need to be extracted and selection of cases for Stage 3.

Stage 3 involved a case-control retrospective analysis of medical records to develop predictive models through the addition of clinical information variables and written discharge document variables. Case selection for Stage 3 was based on the findings of Stage 2. The results of Phase 1 of the study identified a clear need to explore nurse-caregiver communication on hospital-to-home transition information at discharge in greater depth.

Figure 3.1

Flow Chart of Study Design



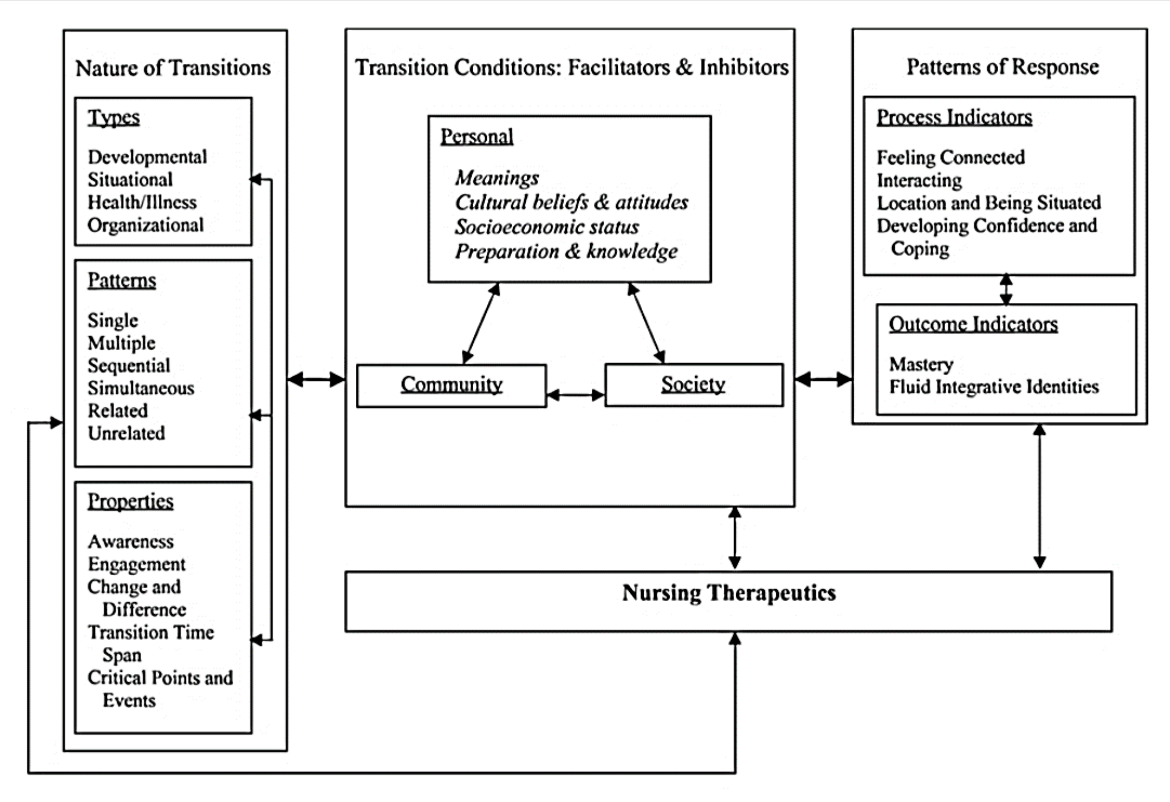
3.2.2 Phase 2 of study

Phase 2 of this study involved five stages of qualitative data collection and analysis, which enabled nurse-caregiver communication of hospital-to-home transition information on the day of discharge to be observed and described. Transitions Theory was used to guide formation of the research questions and selection of the research method in Phase 2 (Meleis et al., 2000; Meleis & Trangenstein, 1994).

The development of Transitions Theory was based on a concept analysis of existing transition theories and five primary studies examining transition experiences from an immigration, human development, and health-illness perspective (Meleis et al., 2000). Four core concepts emerged from the analysis to describe Transitions Theory. These are nature of the transition, transition conditions, patterns of response, and nursing therapeutics. Each concept has multiple sub-concepts and the linkage among the concepts and sub-concepts are displayed in Figure 3.2. The nature of transitions refers to types, patterns, and properties of the transition. Transition conditions consist of personal, community, and societal characteristics that impact the transition. The patterns of response describe transition processes and outcomes following the transition. Nursing therapeutics refers to care provided to facilitate the transition occurring (Meleis et al., 2000; Meleis & Trangenstein, 1994).

Figure 3.2

A Middle-range Theory



Note: This figure displays the core concepts and sub-concepts of the transitions theory. From Experiencing transitions: An emerging middle-range theory", by E. Im, 2000, Advances in Nursing Science, 23(1), p. 17. Copyright 2000 by Wolters Kluwer.

Nurses, as one of the most significant frontline healthcare providers, are routinely involved in transitioning patients and their caregivers from one setting to another based on the needs of patients. Transitions Theory provides a conceptual framework which identifies the complexity and linkages associated with transitioning patients from hospital to home (Im, 2011). This study acknowledges that paediatric patients are at increased risk of adverse outcomes when they transit from acute healthcare services to the home environment as children frequently require ongoing medical care or close monitoring at home post-hospital discharge. Transitions Theory facilitated the research team in this study to formulate research questions against the core components. The nature of the transition is reflected by characteristics of patient's admission, discharge and location; while the child, nurse and caregiver represent transition conditions. Patterns of response include perceptions of nurse-caregiver communication of transition information, recovery experience and utilisation of healthcare services Nursing therapeutics refers to hospital-to-home transition information delivery to prepare caregivers to provide post-transition care for their child at home (Refers to Table 1 of Publication 7).

Transitions Theory also informed selection of research methods in Phase 2. Stage 1 of Phase 2 involved direct clinical observations of the discharge experience focusing on nurse-caregiver hospital-to-home transition information communication. Stages 2, 3, and 4 included semi-structured interviews of nurses and caregivers to obtain information about their personal perspectives, and experiences of transition of care at discharge and recovery post-hospital discharge. Stage 5 involved a retrospective audit of each patient's medical file of patients' from Stage 1 to determine usage of hospital services post-discharge.

Phase 2 supplemented, elaborated and confirmed the quantitative results of Phase 1 that the quality of the communication of the hospital-to-home transition of care information significantly impacts the experience of paediatric patients and caregivers both at discharge and post-hospital discharge (Creswell et al., 2003). The findings of the quantitative and qualitative phases are integrated in the study discussion and conclusion (Creswell, 2003). A matrix of study design and methods addressing specific study objectives is presented in Table 3.1. Methods included data source, data collection and data analysis.

Table 3.1

Research Design and Methods Matrix

Objectives	Methodology/Data Source	Data Collection	Data Analysis
Phase 1: Quantitative method			
Publication 4/ Stage 1 – Study Objective 3 To examine the prevalence and characteristics of all-cause UHRs at a tertiary children's hospital	Retrospective audit of inpatient dataset (2010 to 2014) from a tertiary children's hospital	Data extraction form: 16 variables	Descriptive analysis: mean± standard deviation; Median with interquartile range; Counts and percentages
Publication 5/Stage 2 – Study Objective 4 To identify risk factors associated with 30-day all-cause unplanned hospital readmission at a tertiary children's hospital based on administrative patient dataset	Retrospective cohort comparative study use the same dataset as in Stage 1	Same as Phase 1	Univariate analysis & Forward stepwise multivariable logistic regression; Model discrimination test: c-statistic
Publication 6/Stage 3 – Study Objective 5 To assess if adding clinical information and written discharge documentation variables improves prediction of 30-day same hospital unplanned readmission compared to administrative information using machine learning	A retrospective matched case-control study of auditing medical records (Randomly selected cases based on results of Stage 2)	Data extraction form: 40 variables	Logistic Regression vs. Machine learning analysis methods including Stepwise Logistic Regression; Random Forest; Elastic Net; and Gradient Boosted Tree; Model discrimination test was carried out as Phase 2

Objectives	Methodology/Data Source	Data Collection	Data Analysis
	Phase 2: Qualitative method		
Publication 7/Study Objective 6			
To observe and describe nurse-caregiver communication of pediatric hospital-to-home transition information			
Stage 1: To observe the hospital-to-home transition experience including direct nurse-caregiver communication at discharge; & To describe content and delivery of transition information by nurses at discharge	Direct clinical observation on transitions of care at discharge (patients were purposed selected based on Phase 1 Stage 1 result)	Observational checklist	Content analysis of qualitative data; Descriptive analysis of quantitative data same as Phase 1 Stage 1
Stage 2: To explore the views of caregivers regarding communication of hospital-to-home transition information	Semi-structured interview with caregivers immediately post-discharge	Interview questions	Same as previous Stage
Stage 3: To explore nurses' views of the process involved in hospital-to-home transition information communication practice	Semi-structured interview with nurses post discharging patients from an inpatient ward	Interview questions	Same as previous Stage
Stage 4: To explore the views of caregivers regarding recovery experience post-discharge	Semi-structured phone interview with caregivers 2–4 weeks post-discharge	Interview questions	Same as previous Stage
Stage 5: To review patients' usage of hospital services within 30 days post-discharge	Retrospective audit of medical records	Data collection form same	Descriptive analysis same as Phase 1 Stage 1

3.3 Data Source

As displayed in Table 3.1, a diverse range of data sources were utilised in this two-phase mix-methods sequential explanatory study. The main data source accessed in Phase 1 was an electronic administrative inpatient dataset of a tertiary children's hospital in WA dated from 2010 to 2014. The data was extracted from the Hospital Morbidity Data System (HMDS) of the Western Australia Department of Health. Exclusion criteria used in the data extraction included (1) Emergency department presentations and/or emergency department short-stay unit admissions; (2) Patients who died during hospitalisation; (3) Discharges of mothers attached to neonatal patients who were transferred to the tertiary children's hospital from maternity hospitals; (4) Patients whose parent, guardian or carer discharged them against medical advice; (5) Patients transferred to other hospitals due to incomplete hospitalisation and variations in the discharge process. In the final stage of this phase medical records of the randomly selected patients selected to be involved in Phase 1 were reviewed to extract additional clinical information and to include written information about the transition of information at the time of discharge.

In Phase 2, caregivers of paediatric patients, who were admitted with one of the three diagnoses associated with frequent UHR identified in Phase 1 of the study, tonsillectomy and/or adenoidectomy, appendectomy, or were admitted with bronchiolitis during the data collection period, were invited to be involved. Three wards were selected for the direct clinical observations and interviews given they admit the most number of patients with one of the three diagnoses. The wards included a short-stay surgical unit, a general surgical ward, and a general medical ward. Caregivers, present at the time of discharge of the patient, and staff who provided direct care for the patients and delivered hospital-to-home transition of care information were invited to participate in the direct clinical observations and semi-structured interviews. It was noted that not all caregivers present at discharge who received hospital-to-home transition of care information were the primary caregiver for the child at home post-hospital discharge. The final stage of phase 2 involved a review of medical records of the patients included in Stage 1 to identify if there had been any usage of hospital services within 30 days of the initial discharge.

3.4 Data Collection

The total time to complete data collection for the two phases including ethics approvals was three years. An overview of data collection method used to carry out each stage of this project are presented as per data source (Table 3.1).

3.4.1 Phase 1 Quantitative data collection

3.4.1.1 Stage 1 Retrospective audit of administrative dataset

Data extraction in Phase 1/Stage 1 was guided by four research questions: (1) What is the 5-year prevalence of UHRs? (2) What are the characteristics of UHRs? (3) What is the time interval from index admission to UHRs? and (4) What principal diagnoses at index admission were associated with frequent UHRs? (Refers to data collection form as Appendix B.1).

Unplanned hospital readmissions were identified using admission type (emergency) and the principal diagnosis of the subsequent admission following the index admission. Considering some patients had more than one index admission within the 5-year administrative inpatient dataset, prevalence of UHRs was calculated based on cases (all discharges) and patient-based.

The time interval between the index admission and the readmission was calculated based on the timing of discharge from the index admission to the subsequent unplanned readmission. The day of discharge from the index admission (Day 0) until 30 days after being discharged (Day 30) was considered as an unplanned readmission as this aligned with the majority of the literature. Identification of the top principal index admission diagnoses was assessed on the readmission counts.

A total of 16 variables were extracted from each patient including social-demographic and administrative hospital information. Extracted variables were age, gender, admission status, LOS, funding source as an inpatient, health insurance status, source of referral transport, state/territory of residence, care type, socio-economic indexes for areas (SEIFA), distance to hospital, general anaesthetic, Intensive Care Unit (ICU) stay, day of admission date, day of discharge date, and number of co-diagnosis.

3.4.1.2 Stage 2 Retrospective cohort comparison

Phase 1 Stage 2 used the same dataset and the16 extracted variables used in Phase 1 Stage 1 to address the research question, what risk factors are associated with paediatric UHRs based on the administrative inpatient dataset.

3.4.1.3 Stage 3 Retrospective matched case-control study

Stage 3 of this phase addressed two research questions (1) if adding clinical information and written discharge documentation improves prediction of 30-day same hospital unplanned readmissions compared to examining only administratively collected variables; and (2) if applying machine learning approaches increase prediction accuracy compared with standard logistic regression analysis. Written discharge documentation in this project refers to not only the discharge summary but also the last entry in the patient progress notes by physicians, allied healthcare providers, and nurses.

In addition to the 16 extracted variables from the administrative dataset, 11 variables of clinical information and 13 variables of written discharge documentation were manually extracted from patients' medical records against a developed data collection form (Appendix B.2).

The 11 clinical information variables included significant social history (legal custody issue or patient was under the care of child protection unit), language spoken at home other than English, abnormal laboratory result, imaging result, and vital signs, addition of new medication at discharge to existing medication regime, number of co-diagnosis recorded in the patient progress notes, known allergies, and usage of hospital services 12 months prior to the index admission (number of ED presentation, hospitalisation, and outpatient clinic attendance). The electronic administrative dataset provided by the WA HMDS included patients discharged from 2010 to 2014, however, the information on hospital services usage was not available for patients discharged in year 2010. Therefore, the PhD candidate manually extract the information from medical records of patients included in the study.

The 13 extracted written discharge documentation variables were based on the last written entry made by the healthcare providers in the patients' progress notes and/or from a clinical care pathway, *Nursing Admission and Discharge Planning Form* and/or operation sheet. The variables included completeness of *Nursing Admission and Discharge Planning Form* – nursing admission part, completeness of *Nursing Admission and Discharge Planning Form* – nursing discharge planning part, last written entry made by physician, nurse, or allied healthcare providers, the written evidence of discharge information by physician and nurse, written evidence of discharge medications information included by the physician and/or nurse, and post discharge follow up information made by physician/nurses; consistency of written discharge documentation among healthcare providers, and delay in issuing discharge summary (the date of discharge summary been issued against the date of discharge).

A total of 3,330 patients experienced at least one unplanned hospital readmission between 2010 and 2014. Five hundred and fifty patients from the 3,330 total were randomly selected and matched with 550 patients who had not experienced an unplanned hospital readmission (Zhou et al., 2018). The matching was performed based on age, gender, principal diagnosis of index admission, and proportion of patients with the principal diagnosis in the initial dataset based on the results of Phase 1 Stage 1. The randomisation and matching was computed using Coarsened Exact Matching (Blackwell et al., 2009). Due to the unavailability of medical records for some patients, the final number of paired patients was 470 (total patients = 940).

Sample size was calculated based on previously reported association between written discharge documentation and UHRs. An earlier study identified the absence of a written discharge plan was related to an odds ratio of 1.55 for readmissions (Topal et al., 2014). Other frequently reported risk factors related to UHRs, such as comorbidity, the odds ratios ranged from 1.18 to 5.61 (Beck et al., 2006; Berry et al., 2011; Wijlaars et al., 2016). Therefore, an odds ratio of written discharge documentation is suitable for a baseline power calculation. When assuming a 40% written discharge documentation absence/incompleteness from a dataset, 332 matched case-control pairs (total = 664) are required for the power = 0.8 and alpha = 0.05 (Schlesselman & Stolley, 1982). The sample size was 940, which provided a final power to detect a variable with an odds ratio of 1.45.

3.4.2 Phase 2 Qualitative data collection

3.4.2.1 Stage 1 Direct clinical observations

Phase 2 Stage 1 involved (1) observation of the hospital-to-home transition experience including direct communication of information between nurses and caregivers at discharge; and (2) description of content and delivery of hospital-to-home transition information provided by nurses at discharge. Direct clinical observations were conducted over seven weeks from mid-October to early December 2017. A maximum of three observations a day were undertaken depending on availability of patient discharges and participants' consent.

An observational checklist was developed based on the *Calgary – Cambridge Guides Communication Process Skills*, an established and validated instrument to evaluate a practitioner's communication skills (Kurtz et al., 2005; Simmenroth-Nayda et al., 2014). Additional items were developed and added to the instrument to obtain greater depth and detail about the environment in which the communication took place, such as layout of the room (single vs. multiple beds), levels of noise, and physical location of patient, caregiver and nurse. The revised checklist was reviewed and approved by the hospital ethics committee and a panel of experts including academics and senior nursing staff to ensure face validity of the checklist (Appendix B.3).

The checklist was used to capture interactions between nurses and caregivers at discharge focusing on rapport development, non-verbal behaviour, use of language, involvement of caregivers, and provision of hospital-home transition information (Kurtz et al., 2005). A minimum 30 observations were planned (Bernard, 2000; Morse, 1994) to ensure there was saturation of data. If after 30 observations data saturation was not reached further observations would be carried out until three consecutive observations with no new themes were obtained in accordance with the 'stopping criterion' (Francis et al., 2010). In Phase 2 Stage 1, data saturation was achieved by a total of 31 observations.

The PhD candidate who has extensive experience in paediatric inpatient care completed all the direct clinical observations. The candidate undertook long-service-leave from the hospital whilst completing the direct clinical observations to ensure non-biased recruitment. This allowed each caregiver to make an independent decision about participating in the study as the PhD candidate was not involved in providing direct care to their child (Green et al., 2007). Potential patients who were to be discharged either that day or the following day were identified by the candidate at nursing handover from night shift to morning shift. The PhD candidate then approached nurses and caregivers explaining the research and inviting them to be involved in the study. In order to minimize impact of the PhD candidate's presence on participants' behaviour, during the direct clinical observations, a discreet, and appropriate distance was maintained, whilst remaining sufficiently close to observe (Green et al., 2007). Each observation was recorded using a digital recorder. Field notes were also taken to capture the flow of communication and additional information on the discharge experience (Phillippi & Lauderdale, 2017). Characteristics of all participants, such as age, gender, educational background or employment status, were also obtained following the observations.

3.4.2.2 Stage 2, 3 and 4 Semi-Structured interviews with nurses and caregivers

Stage 2 and Stage 3 involved individual semi-structured interviews with each nurse and caregiver immediately following discharge of the patient from the ward. Interviews were guided by a set of developed questions based on the literature (Appendix B.4 and Appendix B.5). Nurses who had completed the discharge were interviewed and asked their views of the discharge experience and the delivery of the hospital-to-home transition information. Caregivers were asked about their views of the (1) discharge experience; (2) verbal and non-verbal communication practice of nurses at discharge; (3) recall and comprehension of hospital-to-home transition information using teach-back techniques (Griffey et al., 2015; White et al., 2013); and (4) readiness for discharge. Interviews were scheduled in a quiet room on the ward with a sign "Meeting in progress, please do not enter" on the door. The patients and/or other children were cared for by a family member or nurse while the interviews were conducted.

During Stage 4, caregivers, who had been interviewed in Stage 2, were then invited to be reinterviewed two weeks after the initial discharge. The aim of the follow up interview was to ask their views about how useful the hospital-to-home transition information had been and to enable them to describe the recovery experience (Appendix B.4). Interviews of those caregivers who agreed to be involved were conducted by phone at a time convenient for caregivers and were digitally recorded with written consent.

3.4.2.3 Stage 5 Audit patient medical records

The final stage of data collection for Phase 2 involved an audit of the medical records of those patients' who had agreed to take part in Phase 2. Medical records were reviewed to identify usage of hospital services within 30 days of patients' discharge. Each record was assessed to identify if there had been an unplanned ED presentation and/or hospital readmissions and if so was it associated with the initial index admission. Patients' medical records were reviewed using the data collection form as in Appendix B.6.

3.5 Data Analysis

Quantitative data was analysed using SPSS Version 23–25, except for Phase 1 Stage 3 which used R package (version 3.5.1) (R Core Team, 2019), with p-values less than 5% considered as statistically significant (Table 3.1). Patients who experienced an unplanned hospital readmission were compared with patients who were not readmitted. This enabled any potential readmission risk factors to be identified and predictive risk models for paediatric patients to be developed.

Phase 1 Stage 1, involved an audit of the administrative dataset, analysed baseline characteristics of all patients using mean ± standard deviation or median (inter-quartile range) for continuous variables, while counts and percentages were used for categorical variables. In this study, the prevalence of readmissions was calculated on both discharge-based and patient-based analysis because some patients had more than one index admission and readmission during the 5-year data retrieving period. If the patient had more than one unplanned readmission after being discharged within the 30 days, only the first readmission was included for the discharge-based analysis. Discharge-based analysis UHRs = Number of UHRs/Total number of discharges. Patient-based analysis UHRs = Number of patients experienced UHR/Total number of patients.

Phase 1 Stage 2, involved identification of risk prediction factors based on the administrative dataset used as in Stage 1. Univariate analysis was applied to the two groups of data (16 variables) to test for the presence of any difference in baseline characteristics between the groups using chi-square for categorical variables and t-test for continuous variables. Any of the 16 variables, with statistically significant results, were then put into the forward stepwise multivariate logistic regression analysis to remove variables which were not statistically significant. The final multivariate logistic model consisted of statistically significant predictors ($p<0.05$) (Donzé et al., 2013).

Discrimination was assessed by plotting the receiver operating characteristic (ROC) curve and calculating the area under the ROC curve (AUC) or c statistic. The ROC curve is a plot of true positives (sensitivity) against false positives (1-specificity) that provides a summary of sensitivity and specificity across a range of cut points for a continuous predictor (Hanley & McNeil, 1982). The c-statistic refers to the probability that the predicted risk is higher for a case than for a non-case and a c statistic of 1 indicates perfect discrimination and the predicted risks are higher for all cases than non-cases even if the predicted risk differs from the observed risk (Billings et al., 2006; Hanley & McNeil, 1982).

Phase 1 Stage 3, focused on the development of risk prediction models based on administrative dataset and the addition of medical records information. Three groups of variables consisting of 40 variables in each group, were compared by sequentially fitting three logistic regression models: (1) Administrative variables only; (2) Administrative and clinical variables; (3) Administrative, clinical, and written discharge documentation variables. Analysis of deviance test was performed using Chi-squared ($\chi 2$) method for determining significance. To complement the logistic regression analysis, machine learning analysis were applied to highlight variables of substantial relevance for prediction.

A multi-pronged approach to prediction was used to find consistency and robustness across all models. Comparisons between standard logistic regression to machine learning approaches including stepwise logistic regression, random forest, elastic net, and gradient boosted trees were undertaken (the detailed description of each machine learning approach was published in Publication 6). For each model, the performance was evaluated based on the c-statistic performance for the 10-fold cross-validation repeated 10 times. For models with in-built selection (stepwise regression, gradient boosted tree, and elastic net) variable selection was done through the model fitting procedure. For the random forest, the top 10 variables were selected according to their importance. Variable importance quantifies the relative contributions of each variable to the model, defined as the number of times a variable is selected for splitting, weighted by the improvement to the model, and averaged.

In **Phase 2 Stage 1** the audio recordings of direct clinical observations were transcribed verbatim by a professional transcriber. The semi-structured interviews of nurses and caregivers in Stage 2 were transcribed by the PhD candidate verbatim (Graneheim & Lundman, 2004). All transcripts were read and re-read to allow for immersion of data (Green et al., 2007). Content analysis of the transcripts and field notes was undertaken by the PhD candidate using the NVivo 11 and one of the Supervisors using a manual coding process (Hsieh & Shannon, 2005). Initial nodes/codes were assigned to segments of text based on similar meaning words. The nodes/codes were then organised as themes and subthemes (Graneheim & Lundman, 2004). Manual coding of the transcripts was completed inductively based on the categorisation and classification of meaningful text segments. This led to the emergence of themes and subthemes. The development of themes and subthemes were discussed by the PhD candidate and Supervisor until consensus was achieved to ensure consistent interpretation of the transcripts (Graneheim & Lundman, 2004). Data was organised into the three principal procedures/diagnosis used in the study and then each was compared with other. Differences and similarities across themes based on principal diagnosis/procedures were identified.

3.6 Ethical Considerations

Ethics approvals were obtained from the Human Research Ethics Committee of (1) Princess Margaret Hospital for Children, (2) Department of Health WA, and (3) School of

Nursing, Midwifery and Paramedicine (SoNM&P), Curtin University prior to the commencement of data collection. No foreseeable risks for patients and/or nurses and caregivers were identified in either phase of the study. Waivers for consent were sought for Phase 1from the participating hospital and the Department of Health WA due to the volume of patient numbers accessed in the dataset and medical records. There are approximately 28,000 admissions at the participating tertiary children's hospital annually so the estimated number of index admissions from 2010 to 2014 is 140,000. Obtaining consent for the number of patients admitted over the selected five year period was not feasible. Variables extracted from the HMDS are routinely collected for monitoring and measurement of clinical, financial, safety and quality outcomes in the Australian health system.

In Phase 1 Stage 1 and Stage 2, the Unique Medical Record Number (UMRN) of each patient was discarded once the linkage had occurred and no further identifiable data was extracted prior transporting the data file from the Department of Health WA to the SoNM&P, Curtin University. The data file from the Department of Health WA was transported by the use of file encryption, My File Transfer (MyFT). Passwords were sent in separate emails.

A subset of patients' UMRN was requested for Phase 1 Stage 3 to access medical information to further examine UHRs. Unique Medical Records Numbers were kept in a password protected file stored on the password protected laptop, and each UMRN was assigned a numerical code. Data from the chart review was entered directly into the SPSS file on the laptop. The SPSS file was transferred to the password protected computer at the SoNM&P. Upon completion of chart review, the real UMRNs were destroyed, meaning only the assigned patient code and chart review data remain in the SPSS file.

For Phase 2, a participant information sheet introducing the investigators and explaining details of the study was provided to seek written consent from nurses and caregivers prior to conducting observations and interviews (Appendix B.7, B.9, B.11, and B.13). Written consent was obtained from all participants involved in stage 1- 4 of Phase 2 (Appendix 0, 0, 0, and 0).

All participants of Phase 2 were informed that they could choose not to participate and could withdraw at any time without compromising their welfare or position. All collected data was strictly confidential. A numerical code was allocated to each participant involved in Phase 2 Stage 1. The UMRN of patients, for Phase 2 Stage 5, were entered into a code book and kept in a secure place separate from other data. The UMRN was used for auditing patients' usage of hospital service post-discharge. After completing the chart review, the UMRN was destroyed.

Quantitative data were entered into the SPSS-23 and qualitative data into the NVivo-10. All extracted data from both phases of the study are stored at SoNM&P, Curtin University, using a password protected computer in a restricted research office with swipe access and a locked filing cabinet in which the laptop is kept. Only Professor Phillip Della and the PhD candidate have access to the computer. Computers at Curtin University have firewall protection and anti-virus and spyware protection.

The results are reported in aggregate and tabular form to protect the identity of the participants. Results are presented at appropriate national and international conferences and published in appropriate journals. No names or medical records numbers are included in any of the reports or publications.

The SPSS dataset is downloaded to an encrypted CD and will be retained for seven years after the completion of the study in a locked archive room at Curtin University. Hard copy of collected data and written consent are stored safely in a locked cupboard at the School of Nursing and Midwifery, Curtin University, indefinitely in accordance with the National Health Medical Research Council guidelines, WA state law, and the Child and Adolescent Health Service guidelines.

Chapter 4

Research Outcomes

4.1 Chapter Overview

This chapter presents the research outcomes addressing Study Objectives 3 to 6; the chapter has five sections. Following the chapter overview, Section 4.2 presents Publication 4, a peer-reviewed published journal article describing prevalence and characteristics of all-cause unplanned hospital readmissions at a tertiary children's hospital using a 5-year inpatient electronic administrative dataset. Section 4.3 presents Publication 5, a peer-reviewed published journal article, identifying risk factors associated with 30-day all-cause paediatric unplanned hospital readmissions based on the same dataset as Publication 4.

Section 4.4 presents Publication 6, a peer-reviewed published journal article applying advanced machining learning analysis techniques to examine whether the addition of clinical information and written discharge documentation variables improves unplanned readmission prediction compared with administrative variables alone. Section 4.5 presents Publication 7, a peer-reviewed published journal article, observing and describing hospital-to-home transition information communication between nurses and caregivers. Patients' usage of hospital services within 30 days post-hospital discharge is also reported.

4.2 Publication 4

Zhou, H., Della, P.R., Roberts, P.A., Porter, P., & Dhaliwal, S.S. (2018). A 5-year retrospective cohort study of unplanned readmissions in an Australian tertiary paediatric hospital. *Australian Health Review*. http://doi.org/10.1071/AH18123

This publication addressed Study Objective 3: To examine the prevalence and characteristics of all-cause unplanned hospital readmissions from 2010 to 2014 at a tertiary children's hospital in Western Australia.

The *Australian Health Review* was selected for this publication as it is an international, peer-reviewed journal. The *Australian Health Review* publishes aspects of health policy, management and governance; healthcare delivery systems; and other matters of interest to those working in health care. The *Australian Health Review* is a valuable resource for health organisations, including government departments, hospitals, and primary healthcare services. The impact factor of *Australian Health Review* is 1.082 in 2018. Confirmation of adherence to copyright requirements is evidenced in Appendix A.3. This publication has been cited four times by 2 August 2021 as per *Scopus* (Appendix D.1).

Specific objectives of Publication 4 were:

- To determine the 5-year prevalence in paediatric admissions and characteristics of unplanned hospital readmissions;
- To examine the time interval between the paediatric unplanned hospital readmission and the index admission;
- To characterise principal index admission diagnoses associated with frequent paediatric readmissions.

Main findings of Publication 4 were:

- 4,070 discharges (3.03%) and 3,330 patients (4.55%) experienced at least one 30-day unplanned hospital readmission.
- More than half of readmissions occurred by Day 5 post-discharge, 73.6% by Day 10, and 86.1% by Day 5.
- Minimal differences in the rate of readmissions on Days 28, 29 and 30 (0.2%).
- The majority of readmissions for croup and epiglottitis occurred by Day 5.
- The majority of readmissions for acute bronchiolitis and obstructive sleep apnoea requiring tonsillectomy and/or adenoidectomy occurred by Day 15.
- The majority of readmissions for acute appendicitis and abdominal and pelvic pain occurred by Day 30.

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A 5-year retrospective cohort study of unplanned readmissions in an Australian tertiary paediatric hospital

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Abstract

Objective. The aim of this study was to examine the characteristics and prevalence of all-cause unplanned hospital readmissions at a tertiary paediatric hospital in Western Australia from 2010 to 2014.

Methods. A retrospective cohort descriptive study was conducted. Unplanned hospital readmission was identified using both 28- and 30-day measurements from discharge date of an index hospital admission to the subsequent related unplanned admission date. This allowed international comparison.

Results. In all, 73 132 patients with 134 314 discharges were identified. During the 5-year period, 4070 discharges (3.03%) and 3330 patients (4.55%) were identified as 30-day unplanned hospital readmissions. There were minimal differences in the rate of readmissions on Days 28, 29 and 30 (0.2%). More than 50% of readmissions were identified as a 5-day readmission. Nearly all readmissions for croup and epiglottitis occurred by Day 5; those for acute bronchiolitis and obstructive sleep apnoea requiring tonsillectomy and/or adenoidectomy occurred by Day 15 and those for acute appendicitis and abdominal and pelvic pain occurred by Day 30.

Conclusion. This study highlights the variability in the distribution of time intervals from discharge to readmission among diagnoses, suggesting the commonly used 28- or 30-day readmission measurement requires review. It is crucial to establish an appropriate measurement for specific paediatric conditions related to readmissions for the accurate determination of the prevalence and actual costs associated with readmissions.

What is known about this topic? Unplanned hospital readmissions result in inefficient use of health resources. Australia has used 28 days to measure unplanned readmissions. However, the 30-day measurement is commonly used in the literature. Only five Australian studies were identified with a focus on readmissions associated with specific paediatric health conditions.

What does this paper add? This is the first known study examining paediatric all-cause unplanned same-hospital readmissions in Western Australia. The study used both 28- and 30-day measures from discharge to unplanned readmission to allow international comparison. More than half the unplanned hospital readmissions occurred between Day 0 and Day 5 following discharge from the index admission. Time intervals from discharge date to readmission date varied for diagnosis-specific readmissions of paediatric patients.

What are the implications for practitioners? Targeting the top principal index admission diagnoses identified for paediatric readmissions is critical for improvement in the continuity of discharge care delivery, health resource utilisation and associated costs. Because 52% of unplanned readmissions occurred in the first 5 days, urgent investigation and implementation of prevention strategies are required, especially when the readmission occurs on the date of discharge.

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Introduction

Billions of dollars of additional costs are incurred with unplanned hospital readmissions.[1,2] Rehospitalisation has both a physiological and psychological effect on patients and their family or carers.[3–5] In Australia, the unplanned hospital readmission rate is defined as the percentage of unplanned readmissions to the same hospital within 28 days of discharge.[6] However, most studies in the literature use 30 days to measure readmission rates.[7–12] All-cause unplanned hospital readmission rates in children range from 3.4% to 22.4% based on 30-day to 2-year follow-up periods.[1,2,8–14] An American study[15] examined 30-day unplanned hospital readmissions across 72 children's hospitals over a 12-month period, finding that the readmission rate was 6.5% and that the three most common principal diagnoses associated with readmissions were seizure, bronchiolitis and pneumonia. Furthermore, the most common reason for readmission in nine of 10 readmissions was the same diagnosis as the index admission.[15] For condition-specific unplanned readmissions, prevalence ranges from 19% to 31% for mental health conditions based on 12-month measurements,[16–19] from 4.5% to 38% for respiratory diseases based on 28-day to 1-year measurements[20–25] and from 0.3% to 27.8% for general surgeries based on 7-day to 1-year measurements.[26–34]

There is limited published literature measuring all-cause paediatric unplanned hospital readmissions in Australia. Five Australian studies were identified with a focus on specific health condition-associated readmissions; these studies examined readmissions across mental health conditions,[16] asthma,[24,25] term live-born infants[35] and paediatric intensive care patients.[36] Unplanned readmission rates ranged from 0.8%[35] to 38%.[36] In Western Australia (WA), the prevalence of 28-day all-cause readmissions to the same hospital across all metropolitan public health services almost doubled from 2.1% in 2010–11 to 3.9% in 2014–15.[37–41]

Study aim

The aim of the present study was to characterise the frequency and nature of all-cause unplanned hospital readmissions in a tertiary paediatric hospital in WA from 2010 to 2014. Specific objectives were to: (1) determine the 5-year prevalence in paediatric admissions and characteristics of unplanned hospital readmissions; (2) examine the time interval between the paediatric unplanned hospital readmission and the initial hospitalisation; and (3) characterise principal index admission diagnoses associated with frequent paediatric readmissions.

Methods

Study design

A retrospective cohort descriptive study was conducted at the Princess Margaret Hospital for Children (PMH, which was relocated and renamed to Perth Children's Hospital on 10 June 2018), a 220-bed public acute care hospital with approximately 250 000 patient visits (in-patient and out-patient) each year. At the time of the study, the PMH was the only tertiary paediatric facility providing care for children and adolescents within WA.[42]

Data source

Patients of all ages discharged from the PMH between 1 January 2010 and 31 December 2014 were extracted as an electronic administrative in-patient dataset from the WA Hospital Morbidity Data Collection (HMDC). Emergency department presentations and/or emergency department short-stay unit admissions were excluded from the study. In addition, deceased patients and discharges of mothers attached to neonatal patients who were transferred to the PMH from maternity hospitals were excluded from the study, as were patients whose parent, guardian or carer discharged them against medical advice and those patients transferred to other hospitals (because of incomplete hospitalisation and variations in the discharge process).

Ethics approvals were sought from the human ethics research committees of the PMH, Curtin University and Department of Health, WA.

Outcome measures

Hospital readmission is measured from an index admission, the first hospitalisation for a specific clinical condition, to the subsequent unplanned admission. Subsequent admissions that are related to the index admission and occurred unexpectedly within a specified time interval are considered unplanned hospital readmissions. The identification of unplanned hospital readmissions in this study was based on the combination of admission type (emergency) and the principal diagnosis of the subsequent admission following the index admission.

Covariates of interest

Variables extracted from the HMDC included demographic and clinical information for each patients. Demographic variables included age, sex and residential postcode. Clinical data included the date of admission, date of discharge, principal discharge diagnosis, date of readmission, date of discharge from the readmission and the principal diagnosis of readmission. Age was coded into six groups: infants aged <12 months, preschool children aged 1–4 years, primary school children aged 5–8 years, late primary school children aged 9–12 years, lower secondary school children aged 13–15 years, upper secondary school children and young adults aged $\geq$16 years. It is also worth noting that the age limit to be admitted to PMH is <16 years unless special permission is granted by the hospital executives for patients with a pre-existing medical condition.[42]

Residential postcodes of each patient were converted into Socio-economic Indexes for Areas (SEIFA), a broad definition of relative socioeconomic status regarding people's access to material and social resources and their ability to participate in society.[43] The Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) was used in this study with scores that ranged from a percentile 0 to 100%. Lower IRSAD scores relate to households with a greater socioeconomic disadvantage.[43]

In the present study, 4403 condition-specific principal diagnoses based on the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM)[44] diagnoses codes were initially extracted from the HMDC. These ICD-10-AM codes were then grouped according to their first three characters, resulting in 494 groups.[44]

The date of discharge from the index admission (Day 0) until 30 days after being discharged (Day 30) was examined in this study.

Identification of the top principal index admission diagnoses was based on readmission counts.

Data analysis

Data were analysed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA). The baseline prevalence of index admissions and readmissions was calculated on discharge-based and patient-based data because some patients had more than one index admission and readmission during the 5-year period. If the patient had more than one unplanned readmission after being discharged within the 30 days, only the first readmission was included for the discharge-based analysis. Patient characteristics are described as the mean ± s.d. or median with interquartile range (IQR) for continuous variables, and as counts and percentages for categorical variables.

Results

In all, 137 621 discharges from the PMH between 2010 and 2014 involving 75 524 individual patients were extracted from the HMDC. Seven hundred and fifteen discharges, associated with maternity issues and attached to neonatal patients were excluded from the study, as were 192 deceased patients and 136 patients who left the hospital against medical advice. A further 2264 discharges were transfers to other hospitals and were therefore also excluded. Thus, 134 314 discharges of 73 132 patients were included in the final analysis. Of the 73 132 patients, 740 experienced more than one 30-day unplanned hospital readmission; of these 740 patients, 403 had two readmissions, 151 patients had three readmissions and 186 patients had four or more unplanned readmissions. Of the 134 314 discharges, 1479 were admitted with a principal diagnosis of T81 (complications of procedures, not elsewhere classified). In particular, patients were admitted to the PMH when they experienced postoperative complications following an initial surgical procedure that had been performed at other public or private hospitals. The top two postoperative complications were haemorrhage and haematoma ($n = 1024$) and wound infection ($n = 258$). The remaining 197 complications were varied.

Characteristics of all discharges

Based on analysis of all discharges, the number of hospitalisations was similar across the 5-year data collection period

Table 1. Summary of all discharges between 2010 and 2014 from the Princess Margaret Hospital for Children

All percentages are based on the total for a year. Data were analysed on the basis of both discharges (where patients may have multiple visit) and patients. Unless indicated otherwise, data are presented as the mean ± s.d. or as n (%)

	Year of discharge					Total
	2010	2011	2012	2013	2014	
Analysis based on all discharges						
Overall						
No. discharges	24 957	26 165	27 298	28 067	27 827	134 314
Mean ± s.d.	6.2 ± 5.1	6.1 ± 5.1	6.3 ± 5.1	6.3 ± 5.1	6.2 ± 5.1	6.2 ± 5.1
Age (years)						
<1	3364 (13.5)	3588 (13.7)	3675 (13.5)	3686 (13.1)	3885 (14.0)	18 198 (13.5)
1–4	8494 (34.0)	8683 (33.2)	8869 (32.5)	9191 (32.7)	9061 (32.6)	44 298 (33)
5–8	4873 (19.5)	5336 (20.4)	5539 (20.3)	5843 (20.8)	5931 (21.3)	27 522 (20.5)
9–12	4137 (16.6)	4370 (16.7)	4630 (17.0)	4691 (16.7)	4312 (15.5)	22 140 (16.5)
13–15	3227 (12.9)	3353 (12.8)	3752 (13.7)	3856 (13.7)	3666 (13.2)	17 854 (13.3)
≥16	862 (3.5)	835 (3.2)	833 (3.1)	800 (2.9)	972 (3.5)	4302 (3.2)
Sex						
Male	14 422 (57.8)	15 169 (58.0)	15 504 (56.8)	16 371 (58.3)	16 341 (58.7)	77 807 (57.9)
Female	10 535 (42.2)	10 996 (42.0)	11 794 (43.2)	11 696 (41.7)	11 486 (41.3)	56 507 (42.1)
Analysis based on patients						
Overall						
No. discharges	16 777	14 707	14 409	13 935	13 304	73 132
Mean ± s.d.	6.0 ± 5.0	5.9 ± 5.0	5.8 ± 5.0	5.6 ± 5.0	5.3 ± 4.9	5.7 ± 5.0
Age (years)						
<1	2383 (14.2)	2466 (16.8)	2543 (17.6)	2551 (18.3)	2717 (20.4)	12 660 (17.3)
1–4	5694 (33.9)	4751 (32.3)	4536 (31.5)	4390 (31.5)	4294 (32.3)	23 665 (32.4)
5–8	3323 (19.8)	2843 (19.3)	2887 (20.0)	2825 (20.3)	2562 (19.3)	14 440 (19.7)
9–12	2855 (17.0)	2505 (17.0)	2349 (16.3)	2282 (16.4)	2056 (15.5)	12 047 (16.5)
13–15	2152 (12.8)	1908 (13.0)	1927 (13.4)	1715 (12.3)	1550 (11.7)	9252 (12.7)
≥16	370 (2.2)	234 (1.6)	167 (1.2)	172 (1.2)	125 (0.9)	1068 (1.5)
Sex						
Male	9798 (58.4)	8602 (58.5)	8179 (56.8)	8140 (58.4)	7702 (57.9)	42 421 (58)
Female	6979 (41.6)	6105 (41.5)	6230 (43.2)	5795 (41.6)	5602 (42.1)	30 711 (42)

(Table 1). The total number of discharges exceeded 24 900 each year, with a mean age of 6.2 ± 5.1 years. Regarding patient-based analyses (Table 1), the number of patients hospitalised in each year of the study was similar, with a mean age of 5.7 ± 5.0 years. Overall, one-third of patients were aged from 1 to 4 years, and 1.5% of patients were aged >16 years. There were 16% more male than female patients.

Table 2. Summary of patient characteristics for those with and without unplanned hospital readmissions within 30 days of discharge
Data were analysed on the basis of both discharges (where patients may have multiple visit) and patients. Unless indicated otherwise, data are presented as n (%). IQR, interquartile range; LOS, length of stay of the index admission; SEIFA, Socio-economic Indexes for Areas

	Readmission within 30 days	No readmission within 30 days
Analysis based on all discharges		
Total no. patients	4070	130 244
Sex		
Male	2230 (54.8)	75 577 (58.0)
Female	1840 (45.2)	54 667 (42.0)
Age (years)		
<1	682 (16.8)	17 516 (13.4)
1–4	1219 (30.0)	43 079 (33.1)
5–8	713 (17.5)	26 809 (20.6)
9–12	640 (15.7)	21 500 (16.5)
13–15	696 (17.1)	17 158 (13.2)
≥16	120 (2.9)	4182 (3.2)
Age (years)		
Mean ± s.d.	6.3 ± 5.4	6.2 ± 5.1
Median (IQR)	5.0 (1.0–11.0)	5.0 (2.0–10.0)
LOS (days)		
Mean ± s.d.	4.7 ± 13.7	2.5 ± 7.4
Median (IQR)	1.0 (1.0–4.0)	1.0 (1.0–2.0)
SEIFA percentile		
Mean ± s.d.	62.6 ± 27.1	61.1 ± 27.5
Median (IQR)	67.0 (40.0–87.0)	65.0 (40.0–87.0)
Analysis based on patients		
Total no. patients	3330	69 802
Sex		
Male	1850 (55.6)	40 571 (58.1)
Female	1480 (44.4)	29 231 (41.9)
Age (years)		
<1	610 (18.3)	12 050 (17.3)
1–4	938 (28.2)	22 727 (32.6)
5–8	578 (17.4)	13 862 (19.9)
9–12	543 (16.3)	11 504 (16.5)
13–15	581 (17.4)	8671 (12.4)
≥16	80 (2.4)	988 (1.4)
Age (years)		
Mean ± s.d.	6.3 ± 5.4	5.7 ± 4.9
Median (IQR)	5.0 (1.0–11.0)	5.0 (1.0–10.0)
LOS (days)		
Mean ± s.d.	4.7 ± 14.1	2.4 ± 6.6
Median (IQR)	1.0 (1.0–4.0)	1.0 (1.0–2.0)
SEIFA percentile		
Mean ± s.d.	62.8 ± 27.2	61.0 ± 27.6
Median (IQR)	67.0 (40.0–87.0)	65.0 (40.0–87.0)

Characteristics of 30-day unplanned hospital readmissions

Based on analysis of all discharges, readmission rates ranged from 2.97% to 3.03%, with more male than female patients featuring in both the with- and without-readmission groups (Table 2). From a patient-based analysis perspective (Table 2), 4.55% of patients (n = 3330) experienced 30-day unplanned hospital readmissions, which ranged from 3.86% to 5.04% over the 5-year data extraction period. The mean age of the with-readmission group was 6.3 ± 5.4 years, compared with 5.7 ± 4.9 years in the without-readmission group. Length of stay of the index admission was almost double in the with-versus without-readmission group (4.7 ± 14.1 vs 2.4 ± 6.6 days respectively). The mean SEIFA percentile was similar in these two patient groups.

Time interval from index admission to unplanned hospital readmission

Fig. 1 shows the time interval from the discharge date of the index admission to the date of readmission of all-cause unplanned hospital readmissions. Each day from Day 0 to Day 7 accounted for more than 5% of unplanned hospital readmissions (Fig. 1*a*). The highest number of readmissions (532; 16%) occurred on Day 1, followed by Day 2 (n = 345; 10.4%) and Day 3 (n = 251; 7.5%). Of note, 208 readmissions (6.2%) occurred on Day 0. There were minimal differences in the rate of readmissions on Days 28, 29 and 30 (0.5%, 0.7% and 0.5% respectively). Fig. 1*b* shows the cumulative percentage of unplanned hospital readmissions from Day 0 to Day 30. More than half the readmissions (52%; n = 1732) occurred between Day 0 and Day 5, with 73.6% (n = 2450) occurring in the first 11 days (Days 0–10) and 86.1% (n = 2868) occurring in the first 16 days (Days 0–15).

The distribution of time intervals from discharge to unplanned readmission varied between each index admission diagnosis (Fig. 2). Nearly all the readmissions (98%) for the diagnosis code J05 (croup and epiglottitis) occurred by Day 5 after discharge, whereas readmissions for the G47 (sleep disorders) and J21 (acute bronchiolitis) diagnoses primarily (≥95%) occurred by Day 15. Readmissions related to other diagnoses (e.g. K35 (acute appendicitis), R10 (abdominal and pelvic pain) and R56 (convulsions) were spread across the 30 days after discharge (Fig. 2). Fig. 2*a* shows the percentage of condition-specific associated readmissions from Day 0 to Day 30, whereas Fig. 2*b* shows the cumulative percentage of readmissions.

Principal index admission diagnoses associated with frequent paediatric readmissions

The top 10 principal index diagnoses associated with unplanned readmissions are given in Table 3. The most frequent diagnosis was G47 (sleep disorders – obstructive sleep apnoea (OSA) syndrome requiring tonsillectomy and/or adenoidectomy), followed by K35 (acute appendicitis leading to appendectomy) and J21 (acute bronchiolitis). The three most common reasons for readmission are summarised in Table 3. The most common readmission diagnosis was the same diagnosis for the top 10 index admission diagnoses, especially J45 (asthma; 89%). Readmissions related to postoperative complications of initial surgical procedures ranged from 40.5% to 85.7%, with diagnoses

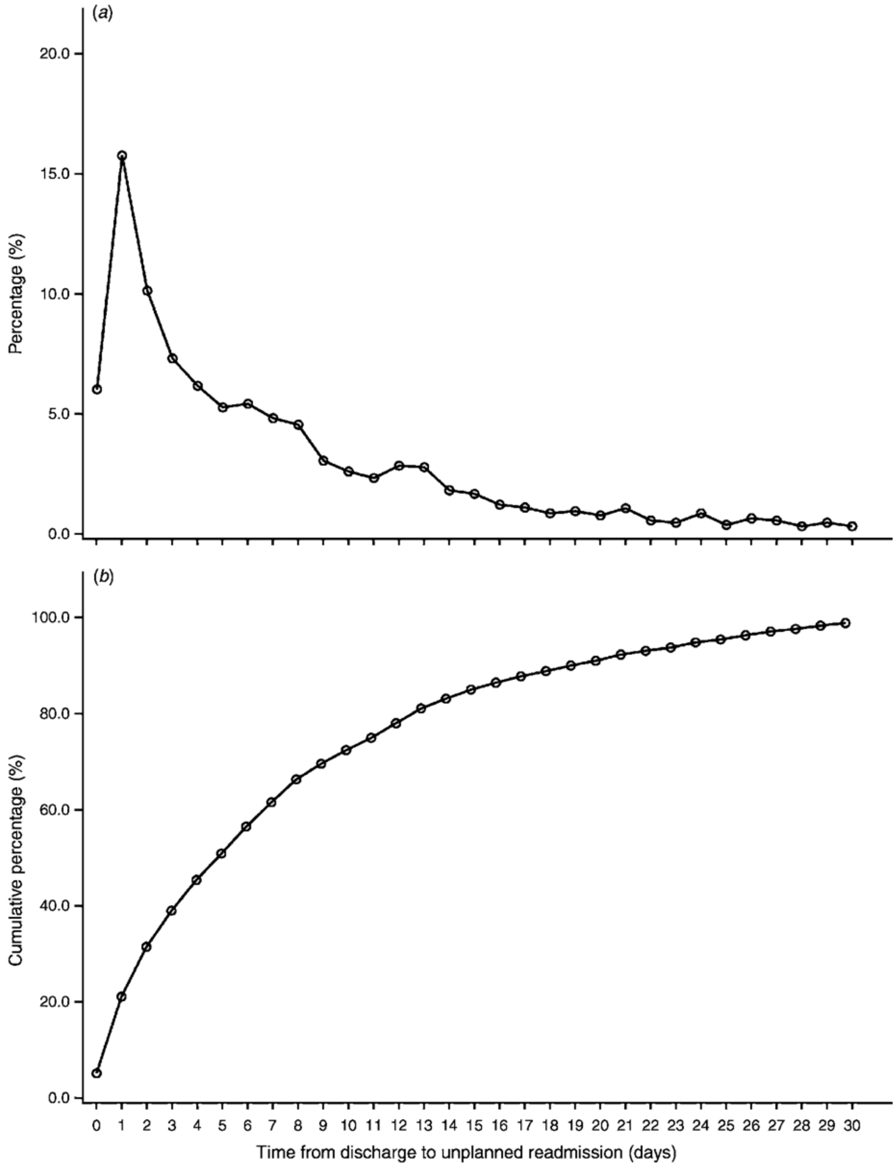

Fig. 1. Time from discharge after the index admission to the subsequent unplanned readmission showing (*a*) the percentage and (*b*) cumulative percentage of unplanned readmissions on each day after discharge.

including G47 (OSA), J35 (chronic diseases of tonsils and adenoids) and K35 (acute appendicitis).

Discussion

This study provides a baseline of the prevalence and characteristics of all-cause unplanned readmissions to the PMH using a large administrative dataset. The study identified a rate of 3.03% readmissions based on discharge analysis and a rate of 4.55% based on patient analysis. Studies conducted in other countries examining all-cause 30-day paediatric readmissions found considerable variations in prevalence rates. In terms of discharge-based analysis, three studies reported readmission rates of 10.3%,[10] 8.8%[13] and 6.5%.[15] In another three studies,

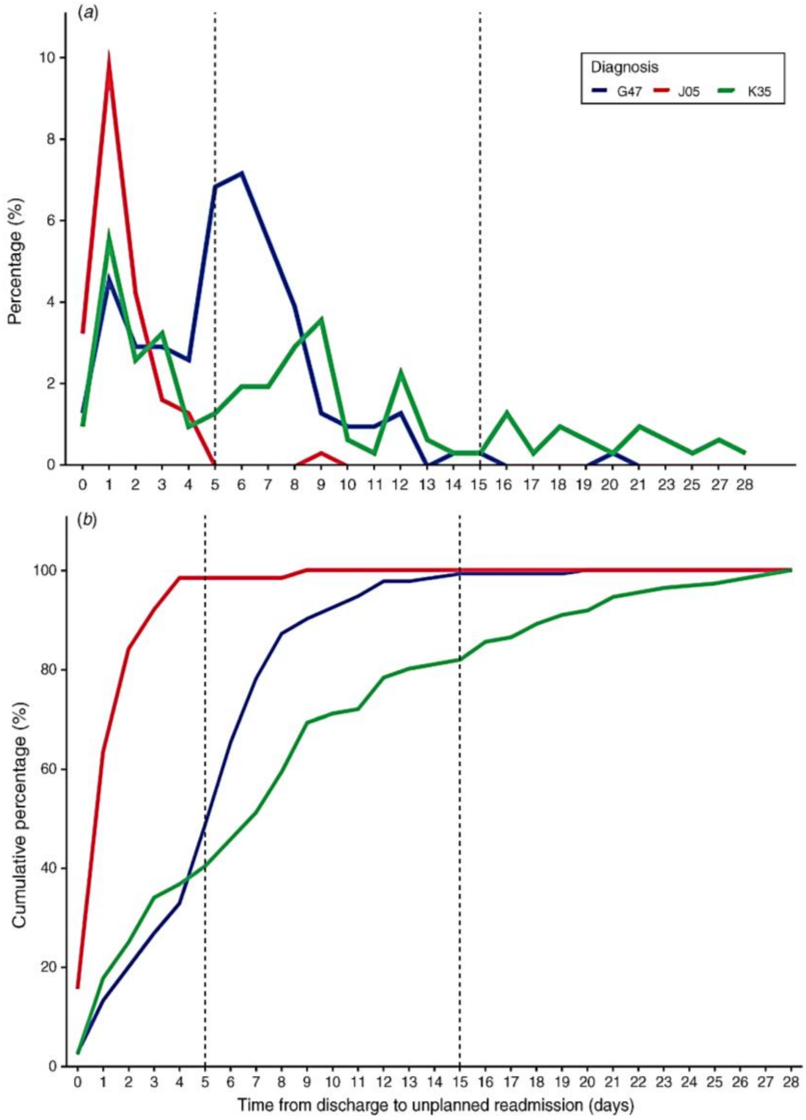

Fig. 2. Time from discharge after the index admission to the subsequent unplanned readmission for three principal diagnoses at index admission showing (*a*) the percentage and (*b*) cumulative percentage of unplanned readmissions on each day after discharge. G47, sleep disorders – obstructive sleep apnoea syndrome requiring tonsillectomy and/or adenoidectomy; K35, acute appendicitis leading to appendectomy; J05, croup and epiglottitis.

readmission rates based on patient analysis were found to be 3.4%,[12] 4.5%[9] and 18.7%.[11] Two studies described readmission rates of 6.5%[8] and 8.8%[45] based on both discharge and patient analyses. Of these eight studies, six examined readmissions to both the same and different hospitals.[8,9,12,13,15,45] The two studies[10,11] that the examined same-hospital readmissions reported much higher rates than found in this study. As highlighted in a recent systematic review,[46] caution is required when comparing readmission rates in the literature, because this is dependent on whether readmissions are based on discharges or patients, and whether readmissions are to the same or different hospitals.

Table 3. Three most common reasons for 30-day unplanned readmission for the top 10 principal index admission diagnoses

Ranking by counts	Principal index admission diagnosis: 3-Digit code	Principal index admission diagnosis: Description of 3-digit code	Most common: Reason for readmission	Most common: No. (%)	Second most common: Reason for readmission	Second most common: No. (%)	Third most common: Reason for readmission	Third most common: No. (%)
1	G47	Sleep disorders (obstructive sleep apnoea syndrome requiring tonsillectomy and/or adenoidectomy)	Complications of procedures	114 (85.7)	Sleep disorders	8 (6.0)	Cysts of oral region	3 (2.3)
2	K35	Acute appendicitis (requiring appendectomy)	Complications of procedures	45 (40.5)	Abdominal and pelvic pain	25 (22.5)	Cysts of oral region	11 (9.9)
3	J21	Acute bronchiolitis	Acute bronchiolitis	64 (66.0)	Abnormalities of breathing	6 (6.2)	Viral infection	4 (4.1)
4	R06	Abnormalities of breathing (wheezing, mouth breathing)	Abnormalities of breathing	55 (57.3)	Asthma	13 (13.5)	Acute bronchiolitis	7 (7.3)
5	B34	Viral infection of unspecified site	Viral infection	38 (42.7)	Acute bronchiolitis	9 (10.1)	Acute upper respiratory infections	7 (7.9)
6	J35	Chronic diseases of tonsils and adenoids (requiring tonsillectomy and/or adenoidectomy)	Complications of procedures	68 (84.0)	Nausea and vomiting	3 (3.7)	Symptoms and signs concerning food and fluid intake or dehydration	3 (3.7)
7	S52	Fracture of forearm	Fracture of forearm	71 (88.8)	Disorder of continuity of bone	5 (6.3)	Complications of internal orthopaedic prosthetic devices, implants and grafts	2 (2.5)
8	R10	Abdominal and pelvic pain	Abdominal and pelvic pain	34 (45.9)	Other functional intestinal disorders	8 (10.8)	Non-specific lymphadenitis	7 (9.5)
9	J45	Asthma	Asthma	65 (89.0)	Abnormalities of breathing	5 (6.8)	Unspecified acute lower respiratory infection	2 (2.7)
10	Z51	Encounter for other aftercare and medical care (i.e. chemotherapy)	Neutropenia	41 (59.4)	Fever of other and unknown origin	10 (14.5)	Complications of cardiac, vascular prosthetic devices, implants or grafts	3 (4.3)

Identification of the frequent principal index admission diagnoses associated with unplanned readmissions is commonly based on total counts.[15] The top 10 diagnoses in this study (Table 3) are consistent with those found in an American study,[15] except for one diagnosis, seizure. An Australian government report stated more than 30% of patients experienced an unplanned readmission following their initial surgical procedure.[7] The most frequent surgical procedure was tonsillectomy and/or adenoidectomy, which is consistent with our findings in a paediatric population.[7] The present study also supported the findings of Berry *et al.*[15] that most readmissions are for the same diagnosis or complications associated with the initial admission. The top diagnoses identified in the present study could be targeted to improve continuity of care at discharge and therefore to reduce the readmission rate.[3–5]

Most studies in the literature use a period of 30 days to measure unplanned hospital readmissions, although some studies have used 7 days[30,45,47] to measure readmissions. Berry *et al.*[15] found that 39% of all-cause readmissions occurred in the first 7 days after discharge and that 61.6% occurred in the first 14 days. In the present study, 52% of readmissions occurred within the first 5 days after discharge, 73.6% occurred in the first 10 days and 86.1% occurred in the first 15 days. The difference in unplanned hospital readmission rates between Days 28 and 30 was 0.2%, confirming that the findings across both periods are comparable. Fig. 2 clearly shows that some diagnoses are captured as Day 30 readmissions (K35, R10 and R56), whereas others are more accurately characterised as Day 15 readmissions (G47 and J21) or Day 5 readmissions (J05). These findings support the Australian Independent Hospital Pricing Authority's[48] emphasis on the need to establish appropriate time intervals to measure readmission according to specific health conditions.[49] This will lead to accurate determination of the prevalence and true cost of readmissions.[50,51] This is particularly important because of the need to improve efficiencies in resource utilisation within the healthcare system, as directed by funders, including government and private health insurance.[48,52]

Limitations

The present study is limited by the fact WA has one tertiary paediatric hospital (the PMH). The present study did not include index admissions to the PMH but then readmitted to non-paediatric hospitals or admission and readmissions to non-paediatric hospitals with paediatric wards. A future study incorporating WA linkage data would address these omissions and enable patients admitted to both non-paediatric hospitals and then the PMH with unplanned hospital readmissions to the same or a different hospital to be captured. This study was a 5-year audit of an administrative database; individual in-patient files were not accessed to capture specific clinical information.

Conclusions

The present study is the first to date to examine paediatric all-cause unplanned same-hospital readmissions in WA based on an in-patient administrative dataset of all PMH discharges from 2010 to 2014. The study found a higher same-hospital readmission rate compared with the WA metropolitan public hospitals,[37–41] but lower than the rates in the US[8–11], UK[13] and Canada.[12] The present study identified that the commonly used 30-day readmission follow-up period requires review because there are differences in the time intervals from discharge to readmission among diagnoses. It is critical to establish the most suitable measurement for readmissions for the accurate determination of the prevalence and true costs of readmissions. Investigations and strategies to reduce the occurrence of 5-day readmissions because of their high prevalence and readmissions on the discharge date are urgently needed. Identification of top index admission diagnoses for paediatric readmissions is essential to improve continuity of care at discharge with the aim of reducing unplanned hospital readmissions.

Competing interests

None of the authors has any conflicts of interest to disclose.

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4.3 Publication 5

Zhou, H., Della, P.R., Porter, P., & Roberts, P.A. (2019). Risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in Western Australia. *Journal of Paediatric and Child Health*. http://doi.org/10.1111/jpc.14492

This publication addressed study objective 4: To identify risk factors associated with 30-day all-cause unplanned hospital readmission at a tertiary children's hospital based on an administrative inpatient dataset.

The *Journal of Paediatric and Child Health* was selected for this publication as it publishes peer-reviewed original research articles of scientific excellence in paediatrics and child health. The impact factor of *Journal of Paediatric and Child Health* is 1.71 in 2019. Confirmation of adherence to copyright requirements is evidenced in Appendix A.1. This publication has been cited twice by 2 August 2021 as per *Scopus* (Appendix D.1).

Main findings of Publication 5 were:

- Seven significant risk factors were identified; age at index admission ≥ 13 years old; utilising private insurance as an inpatient; with greater social-economic advantage; admitted on Friday; discharged on Friday/Saturday/Sunday; ≥ 4 diagnoses at the index admission; LOS ≥ 15 days or longer.
- Two significant protective factors are patient required a general anaesthetic during index admission and patients transferred to the hospital via aeromedical service.
- The area under the receiver operating characteristic curve of the predictive model based on an administrative dataset is 0.645.

Journal of Paediatrics and Child Health

doi:10.1111/jpc.14492

ORIGINAL ARTICLE

Risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in Western Australia

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Aim: To identify risk factors associated with 30-day all-cause unplanned hospital readmission at a tertiary children's hospital in Western Australia.

Methods: An administrative paediatric inpatient dataset was analysed retrospectively. Patients of all ages discharged between 1 January 2010 and 31 December 2014 were included. Demographic and clinical information at the index admission was examined using multivariate logistic regression analysis.

Results: A total of 3330 patients (4.55%) experienced at least one unplanned readmission after discharge. Readmission was more likely to occur in patients who were either older than 16 years (odds ratio (OR) = 1.46; 95% confidence interval (CI) 1.07–1.98), utilising private insurance as an inpatient (OR = 1.16; 95% CI 1.00–1.34), with greater socio-economic advantage (OR = 1.20; 95% CI 1.02–1.41), admitted on Friday (OR = 1.21; 95% CI 1.05–1.39), discharged on Friday/Saturday/Sunday (OR = 1.26, 95% CI 1.10–1.44; OR = 1.34, 95% CI 1.15–1.57; OR = 1.24, 95% CI 1.05–1.47, respectively), with four or more diagnoses at the index admission (OR = 2.41; 95% CI 2.08–2.80) or hospitalised for 15 days or longer (OR = 2.39; 95% CI 1.88–2.98). Area under receiver operating characteristic curve of the predictive model is 0.645.

Conclusions: A moderate discriminative ability predictive model for 30-day all-cause same hospital readmission was developed. A structured discharge plan is suggested to be commenced from admission to ensure continuity of care for patients identified as being at higher risk of readmission. A recommendation is made that a designated staff member be assigned to co-ordinate the plan, including assessment of patients' and primary carers' readiness for discharge. Further research is required to establish comprehensive paediatric readmission rates by accessing linkage data to capture different hospital readmissions.

Key words: 30-day; all-cause unplanned hospital readmission; paediatric; risk factor.

What is already known on this topic

- Follow-up periods for published studies on risk factors associated with all-cause paediatric unplanned readmissions are either 30 days or 1– 2 years.
- Published studies on risk factors for 30-day all-cause paediatric unplanned readmissions have mainly been conducted in the USA, UK or Canada.
- The frequently cited significant risk factors associated with readmission include comorbidity, type of health insurance and illness severity.

What this paper adds

- This is the first published Australian study that developed a moderate discriminative ability predictive model for all-cause paediatric unplanned hospital readmissions using an administrative inpatient dataset.
- Patients who were admitted on Friday or discharged on Friday, Saturday or Sunday or experienced a longer length of hospital stay are at higher risk of being readmitted.
- Requiring a general anaesthetic during the index admission or patients transferred to hospital via an aeromedical service are factors associated with decreased risk of readmissions.

Unplanned hospital readmission rate has been widely accepted as a service performance indicator to evaluate the quality of health-care delivery.[1] A recent systematic review[2] examined research evidence on paediatric unplanned hospital readmissions from 2000 to 2017. Some American studies used 365 days to measure the all-cause unplanned readmissions, and the prevalence was from 16.7[3] to 21.8%.[4] Other studies examined all-cause 30-day unplanned readmissions, and the rates were reported to be 3.8–18.7% (USA),[5–8] 8.8 (UK)[9] and 3.4% (Canada).[10] Unexpected readmissions not only increase the costs of health-care delivery but also result in bed shortages and inefficient use of health-care resources. Families or carers of readmitted children also experience unexpected interruptions of their daily activities.

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As a result, paediatric patients waiting for a hospital bed for elective procedures or children requiring admission via emergency departments may experience cancellation and/or a long waiting period before admission as an inpatient.[1,11]

There has been increased emphasis in recent literature related to the identification of paediatric patients who are at higher risk of being readmitted following initial hospitalisation.[5–10,12] Improvement of transitions of care following discharge targeting those patients will assist in reducing unplanned readmissions.[13] The reported significant risk factors associated with all-cause readmissions include comorbidity, type of health insurance, illness severity, age, gender, ethnicity and day of admission.[5–10]

In Australia, approximately 1.2% of patients, including both adults and children, experienced a 28-day unplanned readmission following elective surgeries in a public hospital. Readmission rates range from 3.6% for tonsillectomy and adenoidectomy, 3.2% following hysterectomy, 2.8% for prostatectomy and 0.3% for cataract extraction.[11]

In Western Australia (WA), the prevalence of 28-day all-cause readmissions to the same hospital across all metropolitan public health services has increased from 2.1% (2010–2011) to 3.9% (2014–2015).[14] Studies conducted in Australia examining risk factors associated with paediatric readmissions have focused on specific health conditions, such as asthma[15,16] and mental health conditions.[17] This study aimed to identify risk factors associated with 30-day all-cause unplanned hospital readmission based on an electronic administrative dataset at a tertiary children's hospital in Western Australia. Australia uses 28 days to measure the all-cause unplanned readmission. However, the 30-day measurement is commonly used in the literature. The selection of the 30-day measurement for this study is to allow international comparison.[18]

Methods

Study design

A retrospective cohort study was conducted using an electronic administrative inpatient dataset extracted from the WA Hospital Morbidity Data Collection for all patients discharged from Princess Margaret Hospital for Children (PMH, which was relocated and renamed Perth Children's Hospital on 10 June 2018). Princess Margaret Hospital was a 220-bed tertiary paediatric facility in WA providing care for children, adolescents and young adults. Inpatient and outpatient visits totalled approximately 250 000 each year.[19] This study was approved by the Human Ethics Research Committee of PMH, Department of Health, WA and Curtin University.

Population

This study defined a cohort of patients of all ages with at least one discharge from PMH between 1 January 2010 and 31 December 2014. Transfers to other hospitals, deaths and discharges against medical advice were excluded due to incomplete hospitalisation and variances in the discharge process. Discharges of mothers attached to neonatal patients who were transferred to PMH from a maternity hospital were also excluded from this study.

Outcome measures/response variable

The 30-day unplanned hospital readmission is the response variable for this study. Index admission is the initial hospitalisation for a specific clinical condition, whereas unplanned hospital readmission is the subsequent unexpected hospitalisation related to the index admission within 30 days of discharge from the initial admission. The identification of unplanned readmissions in this study was based on hospital admission type (unplanned/emergency/non-elective) and the diagnosis of subsequent same-hospital admission related to the index admission. Admissions were considered new index admissions when they occurred more than 30 days following the previous index admission.[20] Only the first index admission was selected for this study for patients who had more than one index admission within the 5-year study period.

Covariates of interest/extracted variables

A total of 16 variables were extracted from the administrative database of Hospital Morbidity Data Collection, including patients' age at admission, gender, residential postcode, admission status, funding source as inpatients, insurance status, source of referral transport, state of residence, care type, interpreter service requirement, intensive care unit stay, general anaesthetic, length of stay, date of admission, date of discharge and number of co-diagnoses.

Age was recoded into six groups as follows: Infants (<12 months), pre-school children (1–4 years), primary school children (5–8 years), late primary school children (9–12 years), lower secondary school children (13–15 years) and upper secondary school children and young adults (≥16 years). The age limit to be admitted at PMH is 15 years unless special permission is granted by the hospital executives for patients with pre-existing medical conditions.[19] A patient's residential postcode was converted into Socio-Economic Indexes for Areas, which represents people's accessibility to material and social resources and participation in society. The Index of Relative Social-Economic Advantage and Disadvantage, with a score of 0–100%, was used in this study. The lower percentage relates to those households with a greater socio-economic disadvantage.[21] Insurance status for this study was coded as either privately insured or no private health insurance. In terms of funding source for hospital inpatients, there is a unique health insurance arrangement in Western Australia, where a patient with private health insurance can choose to be admitted to a public hospital as: (i) a public patient (government funded), and therefore, private health insurance funds are not used or (ii) a private patient using private health insurance funds. Date of admission and discharge was coded as weekdays compared with weekend and designated public holidays from 2010 to 2014.

Data analysis

Statistical Package for the Social Sciences version 23.0 was used to analyse the data. Covariates/extracted variables of patients who experienced 30-day all-cause unplanned same hospital readmission (with-readmission group – coded as 1) were compared with patients who had non-readmission (without-readmission group – coded as 0) to identify readmission risk factors. Characteristics of the patients were described using mean ± standard deviation for continuous variables, while counts and percentages were used for categorical variables.

Univariate analysis was used to test for the presence of any difference in the 16 covariates/extracted variables between the groups. The χ^2 test was used for categorical variables, and the independent sample t-test was used to investigate associations between the extracted variables and unplanned hospital readmissions. All significant variables that emerged from the univariate analysis were included in the development of the multivariate logistic regression model. Forward elimination was used to remove variables not statistically significant. The effects of all variables were expressed as odds ratios (OR) and associated 95% confidence intervals (CI). A P value of less than 0.05 was considered to be statistically significant. The final multivariate logistic model consisted of the least statistically significant predictors.

Sensitivity and specificity were calculated to distinguish patients who experience unplanned readmission. Sensitivity measures the percentage of patients with readmission during the 5-year study period and those who are correctly identified by the model. Conversely, specificity is defined as the proportion of patients who did not experience readmission and who were correctly identified. The area under the receiver operating characteristic (ROC) curve was also generated to demonstrate the discriminative ability of the model. The ROC shows the trade-off between true positives (sensitivity) and false negatives (1-specificity) at all possible thresholds.

Results

The initial extracted administrative inpatient dataset consisted of 137 621 discharges from PMH during the 5-year study period. Following exclusion of patients who were either deceased (n = 192), had left against medical advice (n = 136), were transferred to other hospitals (n = 2264) or were mothers attached to neonatal patients (n = 715), a total of 134 314 discharges from 73 132 patients were included in the final analysis. The mean age of all patients was 5.74 ± 4.97 years. One-third of patients (32.3%) were aged from 1 to 4 years compared to 14.1% of patients who were older than 13 years. There were more male (58%) than female patients (42%).

Of the 73 132 patients, 3330 (4.55%) experienced at least one 30-day unplanned hospital readmission. Table 1 summarises patients' characteristics based on 16 covariates/extracted variables of the with-readmission group and without-readmission group. The mean age of the with-readmission group (6.3 ± 5.4 years) was older in comparison to the without-readmissions group (5.7 ± 4.9 years). There were more male than female patients in both groups. The length of the index hospital admission was almost twice as long in the with-readmission group compared to the without-readmission group (4.7 ± 14.1 vs. 2.4 ± 6.6 days).

Univariate analysis identified 12 of the 16 covariates/extracted variables as being significantly associated with unplanned readmission (Table 2); however, there was no difference between the with- and without-readmission group in terms of the patient's type of health insurance, the Australian state of residence, hospital care type and usage of interpreter service. Forward stepwise multivariable logistic regression analysis identified

Table 1 Patients' characteristics based on 16 covariates/extracted variables of the with-readmission group and without-readmission group

Covariates/Extracted variables	With-30 UHRs (n = 3330), n (%)	Without UHRs (n = 69 802), n (%)
Age, year		
Mean ± SD	6.3 ± 5.374	5.71 ± 4.946
<1	610 (4.8)	12 050 (95.2)
1–4	938 (4)	22 727 (96)
5–8	578 (4)	13 862 (96)
9–12	543 (4.5)	11 504 (95.5)
13–15	581 (6.3)	8671 (93.7)
≥16	80 (7.5)	988 (92.5)
Gender		
Male	1850 (4.4)	40 571 (95.6)
Female	1480 (4.8)	29 231 (95.2)
Index admission status		
Elective	856 (3.9)	20 982 (96.1)
Emergency	2474 (4.8)	48 820 (95.2)
Funding source for inpatients		
Australian health-care agreements	2976 (4.5)	63 883 (95.5)
Private health insurance	294 (6.4)	4314 (93.6)
Others	60 (3.6)	1605 (96.4)
Type of health insurance		
Privately insured	1432 (4.7)	29 310 (95.3)
No private health insurance	1898 (4.5)	4, 0492 (95.5)
Source of referral transport		
Private/Public transport	2363 (4.6)	48 774 (95.4)
Ambulance	467 (5.5)	8676 (94.5)
Aeromedical service	25 (3)	810 (97)
State/Territory of residence		
WA	3312 (4.6)	69 376 (95.4)
Non-WA	18 (4.1)	426 (95.9)
Care type provided		
Acute care	3256 (4.5)	68 325 (95.5)
Other types	72 (4.8)	1551 (95.2)
IRSAD, %		
Mean ± SD	62.77 ± 27.214	61.04 ± 27.555
0–10	51 (3.7)	1320 (96.3)
11–20	264 (4.1)	6227 (95.9)
21–30	226 (4.3)	4972 (95.7)
31–40	352 (4.4)	7570 (95.6)
41–50	400 (4.6)	8214 (95.4)
51–60	253 (4.2)	5843 (95.8)
61–70	304 (4.5)	6391 (95.5)
71–80	227 (4.8)	4509 (95.2)
81–90	566 (4.6)	11 678 (95.4)
91–100	687 (5)	13 078 (95)
Interpreter service		
Required	9 (2.8)	308 (97.2)
Not required	3321 (4.6)	69 494 (95.4)
GA at index admission		
No	1960 (5.2)	35 420 (94.8)
Yes	1370 (3.8)	34 382 (96.2)
ICU stay at index admission		
No	3255 (4.5)	68 887 (95.5)
Yes	75 (7.6)	915 (92.4)

(Continues)

Table 1 (Continued)

Covariates/Extracted variables	With-30 UHRs (*n* = 3330), *n* (%)	Without UHRs (*n* = 69 802), *n* (%)
LOS at index admission, day		
Mean ± SD	4.65 ± 14.146	2.42 ± 6.634
1	1747 (3.5)	48 560 (96.5)
2–7	1178 (6.1)	18 030 (93.9)
8–14	219 (10.2)	1916 (89.8)
≥15	186 (12.6)	1296 (87.4)
Day of index admission date		
Monday	507 (4.5)	10 706 (95.5)
Tuesday	487 (4)	11 781 (96)
Wednesday	588 (4.9)	11 510 (95.1)
Thursday	530 (4.4)	11 491 (95.6)
Friday	565 (5.1)	10 584 (94.9)
Saturday	307 (4.3)	6786 (95.7)
Sunday	346 (4.7)	6944 (95.3)
Weekdays	2619 (4.6)	54 761 (95.4)
Weekend and public holiday	711 (4.5)	15 041 (95.5)
Day of discharge from index admission		
Monday	446 (4.2)	10 113 (95.8)
Tuesday	477 (4.2)	10 975 (95.8)
Wednesday	511 (4.2)	11 608 (95.8)
Thursday	521 (4.2)	11 952 (95.8)
Friday	655 (5.2)	11 937 (94.8)
Saturday	406 (5.4)	7134 (94.6)
Sunday	314 (4.9)	6083 (95.1)
Weekdays	2551 (4.4)	55 391 (95.6)
Weekend and public holiday	779 (5.5)	14 411 (94.5)
Number of co-diagnoses		
0	1162 (3.2)	35 564 (96.8)
1	936 (4.4)	20 278 (95.6)
2	497 (6.4)	7234 (93.6)
3	263 (8.1)	2982 (91.9)
≥4	329 (9.1)	3744 (91.9)

GA, general anaesthetics; ICU, intensive care unit; IRSAD, Index of Relative Social-Economic Advantage and Disadvantage; LOS, length of stay; SD, standard deviation; UHRs, unplanned hospital readmissions; WA, Western Australia.

nine factors that were associated with unplanned hospital readmission within 30 days after discharge (Table 2).

Readmissions were more likely in patients who were 13–15 years of age (OR = 1.30; 95% CI 1.14–1.48) or older than 16 years of age (OR = 1.46; 95% CI 1.07–1.98), utilising private health insurance as an inpatient at a public hospital (OR = 1.16; 95% CI 1.00–1.34) or with a high Index of Relative Social-Economic Advantage and Disadvantage of 90–100% (OR = 1.20; 95% CI 1.02–1.41). Patients admitted on Friday (OR = 1.21; 95% CI 1.05–1.39) or discharged on Friday/Saturday/Sunday are significantly associated with increased risk of readmission (OR = 1.26; 95% CI 1.10–1.44; OR = 1.34; 95% CI 1.15–1.57; OR = 1.24; 95% CI 1.05–1.47, respectively). The likelihood of being readmitted also increased when patients had more than one diagnosis (OR = 2.41; 95% CI 2.08–2.80) or longer than a 24-h hospital stay (OR = 2.39; 95% CI 1.88–2.98). Unplanned readmission was less likely in patients who were transferred to hospital via an aeromedical service (OR = 0.47; 95% CI 0.31–0.71) or had a procedure under general anaesthetics (GA) during the index admission (OR = 0.67; 95% 0.64–0.76).

The ROC curve was generated to illustrate the discriminative ability of the 30-day unplanned hospital readmission predictive model with an area under the ROC curve of 0.645 ± 0.011 (Fig. 1). The sensitivity of the model is represented through the vertical axis, which identifies patients who are likely to be readmitted. Identification of patients who are not likely to be readmitted is represented via the horizontal axis. For a sensitivity of 80%, the model achieved 62% specificity. For a sensitivity of 70%, the model has 50.5% specificity.

Discussion

This is the first published study in WA that developed a multivariate logistic regression model for 30-day all-cause paediatric unplanned hospital readmission using a recent administrative inpatient dataset. Overall, 4.55% of patients discharged from PMH were readmitted to the same hospital. The 30-day same-hospital readmission rate in this study was comparatively lower than rates reported in three hospitals in the USA (6.5–18.7%).[5,7,8] It was, however, higher than the Australian prevalence of 28-day all-cause readmissions across all metropolitan public health services (2.1–3.9%) from 2010 to 2014.[14]

The predictive model developed in this study consists of seven risk factors and two protective factors, and the model had a moderate discriminative ability to predict readmissions. Results from this study confirmed earlier research conducted in Canada[10] – that readmissions are more likely to occur in patients with more than one diagnosis at the index admission. Length of stay associated with index admission was not significantly associated with readmission in two US studies[6,7] compared to the findings of this study – that patients with a longer hospital stay were at a higher risk of being readmitted.

Patients aged between 15 and 18 years were found to be significantly associated with readmission in a study conducted in the USA.[8] This is similar to findings from this study, which identified that patients older than 13 years were nearly 1.5 times more likely to be readmitted compared with younger patients. This may be related to adolescents and young adults with underlying chronic health conditions[3,4,9,22] Further research is recommended[2] to examine whether, potentially, some unplanned hospital readmissions may be unavoidable due to medical complexity.[23]

The association between weekend admission/discharge and unplanned readmission was examined using a single children's hospital administrative dataset.[7] Findings from this study identified that readmissions were more likely to occur when patients were admitted on weekends (OR = 1.09; 95% CI 1.004–1.18). Our study found that not only Friday admissions but also Friday and weekend discharges were associated with higher risks of unplanned readmission. The 'weekend effect' on unplanned hospital readmission for both adults and paediatric patients has been confirmed.[7,24] Care provided over the weekend may be different from weekdays due to limitations in the availability of clinical

Table 2 Univariate and multivariate analyses: Association of 16 covariates/extracted data with unplanned hospital readmission of paediatric patients at Princess Margaret Hospital for Children (2010–2014)

Variables	Univariate OR (upper and lower 95% CI)	*P* value	Multivariate OR (upper and lower 95% CI)	*P* value
Age, year†				
Overall		0.000*		0.000*
5–8	Reference			
<1	1.21 (1.08–1.36)	0.001*		
1–4	0.99 (0.89–1.10)	0.850		
9–12	1.13 (1.00–1.28)	0.042*		
13–15	1.61 (1.43–1.81)	0.000*	1.30 (1.14–1.48)	0.000*
≥16	1.94 (1.52–2.48)	0.000*	1.46 (1.07–1.98)	0.016*
Gender				
Male	Reference			
Female	1.11 (1.04–1.19)	0.003*		
Admission status				
Elective	Reference			
Emergency	1.24 (1.15–1.35)	0.000*		
Funding source as inpatients†				
Overall		0.000*		
Australian health care agreements	Reference			
Private health insurance	1.46 (1.29–1.66)	0.000*	1.16 (1.00–1.34)	0.049*
Others	0.80 (0.61–1.04)	0.098		
Type of health insurance				
Privately insured	Reference			
No private health insurance	1.04 (0.97–1.12)	0.247		
Source of referral transport†				
Overall		0.009*		0.001*
Private/Public transport	Reference			
Ambulance	1.11 (1.00–1.23)	0.043*		
Aeromedical service	0.64 (0.43–0.95)	0.027*	0.47 (0.31–0.71)	0.000*
State/Territory of residence				
WA	Reference			
Non-WA	1.13 (0.70–1.81)	0.613		
Care type provided				
Overall		0.917		
Other types of care	Reference			
Acute care	0.977 (0.24–4.01)	0.974		
IRSAD (%)†				
Overall		0.042*		0.008*
51–60	Reference			
0–10	0.77 (0.53–1.12)	0.171		
11–20	0.98 (0.82–1.17)	0.814		
21–30	1.05 (0.87–1.26)	0.604		
31–40	1.07 (0.91–1.27)	0.397		
41–50	1.13 (0.96–1.32)	0.153		
61–70	1.10 (0.93–1.30)	0.28		
71–80	1.16 (0.97–1.40)	0.107		
81–90	1.12 (0.96–1.30)	0.145		
91–100	1.21 (1.05–1.41)	0.010*	1.20 (1.02–1.41)	0.024*
Interpreter service				
Not required	Reference			
Required	0.61 (0.32–1.19)	0.146		
ICU stay at index admission				
No	Reference			
Yes	1.74 (1.37–2.10)	0.000*		
Had GA at index admission†				
No	Reference			
Yes	0.72 (0.67–0.77)	0.000*	0.67 (0.64–0.76)	0.000*

(*Continues*)

Table 2 (Continued)

Variables	Univariate OR (upper and lower 95% CI)	*P* value	Multivariate OR (upper and lower 95% CI)	*P* value
LOS at index admission, day†				
Overall		0.000*		0.000*
1	Reference			
2–7	1.82 (1.68–1.96)	0.000*	1.42 (1.30–1.55)	0.000*
8–14	3.18 (2.74–3.68)	0.000*	2.35 (1.97–2.82)	0.000*
≥ 15	3.99 (3.40–4.69)	0.000*	2.39 (1.88–2.98)	0.000*
Day of index admission date†				
Overall		0.002*		0.004*
Thursday	Reference			
Monday	1.03 (0.91–1.16)	0.678		
Tuesday	0.90 (0.79–1.02)	0.088		
Wednesday	1.11 (0.98–1.25)	0.096		
Friday	1.16 (1.03–1.31)	0.018*	1.21 (1.05–1.39)	0.007*
Saturday	0.98 (0.85–1.13)	0.792		
Sunday	1.08 (0.94–1.24)	0.275		
Week days	Reference			
Weekend and public holidays	0.99 (0.91–1.08)	0.787		
Day of discharge from index admission†				
Overall		0.000*		0.000*
Thursday	Reference			
Monday	1.01 (0.88–1.14)	0.978		
Tuesday	0.99 (0.87–1.12)	0.844		
Wednesday	0.99 (0.87–1.12)	0.877		
Friday	1.25 (1.11–1.40)	0.000*	1.26 (1.10–1.44)	0.001*
Saturday	1.29 (1.13–1.48)	0.000*	1.34 (1.15–1.57)	0.000*
Sunday	1.17 (1.02–1.35)	0.03*	1.24 (1.05–1.47)	0.012*
Weekdays	Reference			
Weekend and public holidays	1.18 (1.08–1.27)	0.000*		
Number of Co-diagnoses†				
Overall		0.000*		0.000*
0	Reference			
1	1.41 (1.29–1.54)	0.000*	1.28 (1.16–1.41)	0.000*
2	2.10 (1.89–2.34)	0.000*	1.73 (1.53–1.95)	0.000*
3	2.70 (2.35–3.10)	0.000*	2.10 (1.80–2.46)	0.000*
≥4	3.86 (3.45–4.32)	0.000*	2.41 (2.08–2.80)	0.000*

*P < 0.05 (statistically significant results). †Indicates variables were included in the multivariate analysis. CI, confidence interval; GA, general anaesthetics; ICU, intensive care unit; IRSAD, Index of Relative Social-Economic Advantage and Disadvantage; LOS, length of stay; OR, odds ratio; WA, Western Australia.

services, including allied health providers and discharge liaison nurse, and variations in the skills of nursing staff. These limitations may result in incomplete discharge processes and early/immature discharge. This study has shown that the highest percentage of unplanned readmissions is related to Friday admission and Friday discharge (refer to Table 1). With the comparatively large number of discharges on Friday, parents may not receive comprehensive discharge information, impacting the continuity of care following discharge from the hospital.[25] Friday discharge may also be related to parental wishes of having their child at home over the weekend when the patient was not clinically ready to be discharged.

A recent study[9] conducted in the UK identified that patients at a socio-economic disadvantage were more likely to be readmitted. In comparison, this study found that patients residing in areas of greater socio-economic advantage were significantly associated with readmission. In addition, patients utilising private health insurance when admitted to a public hospital were identified as a risk predictor for readmission. Inconsistent findings were reported by two US studies examining the type of health insurance. One study[6] cited having private insurance (OR = 1.14; 95% CI 1.04–1.24) as a significant predictor, but the other study[5] reported that patients who only have public insurance were at a higher risk of readmission (OR = 1.48; 95% CI 1.20–1.83). Coller[8] commented that unplanned hospital readmission is not only an indicator of the quality of health care but also a measure of health service accessibility. In this study, paediatric patients with private health insurance or with advantaged socio-economic status were more likely to re-present to PMH as the first choice rather

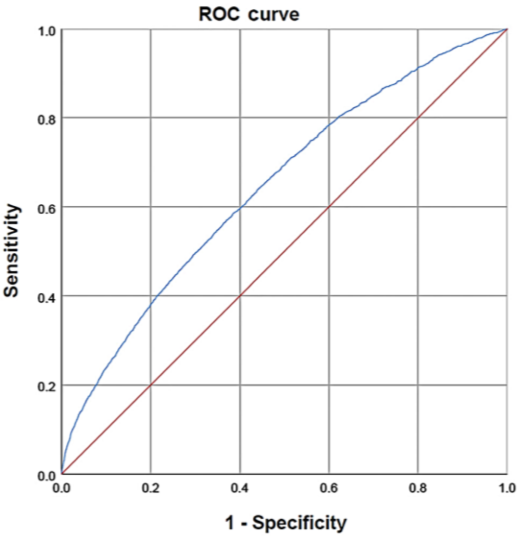

Fig. 1 A receiver operating characteristic (ROC) curve of the risk predictive model with 30-day all-cause unplanned same-hospital readmissions.

than attend a peripheral hospital. Families with greater socio-economic advantage have fewer financial considerations; therefore, they are more likely to return to the same hospital as the index admission regardless of travel distance.

The findings from this study also identified two factors that reduced the likelihood of readmission. These included patients transferred to PMH by aeromedical services and those who experienced a GA during the index admission. Due to the geographical features of WA, patients admitted to PMH via aeromedical services are normally from country or rural areas. Therefore, those patients might present at the regional hospital to seek medical assistance following discharge rather than returning to the Perth metropolitan area. Our study examined all discharges from PMH during the 5-year study period, including patients who had elective surgery under GA as a day surgery procedure and were discharged within 24 h. These patients were screened and selected using a set of criteria, which may have contributed to the result of fewer readmissions.

The area under the ROC of this study is 0.645 for 30-day all-cause readmission. One US study[3] reported a discriminative model ability of area under the ROC of 0.81. However, the model was for 365-day all-cause paediatric readmissions. These two studies are not comparable due to differences in the follow-up measurement of unplanned hospital readmissions.

Conclusions

The results of this study suggests health-care providers need to recognise and develop specific management plans for patients at a higher risk of readmission based on age (≥13 years), number of admitting diagnosis (>1), day of admission (Friday), day of discharge (Friday and Weekends) and length of hospitalisation (>1). For patients at a higher risk of readmission, a structured discharge plan is recommended to be commenced at the time of admission as this will ensure the continuity of care. The discharge plan should be co-ordinated by a designated staff member throughout the course of hospitalisation until the follow-up appointment. Research evidence suggests that readmission might be caused by early/premature discharge. Therefore, it is critical to assess patients' and their primary carers' readiness for discharge in reducing and preventing unplanned readmissions.[26] A further study focusing on adolescents and younger adults with readmissions will assist in understanding reasons and risk factors.

This study has certain limitations. Although PMH is the only tertiary paediatric hospital in WA, there are several general hospitals with paediatric wards. The readmission rate may be underestimated as the study was not designed to detect readmissions to different hospital.[6] The specific instances include (i) patients who had index admissions at PMH were then readmitted to paediatric wards in different hospitals; (ii) paediatric patients who were initially admitted to other hospitals and then readmitted to the same hospital or (iii) patients initially admitted to other hospitals but then readmitted to PMH.

Currently, readmissions are recorded in the inpatient dataset of PMH as an initial admission. A further study accessing WA linkage data to capture the true paediatric unplanned readmission rates in WA is needed. This study accessed administrative inpatient information as electronic medical record keeping has not been implemented at PMH. The covariates/extracted variables in this study, in comparison to some studies,[27,28] lack patients' specific clinical information, for example, laboratory and imaging results, medication usage, inpatient complications and written discharge information. In conjunction with the administrative inpatient information, a future study is required to examine additional clinical information by reviewing medical records at PMH.

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4.4 Publication 6

Zhou, H., Albrecht, M.A., Roberts, Porter, P., & P.A. Della, P. (2021). Using machine learning to predict paediatric 30-day unplanned hospital readmissions: A case-control retrospective analysis of medical records, including written discharge documentation. *Australian Health Review*. https://doi.org/10.1071/AH20062

This publication addressed Study Objective 5: To assess whether adding clinical information and written discharge documentation of hospital-to-home transition information variables improve prediction of 30-day same hospital unplanned readmission compared to administrative information using machine learning analyses.

The *Australian Health Review* was selected for this publication. It explores major national and international health issues and questions, keeping healthcare professionals and researchers updated on evidence-based information and ways of delivering care. The impact factor of *Australian Health Review* is 1.32 in 2020. Confirmation of adherence to copyright requirements is evidenced in A.3.

Main findings of Publication 6 were:

- The inclusion of written discharge documentation variables significantly improved the prediction of readmission compared with models that used only administrative and/or clinical variables in standard logistic regression analysis.
- Highest prediction accuracy was obtained using a gradient boosted tree model (c-statistic 0.654), followed closely by random forest and elastic net modelling approaches.
- Predictive factors include patients' social history (legal custody or patient was under the care of the Department for Child Protection), languages spoken at home other than English, completeness of *Nursing Admission and Discharge Planning Form*, and timing of issuing discharge summary.

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Using machine learning to predict paediatric 30-day unplanned hospital readmissions: a case-control retrospective analysis of medical records, including written discharge documentation

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Abstract.

Objectives. To assess whether adding clinical information and written discharge documentation variables improves prediction of paediatric 30-day same-hospital unplanned readmission compared with predictions based on administrative information alone.

Methods. A retrospective matched case-control study audited the medical records of patients discharged from a tertiary paediatric hospital in Western Australia (WA) between January 2010 and December 2014. A random selection of 470 patients with unplanned readmissions (out of 3330) were matched to 470 patients without readmissions based on age, sex, and principal diagnosis at the index admission. Prediction utility of three groups of variables (administrative, administrative and clinical, and administrative, clinical and written discharge documentation) were assessed using standard logistic regression and machine learning.

Results. Inclusion of written discharge documentation variables significantly improved prediction of readmission compared with models that used only administrative and/or clinical variables in standard logistic regression analysis ($\chi^2_{17} = 29.4$, $P = 0.03$). Highest prediction accuracy was obtained using a gradient boosted tree model (C-statistic = 0.654), followed closely by random forest and elastic net modelling approaches. Variables highlighted as important for prediction included patients' social history (legal custody or patient was under the care of the Department for Child Protection), languages spoken other than English, completeness of nursing admission and discharge planning documentation, and timing of issuing discharge summary.

Conclusions. The variables of significant social history, low English language proficiency, incomplete discharge documentation, and delay in issuing the discharge summary add value to prediction models.

What is known about the topic? Despite written discharge documentation playing a critical role in the continuity of care for paediatric patients, limited research has examined its association with, and ability to predict, unplanned hospital readmissions. Machine learning approaches have been applied to various health conditions and demonstrated improved predictive accuracy. However, few published studies have used machine learning to predict paediatric readmissions.

What does this paper add? This paper presents the findings of the first known study in Australia to assess and report that written discharge documentation and clinical information improves unplanned rehospitalisation prediction accuracy in a paediatric cohort compared with administrative data alone. It is also the first known published study to use machine learning for the prediction of paediatric same-hospital unplanned readmission in Australia. The results show improved predictive performance of the machine learning approach compared with standard logistic regression.
What are the implications for practitioners? The identified social and written discharge documentation predictors could be translated into clinical practice through improved discharge planning and processes, to prevent paediatric 30-day all-cause same-hospital unplanned readmission. The predictors identified in this study include significant social history, low English language proficiency, incomplete discharge documentation, and delay in issuing the discharge summary.

Keywords: administrative data, clinical information, discharge planning, discharge summary, follow-up plan, machine learning, medical records, paediatric hospital readmissions, paediatric unplanned readmissions, retrospective analysis, social history, social predictors, written discharge documentation.

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Introduction

The identification of predictive factors associated with paediatric unplanned readmission to hospital can be used to improve discharge planning processes, and thereby help prevent such readmissions. Prior research has uncovered many of these factors; a recent systematic review[1] of the existing literature extracted 36 unique predictors associated with paediatric unplanned hospital readmissions from 44 studies. The most commonly cited four predictors were comorbidity, health insurance status, length of stay (LOS), and age at the index admission. The review highlighted that statistical identification of predictors depended on what variables were examined in each of the studies. In 33 of the 44 studies, administrative databases and medical records were both accessed. In the remaining 11 studies, only administrative variables were analysed. The number of examined variables ranged from 2[2] to 44[3]. Extracting variables from electronic or hard-copy medical records enriches the data and may assist to rectify coding errors in the administrative dataset. Manual review of medical records does, however, incur significant time and financial impost. Nevertheless, the enhanced prediction capability via including such information may result in significant reductions in readmission rate and healthcare costs.

In addition to sociodemographic and clinical information, three paediatric studies examined the association between written discharge documentation (e.g. follow-up plan or discharge summary) and unplanned readmissions, but the results were not consistent.[4–6] In this project, written discharge documentation refers to not only the discharge summary, but also the last entry within the patient progress notes by doctors, allied healthcare providers, and nurses, as this method allows for comprehensive review of the inter-healthcare professional team members input to the discharge documentation. Variations between studies in how this information is extracted and analysed, along with its effect on prediction of readmissions, suggests further investigations are warranted. Written discharge documentation plays a critical role in the continuity of care following hospital discharge, but extracting this data is challenging for researchers.[7–9]

Apart from adding variables for predictive model development, advances in statistical analysis methods may also improve prediction accuracy, especially with large healthcare datasets. Logistic regression analysis methods are commonly employed in predicting paediatric unplanned hospital readmissions. Advanced machine learning analysis approaches have also been applied to adult[10] and paediatric[11–14] unplanned hospital readmissions, because of their potential to improve predictive model performance.[15] The commonly applied approaches included random forests,[16] least absolute selection and shrinkage operator (LASSO),[11,16,17] and gradient boosted decision trees.[16–18] However, the number of paediatric studies remains limited, and have so far only analysed administrative data.[11–14]

In a recently published study,[19] we developed a logistic regression model based on 16 administratively collected variables as electronic medical records were not available. The model was found with moderate discriminative ability for 30-day all-cause readmission at a tertiary paediatric hospital in Western Australia (WA) (C-statistic = 0.645).

Study aim

This current study added clinical information and written discharge documentation with the aim to determine whether adding these variables improves prediction of 30-day same-hospital unplanned readmissions compared with examining only administratively collected variables. Prediction accuracy was also examined comparing standard logistic regression analysis to machine learning approaches.

Methods

Study design

A retrospective matched case-control study was conducted, which audited the medical records of patients discharged from a tertiary paediatric facility in WA that has approximately 250 000 inpatient and outpatient visits each year.[20] Ethics approvals were obtained from the Human Ethics Research Committee of Health Service, Department of Health, WA (2015/55), Children's Hospital (2015015EP), and Curtin University (HR184/2015).

Data source

The patients included in this study were discharged between 1 January 2010 and 31 December 2014. The original electronic administrative inpatient dataset was extracted from the WA Hospital Morbidity Data Collection (WAHMDC). A total of 3330 patients (4.55%) experienced 30-day unplanned hospital

Table 1. Three groups of extracted variables

Administratively collected (16)	Clinical (11)	Written discharge documentation (13)
Age	Significant social history (legal custody or patient was under the care of Department for Child Protection)	Completion of *Nursing Admission and Discharge Planning Form* (Admission section and Discharge Planning section)
Sex	Language other than English	Operation sheet or the last entry progress note made by doctors
Admission status	Significant laboratory result	Clinical pathway or the last entry progress note made by nurses
Length of hospital say (LOS)	Significant imaging result	Last entry progress note made by allied healthcare providers
Funding source as an inpatient	Significant vital signs	Written evidence of discharge information given by doctors
Health insurance status	Added new medication at discharge upon existing regular medication regime	Written evidence of discharge information given by nurses
Source of referral transport	Number of co-diagnosis recorded in the patient progress notes	Written evidence of discharge medications information by doctors
State/Territory of residence	Known allergies	Written evidence of discharge medications information by nurses
Care type	Usage of hospital services 12 months prior to the index admission: number of emergency department (ED) presentations	Written evidence of follow-up information given by doctors
Socioeconomic indexes for areas (SEIFA)	Usage of hospital services 12 months prior to the index admission: number of hospitalisations	Written evidence of follow-up information given by nurses
Distance to hospital	Usage of hospital services 12 months prior to the index admission: number of outpatient clinic attendances	Consistency of written discharge documentation among healthcare providers
Had general anaesthetic		Delay in issuing discharge summary (date of discharge summary being issued – date of discharge)
Had intensive care unit (ICU) stay		
Day of admission date		
Day of discharge date		
Number of co-diagnosis		

readmission.[21] Hospital readmission was operationalised as an unexpected hospitalisation within 30 days as measured from an index admission. The readmission is related to the principal diagnosis of the index admission. The identification of unplanned hospital readmissions in this study was based on the combination of admission type (emergency) and the principal diagnosis of the subsequent admission following the index admission. Because of the burden associated with extracting data from medical records, out of the initial dataset, 550 patients with readmissions were randomly selected and matched to 550 patients without readmissions by age, sex, principal diagnosis of the index admission, and proportion of principal diagnosis. The randomisation and matching was generated using Coarsened Exact Matching.[22] Due to the unavailability of medical records for some patients, the final number of paired patients was 470 (total patients = 940).

Sample size

Sample size was calculated based on the association between written discharge documentation and unplanned paediatric readmissions. Previous research[5] found the absence of a written discharge plan demonstrated an odds ratio (OR) of 1.55 for readmissions. Other substantive predictive variables, such as comorbidity, possessed ORs from 1.18 to 5.61.[2,23,24] Therefore, we consider OR for written discharge documentation to be suitable for a baseline power calculation. Assuming a rate of 40% written discharge absence/incompleteness from the larger data set, we would need 332 matched case-control pairs (with continuity correction; total = 664, for power = 0.8, and $\alpha = 0.05$) assuming the equal proportion of rehospitalisations in each group.[25] Given our current sample size of 940, we have the power to detect a variable with an OR of 1.45.

Machine learning methods can sometimes require a substantially larger sample size. We therefore used multiple machine learning methods with specific reference to methods that use strong regularisation (e.g. the elastic net) – recommended for situations with a high variable to sample size ratio – and looked for consistency across algorithms for identifying important variables.

Extracted variables

Three groups of variables were analysed (Table 1). The first group (16 administrative variables) were extracted from the initial electronic dataset; the second group (11 clinical information variables) were extracted from patients' medical records; and the third group (13 variables on written discharge documentation) were extracted from the last written entry of healthcare providers in patient progress notes and/or from clinical care pathway. The data extraction was completed by HZ, using a data collection form to ensure consistency. PRD was consulted with any queries. The written discharge documentation variables were initially extracted from patients' medical records and then categorised as 'Yes/No/Not Applicable'. In particular, the *Nursing Admission and Discharge Planning Form* consists of multiple entry areas to be recorded (this form is divided in two sections, Admission and Discharge Planning); our categorisation of 'completeness' was made when all areas of the form were recorded. Partially recorded forms were considered 'incomplete'. The filled contents of the form were extracted and assessed against variables of 'Significant social history (legal custody or patient was under the care of the Department for Child Protection)', 'language spoken other than English', 'known allergies', 'discharge information', 'discharge medication information', and 'follow-up information'.

Missing data

The numbers of missing values were as follows: Significant social history (0 without readmission, 1 with readmission); Source of referral transport (55 without readmission, 59 with readmission); and Completeness of *Nursing Admission and Discharge Planning Form* (6 without readmission, 14 with readmission). Missing data were imputed by random forest imputation using the missForest package in R.[26] This method performs well compared with other imputation procedures, and is able to impute continuous and categorical data, and allows for interactive and non-linear effects. We used default parameter settings from missForest (number of trees = 100, and max iterations = 10).

Statistical analysis

Data processing and analyses were conducted in R (version 3.5.1).[27]

Model comparison of the three sets of variables

This study was interested in whether a group of variables improved prediction, and, to reduce the number of comparisons, we compared three groups of variables by sequentially fitting three logistic regression models: (1) Administrative variables only; (2) Administrative and clinical variables; (3) Administrative, clinical, and written discharge documentation variables.

Analysis of deviance with Chi-squared (χ^2) test was used for determining significance. Analysis of individual variables was not conducted at this stage, but is included in Table 2 for comparison. To complement the logistic regression we used machine learning to highlight variables of relevance for prediction.

Prediction models

Multiple methods were used to ensure consistency and robustness across models, and included logistic regression, stepwise logistic regression, random forest, elastic net, and gradient boosted trees. Performance was evaluated using the C-statistic across the ten repeats of the ten-fold cross-validation.

Stepwise regression methods are standard selection methods in the relevant, existing literature. The 'glmStepAIC' method within the 'caret' package[28] was used for forward stepwise selection to the logistic regression model with the Akaike information criteria (AIC) penalty. Backward elimination gave the same results as forward elimination; therefore, only forward elimination is reported.

Elastic net mixes two regression penalty methods: least absolute shrinkage and selection operator (LASSO)[29] penalty, and ridge penalty.[30] It provides stable and sparse estimates of model parameters. The LASSO penalty produces sparse predictor matrices by shrinking variables, with a proportion shrunk to 0. The ridge penalty shrinks smoothly all coefficients towards 0, while retaining all variables in the model. We used the 'glmnet' package within 'caret' to perform the elastic net. Optimal parameters were evaluated using grid search (α and λ between 0 and 1, with 0.02 step increments).

Random forests build multiple decision trees to create a 'forest' of trees. Each tree is built on a bootstrapped sample of the training data and, at each split, a random subset of the features are chosen for prediction. The number of variables randomly sampled at each split ranged from 2 to 10, in steps of 2. We used the 'randomForest'[31] implementation within 'caret'.

Gradient boosted decision trees are similar to random forests. Trees are iteratively grown using the outcomes from a previously grown tree, applying a larger weighting to the errors from the previous tree's classifications. The 'xgboost' implementation[32] within 'caret' was used. The following tuneable parameters were determined by grid search: interaction depth (from 1 to 5), fraction of variables randomly sampled for each tree (0.1, 0.2, 0.5), and minimum loss reduction to make a split $\gamma = 3, 5, 7$. The learning rate $\eta = 0.01$, and number of trees = 500.

Multiple methods were used to ensure consistency and robustness across models, and included logistic regression, stepwise logistic regression, random forest, elastic net, and gradient boosted trees. These specific methods were selected primarily because they represent the most commonly used methods in the current hospital readmission literature.

Variable selection

For models with in-built selection (stepwise regression, gradient boosted tree, and elastic net), variable selection was done through the model fitting procedure. For the random forest, we selected the top ten variables according to their variable importance. Supplementary Table S1 presents the relative variable importance for the random forest algorithm. The built-in 'varImp' function from the 'caret' package was used to calculate importance. Variable importance quantifies the relative contributions of each variable to the model, defined as the number of times a variable is selected for splitting, weighted by the improvement to the model, and averaged.

Results

Patients' characteristics, based on the three groups of variables, for the with-readmission group and without-readmission group, are presented in Table 2. The length of the index admission (mean ± s.d.) was longer in the with-readmission group compared with the without-readmission group (3.3 ± 6.6 vs 3.0 ± 6.9 days). Patients with significant social history were almost doubled in the with-readmission group compared with the without-readmission group (52 (11.1%) vs 8 (6.0%)). Five patients in the with-admission group required interpreter service but none in the without-readmission group required this service. The mean length of delay in issuing a discharge summary was longer in the with-readmission group compared with the without-readmission group (22.9 ± 39.9 vs 16.8 ± 34.3 days).

Comparison of administrative, administrative and clinical, and administrative, clinical, and written discharge documentation variable groups

The improvement in prediction of unplanned hospital readmissions for each set of variables (administrative, administrative and clinical, and administrative, clinical, and written discharge

Table 2. Characteristics of patients with readmission and without readmission

Data are presented as mean±s.d. or *n* (%) unless otherwise noted. LOS, length of stay; SEIFA, Socioeconomic Indexes for Areas; ICU, intensive care unit; ED, emergency department

Variables		Patients with readmission		Matched patients without readmission		χ^2/*t*-test	d.f.	*P*-value
		n = 470		*n* = 470				
		Mean ± s.d. *n* (%)	Median (10th, 90th percentile)	Mean ± s.d. *n* (%)	Median (10th, 90th percentile)			
Administrative	Age	5.2 ± 4.7	3 (0, 13)	5.3 ± 4.7	4 (0, 13)	0.36	938.0	0.72
	LOS at index admission	3.3 ± 6.6	1 (0, 7)	3.0 ± 6.9	1 (0, 5.1)	0.63	936.4	0.53
	SEIFA percentile	64 ± 28	68.5 (22, 96.5)	62 ± 27	67 (20, 95)	0.50	927.9	0.62
	Distance from residential address to hospital	63 ± 135	18 (7, 98)	75 ± 148	18 (7, 238)	1.25	921.5	0.21
	No. co-diagnoses	2.3 ± 1.9	2 (1, 4)	2.2 ± 2.0	2 (1, 4)	0.92	930.7	0.36
	Sex (female/male)	272 (57.9)/198 (42.1)		272 (57.9)/198 (42.1)		0.00	1.0	1.00
	Admission status (elective/emergency)	368 (78.3)/102 (21.7)		373 (79.4)/97 (20.6)		0.10	1.0	0.75
	Funding source as an inpatient (Medicare/private health insurance/other)	424 (90.2)/9 (1.9)/37 (7.9)		427 (90.9)/13 (2.7)/30 (6.4)		1.50	2.0	0.48
	State/Territory of residence (Western Australia/other)	468 (99.6)/2 (0.4)		466 (99.1)/4 (0.9)		0.17	1.0	0.68
	Insurance status (private/public)	245 (52.1)/225 (47.9)		250 (53.2)/220 (46.8)		0.07	1.0	0.79
	Source of referral transport (ambulance/aeromedical/private transport)	338 (71.9)/2 (0.4)/71 (15.1)		338 (71.9)/6 (1.3)/71 (15.1)		1.99	2.0	0.37
	Care type (acute care/other)	462 (98.3)/8 (1.7)		464 (98.7)/6 (1.3)		0.07	1.0	0.79
	Had general anaesthetics (no/yes)	271 (57.7)/199 (42.3)		272 (57.9)/198 (42.1)		0.00	1.0	1.00
	Had ICU stay (no/yes)	460 (97.9)/10 (2.1)		465 (98.9)/5 (1.1)		1.08	1.0	0.30
	Day of admission date (Monday to Sunday)	75 (16.0)/55 (11.7)/92 (19.6)/75 (16.0)/65 (13.8)/54 (11.5)/54 (11.5)		73 (15.5)/69 (14.7)/83 (17.7)/65 (13.8)/68 (14.5)/64 (13.6)/48 (10.2)		4.05	6.0	0.67
	Day of admission date (weekday/weekend and public holiday)	351 (74.7)/119 (25.3)		355 (75.5)/115 (24.5)		0.05	1.0	0.82
	Day of discharge date (Monday to Sunday)	59 (12.6)/67 (14.3)/69 (14.7)/86 (18.3)/79 (16.8)/52 (11.1)/58 (12.3)		77 (16.4)/72 (15.3)/78 (16.6)/65 (13.8)/76 (16.2)/49 (10.4)/53 (11.3)		6.41	6.0	0.38
	Day of discharge date (weekday/weekend and public holiday)	350 (74.5)/120 (25.5)		358 (76.2)/112 (23.8)		0.28	1.0	0.60
Clinical	No. hospital admissions in the previous 12 months	1.2 ± 1.3	1 (0, 2)	1.0 ± 0.7	1 (0, 1)	4.82	535.7	<0.01
	No. ED presentations in the previous 12 months	0.8 ± 2.7	0 (0, 2)	0.1 ± 0.7	0 (0, 0)	4.31	712.5	<0.01
	No. outpatient clinic attendances in the previous 12 months	2.3 ± 7.4	0 (0, 4)	0.9 ± 5.5	0 (0, 1)	3.37	861.4	<0.01
	No. significant laboratory results	1.6 ± 3.5	0 (0, 7.2)	1.5 ± 3.4	0 (0, 5)	0.50	937.6	0.62
	No. significant imaging results	1.0 ± 2.2	0 (0, 3)	0.9 ± 2.0	0 (0, 3)	0.92	929.4	0.36
	No. significant vital signs	1.3 ± 1.9	0 (0, 4)	1.2 ± 1.8	0 (0, 3)	1.35	934.3	0.18
	No. past medical history recorded in the progress notes	1.1 ± 1.7	1 (0, 3)	0.6 ± 1.0	0 (0, 2)	5.64	776.2	<0.01
	Significant social history (no/yes)	417 (89.0)/52 (11.0)		442 (94.0)/28 (6.0)		7.28	1.0	<0.01
	Language spoken other than English (no/yes/interpreter service required)	456 (97.0)/9 (2.0)/5 (1.0)		460 (97.9)/10 (2.1)/0 (0)		5.07	2.0	0.08
	Added new medication at discharge upon regular medications (no/yes)	438 (93.1)/32 (6.9)		445 (94.7)/25 (5.3)		0.67	1.0	0.41
	History of allergies (no/yes)	428 (91.1)/42 (8.9)		422 (89.8)/48 (10.2)		0.31	1.0	0.58

(*Continued*)

Variables		Patients with readmission $n = 470$ Mean ± s.d. n (%)	Patients with readmission $n = 470$ Median (10th, 90th percentile)	Matched patients without readmission $n = 470$ Mean ± s.d. n (%)	Matched patients without readmission $n = 470$ Median (10th, 90th percentile)	χ^2/*t*-test	d.f.	*P*-value
Written discharge documentation	Delay of issuing discharge summary (days)	22.9 ± 39.9	8 (0, 68)	16.8 ± 34.3	6 (0, 41)	2.38	844.2	0.02
	Completeness of *Nursing Admission and Discharge Planning Form*, Admission section (yes/no)	232 (49.4)/224 (47.7)		271 (57.7)/193 (41.1)		4.96	1.0	0.03
	Completeness of *Nursing Admission and Discharge Planning Form*, Discharge Planning section (yes/no)	218 (46.4)/238 (50.6)		272 (57.9)/192 (40.9)		10.40	1.0	0.01
	Progress note or operation sheet last entry by doctors (yes/no)	454 (96.6)/16 (3.4)		452 (96.2)/18 (3.8)		0.03	1.0	0.86
	Progress note or *Clinical Pathway* last entry by nurses (yes/no)	426 (90.6)/44 (9.4)		441 (93.8)/29 (6.2)		2.90	1.0	0.09
	Progress note last entry by allied healthcare providers (yes/no)	371 (78.9)/99 (21.1)		389 (82.8)/81 (17.2)		1.99	1.0	0.16
	Discharge information documented by doctors (yes/no)	454 (96.6)/16 (3.4)		456 (97.0)/14 (3.0)		0.03	1.0	0.85
	Discharge information documented by nurses (yes/no)	431 (91.7)/39 (8.3)		444 (94.5)/26 (5.5)		2.90	2.0	0.23
	Discharge medication information documented by doctors (yes/no/not applicable)	277 (58.9)/188 (40.0)/5 (1.1)		262 (55.7)/202 (43.0)/6 (1.3)		1.01	2.0	0.60
	Discharge medication information documented by nurses (yes/no/not applicable)	262 (55.7)/186 (39.6)/22 (4.7)		253 (53.8)/204 (43.4)/13 (2.8)		3.30	2.0	0.19
	Follow-up plan documented by doctors (yes/no/not applicable)	436 (92.8)/21 (4.5)/13 (2.8)		433 (92.1)/16 (3.4)/21 (4.5)		2.57	2.0	0.28
	Follow-up plan documented by nurses (yes/no/not applicable)	387 (82.3)/70 (14.9)/13 (2.8)		382 (81.3)/67 (14.3)/21 (4.5)		1.98	2.0	0.37
	Consistency of written discharge information documented among healthcare providers (yes/no)	364 (77.4)/106 (22.6)		376 (80.0)/94 (20.0)		0.77	1.0	0.38

Table 3. Model performance comparison

Analysis approaches	C-statistics/Mean	C-statistics/s.d.	Sensitivity	Specificity
Model 1: Administrative model				
Logistic regression	0.487	0.066	0.506	0.465
Stepwise logistic regression	0.477	0.049	0.531	0.444
Random forest	0.519	0.061	0.533	0.503
Elastic net	0.5	0	1	0
Gradient boosted tree	0.509	0.045	0.507	0.507
Model 2: Administrative + clinical model				
Logistic regression	0.585	0.051	0.653	0.468
Stepwise logistic regression	0.593	0.058	0.708	0.451
Random forest	0.603	0.054	0.679	0.46
Elastic net	0.616	0.047	0.836	0.358
Gradient boosted tree	0.624	0.054	0.869	0.319
Model 3: Administrative + clinical + written discharge documentation model				
Logistic regression	0.609	0.054	0.646	0.514
Stepwise logistic regression	0.617	0.05	0.654	0.512
Random forest	0.642	0.052	0.652	0.521
Elastic net	0.635	0.048	0.753	0.414
Gradient boosted tree	0.654	0.053	0.774	0.439

documentation) was sequentially assessed using logistic regression model comparison with standard significance testing. A model with only administrative variables did not significantly improve prediction (administrative model vs intercept only model, $\chi^2_{32} = 27.4$, $P = 0.70$). By contrast, the inclusion of clinical variables significantly improved prediction over the administrative-only model ($\chi^2_{12} = 86.1$, $P < 0.01$), and the inclusion of written discharge documentation variables further improved prediction over the administrative and clinical variables model ($\chi^2_{17} = 29.4$, $P = 0.03$).

Prediction model performance of standard logistic regression to machine learning approaches

Prediction performance for each method obtained from the 10 × 10-fold cross-validation is presented in Table 3. The best performing prediction model according to the mean receiver operating curve (ROC) statistic (C-statistic) was the gradient boosted tree model using all three sets of variables (administrative, administrative and clinical, and administrative, clinical, and written discharge documentation), followed closely by the random forest and elastic net. Consistent with the logistic regression above, models using only administrative data performed no better than chance, and substantial improvements in the C-statistic were seen by including clinical and written discharge documentation data.

Fig. 1 presents the ROC curves for each machine learning algorithm. ROC curves were extracted from the predictions of the 10 × 10-fold cross-validation.

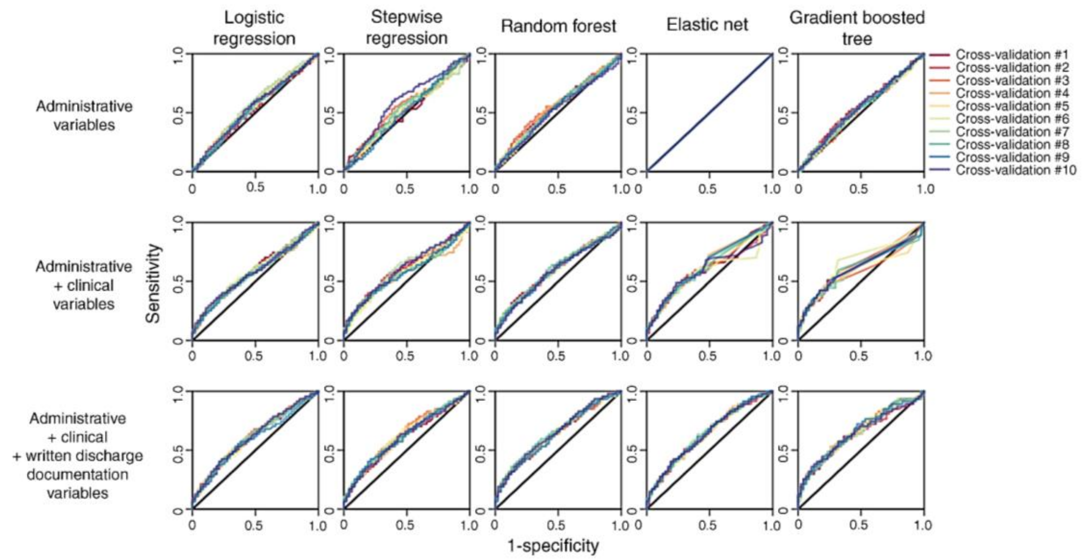

Fig. 1. Receiver operating characteristic (ROC) curve of 10-fold cross validations of each predictive modelling approaches.

Variables included in the prediction models

Table 4 presents the variables selected for each model. Due to the failure of the administrative data analysed in isolation to provide predictions above chance, variable selections for Model 1 are considered unreliable and are marked with a circle for comparison purposes.

There was considerable concordance in the variables deemed useful for prediction across models. Principally, variables representing clinical information, including usage of hospital services within the past 12 months (number of admissions, emergency department (ED) presentations, and outpatient clinic attendance), number of past medical histories recorded in the progress notes, social history, and language spoken other than English were selected across multiple models, including by the elastic net. Variables relating to written discharge documentation were also selected, including completion of nursing admission and discharge planning documentation and date of discharge summary issued. The elastic net did not select any administrative variable and the gradient boosted tree selected only one administrative variable in Model 3 (distance from the hospital).

Languages spoken other than English/interpreter services requirement was selected by the elastic net and stepwise logistic regression models. It is worth noting that a total of five patients in the dataset required interpreter service at the index admission and all of them experienced 30-day unplanned readmission. The low cell count potentially precludes the variable from emerging as a useful predictor in other models, and suggests caution in interpreting the influence of this variable given the low count.

Discussion

We present a matched case-control study using retrospective analysis of patients' medical records to identify paediatric 30-day all-cause same-hospital unplanned readmissions. Model prediction improvements were identified when adding clinical information and written discharge documentation compared with the available administrative data. Previous paediatric studies[3,11–14,33–35] reported predictive model performance, with only one study[34] examining both clinical and administrative data by reviewing patients' medical record charts. Previous studies that have applied machine learning to paediatric readmission prediction obtained similar [13] or better performance[11,12] to the current study. However, our study used a matched case-control design, with matching across age, sex, and diagnosis that may better identify factors contributing to readmission, distinct from diagnosis.

Four of the identified predictors in this study were consistent with previous research, including the number of hospitalisations prior to the index admission,[23] day of discharge,[36] LOS,[33] and the number of comorbidities.[2,23,24,33,37] Previous studies have also investigated socioeconomic status in terms of using the area-level deprivation[2,38] and type of health insurance.[24,33,37,38] This study extracted patients' significant social history (e.g. under the care of the Department for Child Protection) from their medical records and found a positive association with readmissions. The use of an interpreter service was also selected as a predictor of unplanned readmissions; however, interpreter service usage was only selected by two of the machine learning models (stepwise logistic regression and elastic net), suggesting some caution when interpreting the utility of this variable in predicting readmission. Furthermore, there is inconsistency in the literature with respect to this variable and how well it is able to predict readmission. Previous studies[6,39] that have examined whether speaking a language other than English was associated with unplanned hospital readmissions have been inconclusive due to low numbers of cases in the dataset,[40] as was the case in this study's dataset. Future studies could examine whether a

Table 4. Variables selected by each model

GLM, logistic regression; G-S, stepwise logistic regression; RF, random forest; EN, elastic net; XGB, gradient boosted tree

Variables		Model 1					Model 2					Model 3				
		GLM	G-S	RF	EN	XGB	GLM	G-S	RF	EN	XGB	GLM	G-S	RF	EN	XGB
Administrative	Age			○		○										
	Sex (male)			○												
	Insurance status (private)			○												
	Admission status (emergency)			○												
	Socioeconomic Indexes for Areas (SEIFA) percentile			○		○										
	Distance from residential address to hospital		○	○		○										X
	Length of stay at index admission			○		○			X					X		
	No. co-diagnosis			○		○			X					X		
	Had general anaesthetic at index admission			○		○							X			
	Source of referral transport (ambulance)			○		○							X			
	Day of discharge date		○			○	X	X	X			X	X			
	Day of admission date	○	○			○	X	X	X			X	X			
	Day of admission (weekday/weekend and public holiday)	○	○				X	X				X	X			
Clinical	No. admissions in the previous 12 months						X	X	X	X	X	X	X	X	X	X
	No. emergency department presentations in the previous 12 months						X	X	X	X	X	X	X	X	X	X
	No. outpatient clinic attendances in the previous 12 months								X		X			X	X	X
	No. past medical histories recorded in the progress notes						X	X	X	X	X	X	X	X	X	X
	Significant social history								X				X	X	X	X
	Language spoken other than English (interpreter service required)							X					X		X	
	Significant vital signs								X							
	Known allergies							X					X			
Written discharge documentation	Completeness of *Nursing Admission and Discharge Planning Form*, Discharge Planning section (incompleteness)											X	X	X	X	X
	Completeness of *Nursing Admission and Discharge Planning Form*, Admission section (incompleteness)												X	X	X	X
	Delay in issuing discharge summary													X	X	X
	Progress note or *Clinical Pathway* documentation at discharge by nurses (not recorded)												X			
	Follow-up information documented by doctors (not recorded)												X			

sample enriched in people requiring interpreter services contributes significantly to readmission.

Social history and English language proficiency are routinely assessed at the time of admission, and this study highlights the need for early commencement of discharge planning for these patients.[19] Patients identified as having significant social history at the time of admission require a designated hospital-based social worker to assess and provide social needs for the family/caregiver. The social worker should also collaborate with other healthcare providers to implement a discharge planning process that ensures continuity of care at home, post-discharge.[41] Interpreter services should be available throughout hospitalisation for families/caregivers with language barriers, and are crucial at the time discharge information is delivered by doctors and nurses. The 'teach-back process' is also recommended to ensure families'/caregivers' understanding of the discharge information.[42]

The quality of written discharge documentation was examined in this study. Incomplete nursing admission and discharge planning documentation, and delay in issuing discharge summaries were associated with unplanned readmissions. Previous research is inconsistent in reporting the association between written discharge documentation and readmissions. One study[5] found that not providing a written instructional discharge plan to caregivers of children with asthma resulted in a 1.55 times higher readmission rate. A second study[6] reported that having discharge follow-up plans contributed to readmissions; however, this result was possibly due to the low rate of primary care providers follow-up plan documentation in the discharge summary. A third study[4] examined the association between asthma patients who were given follow-up appointments and asthma patient readmissions, but the results were inconclusive. Completeness of discharge documentation may reflect on the level of comprehensiveness of discharge information conveyed to families/caregivers.[8] However, our study conducted limited research into what and how the discharge information is communicated between healthcare providers and families/caregivers. A clinical observational study is, therefore, required to explore communication practice at discharge. It is imperative to complete and distribute discharge summaries to the caregiver's/family's general practitioner prior to sending a patient home.[7,43] Discharge summaries contain detailed admission information for when the patient seeks medical advice following hospital discharge, and therefore may prevent unnecessary return ED visits or even unplanned readmissions.

This is the first known study using machine learning approaches to predict paediatric unplanned readmissions in Australia. Stepwise logistic regression, random forest, elastic net, and gradient boosted tree approaches were utilised and compared with standard logistic regression analysis. We found modestly greater prediction accuracy using machine learning for the identification of unplanned readmissions, especially using gradient boosted trees. Similarly, an adult population study[17] also found substantially improved prediction of unplanned hospital readmissions using machine learning.

A limitation of this study is that principal diagnosis of the index admission was not examined as a predictor because it was used to match cases and controls. This study is also limited by a specified local context of WA. In comparison to the literature, this study was based on 470 matched case-controls, a small sample size, due to the difficulty and cost of auditing patients' medical records. Therefore, use of electronic medical records is warranted to allow easy access not only to clinical information but also to written discharge documentation information. A larger sample size is also required to further leverage the benefit of machine learning approaches in the development of predictive models for unplanned paediatric readmissions, as we used a highly constrained approach to prevent overfitting. This retrospective cohort study used historical data from 2010 to 2014, which may reduce the relevance to current clinical practice. However, risk factors associated with paediatric unplanned hospital readmissions have remained stable over the last decade, based on our recently published systematic review,[1] indicating that the datasets used in this study provided relevant information regarding current readmission factors.

Conclusions

Adding clinical information and written discharge documentation demonstrated incremental improvements in prediction of paediatric unplanned hospital readmissions. Machine learning approaches, especially gradient boosted trees, achieved improved prediction accuracy over standard logistic regression analysis. Social and written discharge documentation variables including social history, poor English language proficiency, incomplete discharge documentation, and delay in issuing discharge summary, add value to prediction and our understanding of unplanned hospital readmissions. These predictors could also be translated into clinical practice of discharge planning to help prevent paediatric 30-day all-cause same-hospital unplanned readmission.

Competing interests

The authors have no competing interests to declare.

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4.5 Publication 7

Zhou, H., Roberts, P.A., & Della, P.R. (2021). Nurse-caregiver communication of hospital-to-home transition information at a tertiary pediatric hospital in Western Australia: A multi-stage qualitative descriptive study. *Journal of Pediatirc Nursing*, *60*, 83–91. https://doi.org/10.1016/j.pedn.2021.02.017

This publication addressed Study Objective 6: To observe and describe nurse-caregiver communication of pediatric hospital-to-home transition information.

The *Journal of Pediatric Nursing* was selected for this publication as it is the Official Journal of the Society of Pediatric Nurses and the Pediatric Endocrinology Nursing Society; the *Journal of Pediatirc Nursing* publishes evidence-based practice and research articles pertinent to the nursing care needs of healthy and ill infants, children, and adolescents, addressing both physical and psychosocial needs. The impact factor of JPN is 1.495 in 2020. Confirmation of adherence to copyright requirements is evidenced in Appendix A.4.

Specific objectives of Publication 7 were:

- To observe the hospital-to-home transition experience, including communication of information between nurses and caregivers at discharge;
- To examine content and delivery of transition information at discharge;
- To explore caregivers' views of transition information, communication practice and the recovery experience post-discharge;
- To explore nurses' views of transition information communication practice;
- To examine patients' usage of hospital services within 30 days of discharge.

Main findings of Publication 7 were:

- Across the three admitting diagnoses/procedures, six common components of verbally delivered hospital-to-home transition information are diagnosis/procedure and treatments information, expected symptoms, continuity of care required at home, when and where to seek medical assistance, follow up requirements post-discharge, and confirmation of caregivers' understanding of information. The structure of transition information delivery varied depending on the three diagnoses/procedures.
- Duration of nurse-caregiver communication and delivering transition information primarily depended on nurses' experience and speciality area.

- Caregivers were overwhelmed with the amount of information, and others felt the information was inadequate and/or inconsistent. Some caregivers perceived their child was not ready for discharge and felt uncertain about providing care at home.
- Eight caregivers reported delayed recovery post-discharge from unexpected health issues.
- Seven presented to the Emergency Department within 2–19 days post-discharge, of which three were readmitted.
- Primary caregivers of the three readmitted patients had limited English proficiency and were not present when the transition information was provided.

Journal of Pediatric Nursing 60 (2021) 83–91

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Nurse-caregiver communication of hospital-to-home transition information at a tertiary pediatric hospital in Western Australia: A multi-stage qualitative descriptive study

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A B S T R A C T

Purpose: To observe and describe nurse-caregiver communication of hospital-to-home transition information at the time of discharge at a tertiary children's hospital of Western Australia.

Design and methods: A multi-stage qualitative descriptive design involved 31 direct clinical observations of hospital-to-home transition experiences, and semi-structured interviews with 20 caregivers and 12 nurses post-discharge. Eleven caregivers were re-interviewed 2–4 weeks post-discharge. Transcripts of audio recordings and field notes were analyzed using content analysis. Medical records were examined to determine patients' usage of hospital services within 30 days of discharge.

Results: Four themes emerged from the content analysis: structure of hospital-to-home transition information; transition information delivery; readiness for discharge; and recovery experience post-hospital discharge. Examination of medical records found seven patients presented to the Emergency Department within 2–19 days post-discharge, of which three were readmitted. Primary caregivers of three readmitted patients all had limited English proficiency.

Conclusion: The study affirmed the complexity of transitioning pediatric patients from hospital to home. Inconsistent content and delivery of information impacted caregivers' perception of readiness for discharge and the recovery experience.

Practice implications: Nurses need to assess readiness for discharge to identify individual needs using a validated tool. Inclusion of education on hospital-to-home transition information and discharge planning/process is required in the orientation program for junior and casual staff to ensure consistency of information delivery. Interpreter services should be arranged for caregivers with limited language proficiency throughout the hospital stay especially when transition information is being provided. Nurses should apply teach-back techniques to improve caregivers' comprehension of information.

Introduction

Transitioning patients within and across healthcare facilities, including hospital to home, is recognized as a complex process. Insufficient planning and lack of continuity of care for patients post-transition may result in adverse outcomes, such as unplanned Emergency Department (ED) presentations or hospital readmissions (Desai et al., 2015; Zhou et al., 2019). Children are at a greater risk as caregivers need to negotiate post-transition care (Glick et al., 2017; Lerret, 2009).

Research evidence on effectiveness of transition communication and pediatric discharge experience is limited and inconsistent. Children experienced unproblematic or prolonged recovery periods post-hospital discharge with some requiring re-hospitalization (Ford et al., 2012). The impact of post-hospital discharge on caregivers includes not only physical strain of juggling the child, family and work commitments, but also psychological stress of monitoring the child's well-being (Ford et al., 2012; Pinto et al., 2015). Providing comprehensive post-discharge information is associated with a higher level of caregivers' readiness for discharge and lower unplanned hospital readmission rates (Lerret et al., 2015; Parikh et al., 2018). Poor communication of post-discharge information increases the risk of a patient experiencing an adverse outcome (Harlan et al., 2010). Readiness for discharge in this study refers to caregivers' perceptions of whether they feel ready

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Journal of Pediatric Nursing 60 (2021) 83–91

to take their child home and understand fully the care required post-hospital discharge.

Terminology to describe communication of discharge information is inconsistent varying from education sessions (Lerret et al., 2015; Weiss et al., 2017) to sharing information sessions (Elliott et al., 2014; Keatinge et al., 2009). The fundamental purpose of provider-caregiver discharge information is to facilitate continuity of care. In the context of this study, communication of discharge information is referred to as hospital-to-home transition information. Research evidence has mainly been collected via questionnaires and interviews with healthcare providers and parents. Direct observation of the delivery of transition information communication between nurses and caregivers at discharge is scarce.

Transition theory recognizes hospital discharge as a period of vulnerability for pediatric patients due to the requirements for ongoing medical care or close monitoring at home (Meleis et al., 2000; Meleis & Trangenstein, 1994). Transition theory consists of four significant components: nature of the transition, nursing therapeutics, transition conditions and patterns of response. Transition theory was used in this research to inform and facilitate conceptualization and selection of study methods. The nature of the transition is reflected by characteristics of admission, discharge and location; while the child, nurse and caregiver represent transition conditions. Nursing therapeutics refers to hospital-to-home transition information delivery to prepare caregivers in providing continued care for their child at home. Patterns of response include perceptions of nurse-caregiver communication of transition information, recovery experience and utilization of healthcare services. The linkages between the transition theory components, study focus and methods are outlined in Table 1.

Transition Theory framed our study purpose to observe and describe the experience of nurse-caregiver communication of hospital-to-home transition information on the day of discharge using three health conditions, which are associated with frequent unplanned hospital readmissions. Specific objectives included:

(1) To observe the hospital-to-home transition experience including communication of information between nurses and caregivers at discharge;
(2) To examine content and delivery of transition information at discharge;
(3) To explore caregivers' views of transition information, communication practice and the recovery experience post-discharge;
(4) To explore nurses' views of transition information communication practice; and
(5) To examine patients' usage of hospital services within 30 days of discharge.

Design and methods

Study design, setting, and sampling

A 3-stage qualitative descriptive research design was selected: direct clinical observations, semi-structured interviews, and medical records audit. Data collection spanned from October 2017 to February 2018. Purposive sampling was used to ensure a variety of health conditions, and inpatient care settings were explored. Children admitted for tonsillectomy and/or adenoidectomy, appendectomy, and bronchiolitis were selected. These diagnoses were previously identified as those most frequently associated with unplanned hospital readmissions (Zhou, Della, Roberts, Porter, & Dhaliwal, 2018). Three wards from a Western Australian tertiary pediatric hospital were selected as a short-stay surgical unit, general surgical and medical ward. Caregivers of children and

Table 1
Linkage between the transitions theory and study focus and methods.

Transitions theory	Nature of the transition	Transition conditions	Nursing therapeutics	Patterns of response
Application of Components	Descriptors of the type, pattern, and properties of a transition	Personal, Community or Society related conditions impact transition progress	Focuses on the transitions care at discharge from an acute hospital to home to ensure continuity of care post-discharge The nursing strategy is communicating with caregivers in regards the hospital-to-home transition information	Process indicators - Comprehension of hospital-to-home transition information Outcome indicators - Recovery experience and utilization of healthcare services post-discharge
Study focus	Characteristics of the admission: Principal diagnosis, Length of stay	Characteristics of child: Age, Gender	Hospital-to-home transition information communication between nurses and caregivers at discharge	Caregivers' views of transition information communication practice and experience immediately post-discharge
	Characteristics of the discharge: Date and time of discharge	Characteristics of caregivers: Age, Gender, employment status, highest educational qualification, Language spoken at home, primary caregiver at home if different from adult at discharge	Duration, content and delivery of transition information by nurses at discharge	Nurses' views of transition information communication practice post discharging the patient
	Characteristics of the inpatient ward and room: Number of beds in the room, Noise level, Source of noise	Characteristics of nurses: Job position, Specialty area, Age, Years of nursing experience, Years of current hospital working experience		Caregivers' views on usefulness of transition information and the recovery experience 2–4 weeks post-discharge Patients' usage of hospital services within 30 days of discharge Unplanned Emergence Department visit Unplanned hospital readmission
Study Methods	Examination of patient's medical records Direct observation using checklist	Hard copy survey questions following interview		Direct clinical observation of nurse-caregiver communication at discharge Semi-structured interview with (1) caregivers immediately & 2–4 weeks post-discharge (2) nurses post discharging patients Audit of patient's medical records

nurses who delivered transition information were invited to participate. Potential participants were given a written information sheet explaining the research and data collection methods. It is acknowledged that the caregiver at discharge who received transition information may not be the primary caregiver, who cared for the child at home.

Data collection procedures

Stage 1 involved direct clinical observations, including observation and transcription of the audio recordings of communication between caregivers and nurses at the time of discharge (Dyrstad et al., 2015). An observational checklist was developed based on the *Calgary – Cambridge Guides Communication Process Skills.* The *Calgary* checklist is an established and validated observational instrument to evaluate a practitioner's communication skills (Kurtz et al., 2005; Simmenroth-Nayda et al., 2014). The observation checklist was used to capture interactions between nurses and caregivers in the discharge context, noting rapport development, non-verbal behavior, language usage, engagement of patient and caregiver, and quality of discharge information delivery. Additional items were added to the checklist form to provide context to the discharge environment, including physical location of the patient, caregiver and nurse (Appendix). A panel of experts, including academics and nurses, reviewed the checklist, which was then approved by the hospital ethics committee. Thirty observations were planned (Bernard, 2000; Morse, 1994). If data saturation was not reached after the first 30, further observations would be carried out until three consecutive observations identified no new themes (Francis et al., 2010).

The first author completed all the direct clinical observations. Patients who might be discharged on the same or following day were identified at handover. Caregivers and nurses were approached by the researcher, who explained the research and inviting them to participate. To minimize the impact of the researcher's presence on participants' behavior, a discreet and appropriate distance was maintained, remaining sufficiently close to observe (Green et al., 2007). The discharge experience was observed once the decision for discharge had been agreed by the treating doctor and when the nurse, who provided direct care, was ready to communicate with caregiver/patient in regards to the discharge process. Each conversation between nurse and caregiver/s were digitally recorded. Field notes were taken to capture the flow of communication and to provide additional information (Phillippi & Lauderdale, 2017). Characteristics of all participants were obtained including age, gender, educational background and employment type. Each observed discharge experience was completed when the nurse concluded the conversation with caregiver/patient and advised the caregiver/patient they could be discharged.

In stage 2, semi-structured interviews were conducted and recorded with each nurse and caregiver on patient discharge. Caregivers were interviewed for their views of (1) discharge experience; (2) verbal and non-verbal communication practice of nurses; (3) recall and comprehension of transition information using teach-back techniques (Griffey et al., 2015; White et al., 2013); and (4) readiness for discharge. Nurses were then interviewed about their views on the discharge experience. Interviews were conducted in private and were audio-recorded. Two to four weeks following discharge, the same caregiver were re-interviewed and asked about the usefulness of care transition information they received and the child's recovery experience. Caregiver interviews were conducted via phone and digitally recorded.

The final stage of data collection examined patients' medical records to determine patient's utilization of hospital services within 30 days following discharge (unplanned ED presentation and hospital readmission).

Data analysis

Audio recordings of direct clinical observations and interviews were transcribed verbatim (Graneheim & Lundman, 2004). All transcriptions were read and re-read to allow for immersion of data (Green et al., 2007). Content analysis of the transcripts and field notes were undertaken by the first author using NVivo 11, a qualitative data analysis computer software package, and the second author using a manual coding process (Hsieh & Shannon, 2005). The first author assigned initial nodes/codes to segments of text based on similar meaning words. The nodes/codes were then organized as themes and subthemes (Graneheim & Lundman, 2004). Simultaneously, the second author independently coded transcripts manually using the inductive approach based on the categorization and classification of meaningful texts (Green et al., 2007). This lead to the emergence of themes and subthemes. The first and second authors discussed the themes and consulted with the third author until consensus was achieved (Graneheim & Lundman, 2004). Data were organized into the three principal procedures/diagnosis, and then each was compared with others. Differences and similarities across themes based on principal diagnosis/procedures were identified.

Ethics

Ethical approval was obtained from the Human Research Ethics Committee of the Child and Adolescent Health Service (2015015EP) and the Curtin University (HR184/2015), Western Australia. Informed written consents were obtained from caregivers and nurses before commencing data collection. Participants were informed their participation in this study was voluntary, and they could withdraw at any time.

Results

The results are presented according to the three data collection stages used in the study.

Stage 1 – clinical direct observations

Participant characteristics included the patients, nurses and caregivers. A total of 31 hospital-to-home transition experiences were observed. Patient characteristics were grouped based on the patients' principal diagnosis/procedure (Table 2). Thirteen patients had appendectomy procedures for an inflamed or perforated appendix. Ten patients had a tonsillectomy and/or adenoidectomy, and eight were admitted with bronchiolitis requiring oxygen therapy and/or nasogastric feeds. Seventeen were male and four female. Patient ages varied from 1 to 14 months (bronchiolitis), 2–9 years (tonsillectomy/adenoidectomy), and 3–15 years (appendectomy). Length of hospital stay ranged from 2 to 25 days with an average stay of 4.3 days.

Primary caregivers were all females; however, seven were not present at their child's discharge (Table 3). Twenty-seven caregivers provided their age, which ranged from < than 30 years ($n = 12$), 31–40 years ($n = 10$), > than 41 years ($n = 5$). Nine caregivers had either Bachelor Degree or Master Degree, and 18 were employed. Five families spoke a language other than English at home, including Indian, Nepalese, Arabic, or Vietnamese.

Twenty-four nurses were involved in the delivery of transition information, 16 were registered nurses (Table 3). Length of employment ranged from less than a year to over 30 years, with the average seven years. Eight nurses were younger than 25 years and four older than 51 years.

Of the 31 observed hospital-to-home transition experiences, 22 nurses and caregivers gave permission to record their conversation. Seven caregivers and two nurses felt uncomfortable being recorded but allowed the researcher to observe and take field notes. All discharge encounters took place in the patient's room. Ten discharge encounters occurred with noise in the background; only one caregiver asked for a game volume to be turned down. Twenty-one patients were discharged on a weekday and 10 over weekends. Twenty-two patients were

H. Zhou, P.A. Roberts and P.R. Della

Journal of Pediatric Nursing 60 (2021) 83–91

Table 2
Characteristics of patients, discharge information delivery process, and healthcare services usage following discharge.a

Study ID	Age (year)	Gender	Ward	LOS (Day)	Day of discharge	Time of discharge (HH: MM)	Duration of nursing discharge (MM: SS)	Number of bed per room	Room noise level	Source of noise	Use of PMH services post discharge (day)		
											Ward Contact	ED Visit	UHR/LOS
Tonsillectomy ± Adenoidectomy													
1	6	Male	A	4	THU	10:45	11:45	2	Quiet			D-5	
3	6	Female	A	2	FRI	09:30	05:26	2	Quiet				
4	9	Female	A	2	FRI	10:30	07:46	2	Quiet				
5	6	Male	A	2	FRI	13:35	13:10	6	Mod-High	Other patient			
7	2	Female	A	2	SAT	09:20	04:39	6	Mod-High	Other patient			
8	7	Male	A	2	SAT	10:00	09:29	2	Quiet			D-9	
9	4	Female	B	3	SUN	11:50	09:02	1	Mod	TV/Games		D-2	
13	4	Male	B	2	SAT	10:30	06:53	3	Quiet				
14	6	Female	B	2	SAT	11:00	08:00	1	Low	TV/Games			
23	3	Male	B	2	FRI	09:45	05:45[a]	3	Low	Other parents	D-5		
Appendectomy													
2	10	Female	A	2	THU	10:30	03:30	2	Quiet				
6	8	Male	A	2	FRI	13:00	06:26	6	Low -Mod	Other parents			
10	8	Male	A	3	TUE	10:30	05:01	6	Low -Mod	Other parents			
11	15	Male	A	2	TUE	13:00	01:36[a]	2	Quiet				
12	6	Male	A	2	TUE	18:35	02:56[a]	2	Quiet				
15	7	Male	B	5	SAT	14:30	05:55	1	Quiet				
16	11	Male	B	4	MON	11:30	05:42	4	Low	Other patient			
19	10	Male	A	2	THU	12:00	01:15	2	Quiet				
20	5	Male	A	5	FRI	09:50	09:11	6	Low	Other parents	D-0		
24	11	Female	B	14	FRI	09:50	03:55[a]	2	Quiet				
25	11	Male	B	8	SUN	11:00	03:05[a]	1	Quiet				
30	3	Male	B	25	TUE	14:30	10:32	1	Low	TV/Games		D-2	
31	9	Female	B	7	MON	12:20	03:36	1	Quiet				
Bronchiolitis													
17	7/12	Male	C	3	TUE	11:00	00:15	1	Quiet				
18	10/12	Female	C	4	THU	9:50	04:27	1	Quiet			D-19	D-19/1 day
21	1/12	Female	C	5	SUN	11:00	00:55[a]	1	Quiet				
22	7/12	Male	C	3	MON	11:15	03:32[a]	1	Quiet			D-9 D-12	D-12/7 days
26	13/12	Female	C	2	SAT	10:30	03:10	1	Quiet				
27	14/12	Female	C	4	WED	10:40	06:04	1	Quiet				
28	9/12	Female	C	2	WED	16:20	00:45[a]	1	Quiet			D-17	D-17/2 days
29	8/12	Female	C	5	SUN	14:55	08:06	1	Quiet				

Abbreviations: LOS, Length of Stay; ED, Emergency Department; UHR, Unplanned Hospital Readmission.
[a] Duration of Discharge encounters were referred to field notes as consent not given for audio recording by either nurses or parents.

discharged before midday and nine patients in the afternoon or early evening.

All hospital-to-home transition experiences involved verbal communication of transition information regardless of whether written information was distributed. The discharge encounters lasted from 15 s to 13.2 min. Post-tonsillectomy/adenoidectomy the discharge encounter with caregivers averaged 8.2 min, appendectomy 5 min and for bronchiolitis 3 min. Three of the 31 caregivers were not offered written discharge information prior to discharg. All those three caregviers were with patients admitted with bronchiolitis. Written transition information was mostly distributed to caregivers just before discharge, and only two caregivers had the opportunity to read the sheet before discharge.

Structure of verbally delivered hospital-to-home transition information

Analysis of all transcribed recordings and field notes resulted in the identification of six common components across the three diagnoses/procedures. The components include information on diagnosis/procedure and treatments, expected symptoms, continuity of care from hospital to home, when and where to seek medical assistance, follow up requirements post-discharge, and confirmation of caregivers' understanding of information. The structure of transition information delivery varied depending on the three diagnoses/procedures. Table 4 presents the coding coverage in percentage of common components of transition information. The coding coverage indicates how much of the text is coded as a percentage of the total transcript. The bolded percentages shown in Table 4 are the two highest components for each diagnosis highlighting the importance of transition information focus. Nurses concentrated on wound management, discharge medication (antibiotics), and unexpected symptoms for appendectomy patients. Information for post-tonsillectomy/adenoidectomy patients emphasized pain management and prevention of postoperative bleeding. The focus for patients with bronchiolitis was on respiratory symptoms and when and where to seek medical assistance.

Delivery of verbal hospital-to-home transition information

Nurses predominantly led conversations with caregivers. In contrast, caregivers responded to information by stating '*Ok*' or repeating keywords. Some caregivers sought clarification on specific information; for example, when the patient was advised to '*Eat and drink as per normal*', a caregiver enquired '*How much should we be aiming for him to drink as a minimum…?*' The majority of nurses assessed caregivers' understanding after delivering each component of information by asking '*Do you understand that…* or '*… any questions?*'

Nurses' approach in delivering transition information varied depending on their years of experience and speciality area practice. Recent

H. Zhou, P.A. Roberts and P.R. Della *Journal of Pediatric Nursing 60 (2021) 83–91*

Table 3
Characteristics of carer of patients and nurses who discharged patients.

Study ID	Carers of patients						Nurses who discharged patient					
	Primary caregivers	Languages spoken at home	Adult at discharge	Age of adult at discharge	Highest education of adult at discharge	Employment status of carer at discharge	ID	Age	Job position	Speciality area/ward	Years of Nursing (Year)	Years of nursing at PMH (year)
Tonsillectomy ± Adenoidectomy												
1	Mother	No	Mother	21–25	Vocational training	Employed	N1	21–25	RN	A	2	2
3	Mother	No	Mother	26–30	Secondary school	Homemaker	N3	51–55	RN	A	34	5/12
4	Mother	Hindi	Mother	31–35	Secondary school	Homemaker	*N3*					
5	Mother	No	Father	31–35	Vocational training	Employed	N4	56>	RN	A	38	25
7	Mother	No	Mother	26–30	Secondary school	Homemaker	N5	26–30	RN	A	7	3
8	Mother	No	Mother	31–35	Diploma	Employed	N6	21–25	RN	A	8/12	8/12
9	Mother	No	Father	26–30	Vocational training	Employed	N7	36–40	CN	B	15	12
13	Mother	No	Mother	31–35	Master Degree	Employed	N9	41–45	CN	B	17	17
14	Mother	No	Father	46–50	Vocational training	Employed	N10	21–25	RN	B	2	1
23	Mother	No	Mother	21–25	Diploma	Employed	N17	21–25	RN	B	10/12	10/12
Appendectomy												
2	Mother	No	Mother	41–45	Master Degree	Employed	N2	21–25	EN	A	3	6/12
6	Mother	No	Mother	41–45	Master Degree	Employed	*N4*					
10	Mother	No	Father	36–40	Secondary school	Employed	N8	36–40	RN	A	17	17
11	Mother	No	Mother	41–45	Secondary school	[a]	*N8*					
12	Mother	No	Mother	26–30	Bachelor Degree	Employed	*N6*					
15	Mother	No	Mother	36–40	Vocational training	Self-Employed	*N10*					
16	Mother	No	Father	46–50	Bachelor Degree	Employed	N11	36–40	CN	B	19	14
19	Mother	No	Mother	41–45	Bachelor Degree	Employed	N14	31–35	CN	Relieving to A	6	5
20	Parents	Nepali	Father	36–40	Master's degree	Employed	N15	56>	RN	A	45	30
24	Mother	No	Mother	[a]	[a]	[a]	N18	51–55	CN	B	35	30
25	Mother	No	Mother	[a]	[a]	[a]	N19	26–30	RN	B	5	5
30	G/Mother	No	G/Mother	[a]	[a]	[a]	N23	21–25	RN	B	10/12	10/12
31	Mother	No	Father	26–30	Vocational training	Employed	N24	21–25	RN	B	4/12	4/12
Bronchiolitis												
17	Mother	No	Mother	26–31	[a]	[a]	N12	[a]	EN	C	[a]	[a]
18	Mother	Germany	Father	26–32	Diploma	Homemaker	N13	21–25	RN	C	10/12	10/12
21	Mother	No	Mother	36–41	[a]	Homemaker	*N13*					
22	Mother	Arabic	Father	26–30	Bachelor Degree	Employed	N16	41–45	RN	Casual Pool to C	20	6
26	Mother	No	Mother	21–25	Secondary school	Employed	N20	36–40	RN	C	19	6/12
27	Mother	No	Mother	36–40	Bachelor Degree	Homemaker	N21	26–30	RN	C	18/12	18/12
28	Mother	Vietnamese	Mother	31–35	[a]	[a]	*N21*					
29	Mother	No	Mother	21–25	Secondary school	Homemaker	N22	46–50	CN	C	5	5

Abbreviations: RN, Registered Nurse; EN, Enrolled Nurse; CN, Clinical Nurse.
[a] Information was not provided by carers at time of discharge.

graduates with less than one year working experience closely followed written transition information, while more experienced nurses incorporated their experiences using simple language to convey the discharge information. The verbatim statements illustrate this: a junior nurse verbalized '*… (have) lots of crunchy hard foods… that stops those scabs from forming where the tonsils were…*' (N1) While a senior nurse with more than 30 years' working experience in the clinical specialty created a vivid picture as '*… so hard food, rough food, meat, vegetables, toast…the importance of that, it's a bit like when you have a broom, and you're sweeping up the floor, and it gets all the rubbish off the floor…when they're eating*

Table 4
Coding coverage in percentage of the common components of hospital-to-home transition information as calculated by the NVivo-11.

DX	Diagnosis/treatment	Expected Symptoms	Continuity of care from hospital to home						When & Where to seek medical assistance	Follow up	Confirming Parent/carer's understanding
			Pain Assessment/Management	Discharge Medication	Hydration/Diet	Activities & Schooling	Wound management	Prevent Bleeding & 2-week Metro stay			
A	7%	7%	12%	**17%**	2%	10%	**20%**	N/A	12%	9%	4%
B	17%	**23%**	N/A	N/A	5%	15%	N/A	N/A	**28%**	6%	6%
T	2%	8%	5%	**47%**	4%	7%	N/A	**14%**	5%	4%	4%

Abbreviations: DX, Principal Diagnosis; A, Appendectomy; B, Bronchiolitis; T, Tonsillectomy/Adenoidectomy. The bolded percentages shown in Table are the two highest components for each diagnosis highlighting the importance of transition information focus.

rough food it scraps that residue off the back of their throat, and it just prevents them from getting infection building up under that area where their tonsils were...' (N4).

Even though written transition information was used to guide some of the verbal conversations, inconsistent information was, at times, provided to caregivers. Patients following tonsillectomy/adenoidectomy were advised by some nurses to take the medication regularly as *'...Oxycodone ...that's your strong one, so give morning and night for the first couple of days...'* (N17); while other nurses recommend caregivers to administrate Oxycodone only if child's pain is not managed by simple analgesia as *'...Oxycodone...when her pain, not managed by Panadol, ... this is quite strong medicine, ...'* (N7).

Stage 2 – semi-structured interviews with caregivers and nurses

Interviews with caregivers immediately post-hospital discharge

Twenty-three caregivers initially consented to participate in the interview immediately post-discharge. Eight caregivers, who declined consent, indicated they had family commitments or felt uncomfortable to be interviewed. Three caregivers, who initially consented, had to leave the hospital immediately post-discharge due to transport. Therefore, a total of 20 caregiver interviews was conducted. The duration of interviews ranged from 10 to 47 min, with an average of 20.4 min.

Caregivers' overall perception on hospital-to-home transition information. An initial open-ended question sought information about the overall experience of the discharge process. The majority of caregivers described the process as *'straight forward'*, and they had *'a positive experience'* with *'No issues at all'*. They appraised the content of hospital-to-home transition information provided as *'good'* and *'very informative'*. Two caregivers described feeling overwhelmed with the amount and type of information as *'...a bit bombarded and confused' and '...It's just different information than what we normally take'* (Caregiver of P14). Some caregivers reported seeking clarification of information; for example, one caregiver enquired after observing how another nurse discharged patients with the same condition as *'We didn't get any discharge advice about school and sport ... Then (nurse) said 'Right, you need antibiotics, just make sure you have got five days' worth and follow-up in two weeks...'* (Caregiver of P19).

Caregivers' comprehension of hospital-to-home transition information. Interviews immediately post-discharge revealed that caregivers understood and recalled the hospital-to-home transition information, especially details about when and where to seek medical attention after discharge. Caregivers were less accurate, remembering the exact medication name or dosage; however, they did know the type of medication and where to locate detailed information.

Caregivers' perceptions of verbal and non-verbal communication by nurses. Caregivers described the way nurses communicated information as *'in a tone and manner that was ok for the presence of a child'* and *'everything was explained thoroughly'* (Caregiver of P7). Caregivers felt staff were *'very approachable'* as *'...they would answer questions...'*. Two caregivers commented on the speed of information provided by nurses as *'it's fairly quickly delivered ...the information comes quite quickly...so I didn't always remember the things they said...'* (Caregiver of P1).

Caregivers commented about their perception of non-verbal communication. The majority described nurses as *'very warm'* with *'great eye contact'* and *'...a gesture that didn't seem to distance'*. While others observed differences among nurses in terms of *'personality and bedside manner'*, which impacted on caregivers' experience. For example *'... (nurse) just didn't seem confident, and the movement is a bit hesitate... it's crucial that you feel confident the nurses and doctors know what they're doing.'* (Caregiver of P31)

Caregivers' views on readiness for discharge. Caregivers expressed differing views about whether they thought their child was ready for discharge and if they were ready to provide care at home. Some families were keen and ready to go *'... We have the information, totally ready!'*, while others were uncertain or even anxious about discharge, lacking confidence and preparedness. For example *'I hope I am ok..., I have to trust them (giggle)...'* (Caregiver of P18); *'I am a bit nervous, actually...'*; or *'En...I wasn't that prepared for going home...'* (Caregiver of P3)

Some felt their children were not ready to be discharged, commenting *'...I find (patient) still got that phlegm and cough and that does, give me anxiety...'* or *'... don't think (patient) is ready to be discharged'.* (Caregiver of P27) One mother indicated that her child was discharged too early due to late surgery *'...come out from surgery 3 a.m.... and then discharged, oh, that was like 5 h (post-surgery). I don't think that's appropriate; I think...if you are moving around and tolerating diet...tolerate pain with pain relief, then the child will be discharged'* (Caregiver of P19).

Interviews with caregivers 2–4 weeks post-discharge

Caregivers who had agreed to participate in phone interviews were sent a reminder text message 2–4 weeks post-discharge. Eleven caregivers responded and accepted the request. Interviews ranged from 5 to 21 min with an average of 11.8 min and focused on recovery experience and usefulness of the hospital-to-home discharge information.

Recovery experience. Of the eleven interviewed caregivers, three described the recovery experience as uneventful as *'no problem at all'*. Eight caregivers reported their child having unexpected issues and delayed recovery. One caregiver described their experience as *'...a bit of road, to say the least!'* Others commented on the child's slow recovery as longer than expected *'...Day 12 was pain-free day...'* or *'...in total, he had two weeks off (school)'* (Caregiver of P6). As a result, children were not only physically *'exhausted'* or *'warned out'*, but also felt *'stressed'* or *'anxious'*. Meanwhile, caregivers expressed feeling *'... disappointed...'* or *'very confused'* as *'you didn't know what you are looking for ...'*.

Caregivers of six children reported prolonged pain *'in his stomach* or *shoulder tip pain'*, or *'ulcerated uvular'* caused by intubation. Other children experienced *'a high temperature (39.8) '*, *'... blood in saliva, tiny, strike...'* or *'... vomiting a lot of liquid...'*.

Of the eight children who experienced unexpected health issues, three children were taken to the ED. Each was examined and provided with advice on pain management or prescribed antibiotics. Of the remaining five, three caregivers monitored their children and administered analgesics according to the discharge information, and two contacted the ward.

The usefulness of hospital-to-home transition information. The majority of caregivers described the information as *'sufficient'* and *'very helpful'* as *'it covered everything'* during the post-discharge phase; others felt *'...the information...was a broad... don't believe it is specific enough'* (Caregiver of P10). Apart from what to look out for, caregivers indicated they would like more information about what to expect in the recovery phase as reassurance. One caregiver stated *'The bit that was missing is what to expect...we still don't know what's normal ... she's still having pain (day 10)...?* (Caregiver of P31).

Caregivers were asked to compare the usefulness of verbal hospital-to-home transition information provided at discharge to the written information sheet. The majority indicated they appreciated the verbal communication and written information was considered as a backup. Comments were *'... haven't read it ...* or *'...I filed for future reference'.* One caregiver commented about the timing of receiving the written information as *'given one or two hours before (discharge and I didn't have time to read it...'* (Caregiver of P20). The caregiver recommended earlier distribution, *'...the day before discharge' or 'when the child is stable after the surgery...' parents can then ask questions for clarifications* (Caregiver of P23). The information should not be given at admission because '... *you are worried about your child and a lot of things happening.* Caregivers stated the post-discharge medication diary was useful as '...*it was really good; otherwise, I would forget ... I kept it updated*' (Caregiver of P9).

Interviews with nurses

Only 12 out of the 24 nurses were available within the week of the discharge to be interviewed, which were conducted in private lasting nine to 31 min, with a mean of 17.8 min.

Hospital-to-home transition information. Interviews commenced with a question about the delivered hospital-to-home transition discharge information. Nurses generally went through transition information with caregivers based on the specific written information sheet for surgical patients. Nurses who discharged patients with bronchiolitis indicated that physicians had already performed a comprehensive assessment and provided advice, and therefore they provided brief information.

Despite having written information, nurses recognized that '...*the way you deliver information becomes very individual*', and it is dependent on the area of speciality and experience. Seniors noted that junior or new staff to the ward '...*would read every single word, even it didn't apply*; whereas an experienced practitioner would '...*rather than reading would have a conversation, from experience*' (N22).

Nurses recommended commencing communication of transition information earlier than '*in the last 15 min*'. One nurse, following a complicated country discharge involving flights and medication arrangements, also suggested to break down the information into a couple of sessions.

Distribution of written hospital-to-home transition information. Nurses acknowledged that the content of written hospital-to-home transition information for tonsillectomy/adenoidectomy is regularly updated. The appendectomy and bronchiolitis information they felt required urgent updating. Some nurses suggested expanding written information to include a detailed description of signs and symptoms of deterioration, especially for bronchiolitis. Others commented some of the written advice warranted clarification, such as '...*the guideline...is a bit, open to interpretation... an example...patient have to be eating and drinking (before discharge). Well, what's sufficient eating and drinking...there is no guidelines on specific quantity...*' (N9).

Nurses recognized that written transition information was not regularly distributed to caregivers of patients with bronchiolitis. Insufficient time was identified as a reason for not providing the written information, as it is '*actually time-consuming*' to locate and print the document. The majority of nurses suggested '...*every ward should give the same information*' guided by written information while talking to caregivers to ensure comprehensiveness and consistency.

Nurses were also of the view that written information should be given to caregivers earlier. Caregivers would then have the opportunity to read the information and seek clarification. The ideal time was a day before the estimated discharge date or when the patient is medically stable, but not at the time of admission.

Transition information communication practice. All participants verbalized their views on what characterised '*good*' verbal and non-verbal communication practice when delivering hospital-to-home transition information. Effective verbal communication skills were identified as '*speak clearly*', '*speak to the child first*' and '*have a conversation*' with caregivers rather than '*teaching session*'. Nurses also said they spoke in '*simple terms*' and '*keep all the jargon to the minimum*' so the information was '*easy to be understood by parents*'. Two commonly identified non-verbal communication skills were '*get down to their level*' and engaging caregivers with '*eye contact*'. Three nurses, however, admitted they '*talked too quickly sometimes*' and they should '*slow down a little bit*' and '... *maybe pausing at each, kind of, paragraph...*'.

Five junior nurses with less than one year working experience acknowledged the challenging nature of hospital-to-home transition information delivery and identified a lack of education and resources. Junior staff indicated they learned the discharge process '*only through asking and watching...*' and '*you just don't know what you are doing!*' (N23) Some nurses suggested the need to incorporate transition information contents and delivery methods in nursing tertiary curriculum '*Not much learnt from the university. Pretty much you figure out on the way ...*' (N24); while others suggested the ward needed to arrange in-service sessions on admission and discharge requirements specifically related to diagnosis and procedures.

Preparation and assessment of readiness for discharge. When asked to reflect on preparation and assessment of readiness for discharge, three nurses were of the view there was insufficient discharge preparation mainly related to an unclear plan from the physician, organization of discharge medication and/or transport or incomplete documentation. An example was '...*it can be, mostly quite messy...a lot of things aren't done in advance... the scripts...or...waiting for summaries, or the plan...*' (N10).

Nurses commented that there is no formal assessment of readiness for discharge. For patients who undergo tonsillectomy/adenoidectomy nurses indicated they follow a set of discharge criteria embedded in the clinical care pathway. The criteria focuse on oral intake, pain management and observation of haemorrhage. For patients with bronchiolitis or post-appendectomy, nurses tend to rely on physicians' assessment and the decision whether the patient is medically fit to be discharged.

To facilitate the discharge process, nurses recommended implementing a discharge checklist, for hospital-to-home transition information, medication, follow up appointment, and transport/accommodation for country patients. This checklist could also be used by nurses to record when a particular activity is achieved, which relates to readiness for discharge.

Stage 3 – examination of patients' medical records

Examination of 31 observed patients' medical records was undertaken 30 days after discharged. Seven patients (22.6%) had presented between Day-2 to Day-19 at the ED of the same hospital with concerns related to their initial admission (Table 1). Of the seven, one patient presented to the ED twice, on Day-9 and Day-12. Presenting issues included pain postoperatively or respiratory distress. Four patients were discharged from ED the same day with advice on pain management and/or antibiotics.

Three patients initially admitted with bronchiolitis were re-hospitalized for one to seven days. Examination of clinical notes revealed that all three families were recent migrants to Western Australia. All three families spoke languages other than English at home, and the admission notes documented each mothers' English language as limited. For all three children, the mother was the primary caregiver but was not present when the hospital-to-home transition information was provided.

Discussion

The Transition Theory was a useful framework for guiding the conceptualization of the study. Multiple sources of data were collected in this multi-stage qualitative descriptive study verifying the trustworthiness and enhancing the quality of the findings, allowing for an in-depth understanding of participant's perceptions on hospital-to-home information communication between nurse and caregiver.

Four key themes emerged from the analysis of the transition data: the structure of hospital-to-home information, information delivery, readiness for discharge, and discharge recovery experience. Examination of the structure of verbally delivered hospital-to-home transition information across all three diagnosis/procedures identified six common components despite information provided to caregivers varying for each of the three procedures/diagnoses. Information post-discharge, especially concerning pain management, wound management, and hydration/diet was the most consistently repeated components. This differs from previous studies that identified transition information as most centred around providing information about restrictions and warning signs for potential complications (Gutman et al., 2018; Holland et al., 2016; Unaka et al., 2017), knowing who to contact (Solan et al., 2015), and medication dosage (Gutman et al., 2018; Lerret et al., 2014).

In this study, delivery of transition information to caregivers varied in the time taken, source of information, consistency of delivery, and communication approach. Previous studies identified that the amount of time nurses spent communicating transition information varied significantly (Keatinge et al., 2009; Solan et al., 2015). An earlier literature review suggested avoiding providing discharge information when a child is undergoing a procedure (Keatinge et al., 2009). This study confirmed this finding with caregivers and nurses, indicating they would have preferred to commence the day before discharge rather than wait until the last minute. Caregivers in this study and a previous study preferred transition information to be broken down into sessions, so they are not overwhelmed with the amount of information (Solan et al., 2015).

Despite the majority of nurses in this study using written transition information to guide discharge communication, there was inconsistency in the content of verbally delivered information, supported by earlier studies (Harlan et al., 2010; Keatinge et al., 2009). The content was heavily dependent on nurses' years of working experience and speciality area of practice. Junior staff found providing transition information challenging due to their limited experience and lack of standardization of the information, as identified previously (Chidume & Pass-Ivy, 2019). Study findings confirmed those of earlier studies in that information provided at discharge was too generalized for some caregivers (Keatinge et al., 2009; Pinto et al., 2010, 2015). Caregivers in this study also identified unmet information needs, such as what signs and symptoms to expect and duration of recovery and this impacted caregivers' perceptions of whether they felt ready for discharge (Lerret et al., 2014, 2015; Solan et al., 2015; Weiss et al., 2017).

Nurses in this study did not formally assess patients' or caregivers' readiness for discharge. Some caregivers interviewed immediately post-discharge, expressed concerns that they felt their child's health condition was not fit for discharge as certain symptoms were still present. Others felt anxious about taking their child home and providing continued care, which is consistent with an earlier study (Aydon et al., 2018). Caregivers who perceive they are not ready for discharge are more likely to experience coping difficulties and have low adherence to medication administration (Lerret et al., 2015).

Readiness for discharge refers to caregivers understanding of transition information. Ensuring assessment of caregivers' comprehension and retention of information are essential before discharge (Keatinge et al., 2009). This study confirmed earlier research on how nurses assessed caregivers' understanding of transition information (Gutman et al., 2018). The use of close-end invitation questions (i.e., Do you have any questions?) or direct close-ended questions (i.e., Do you understand?) do not offer caregivers the opportunity to absorb and recall information. The "Teach-back" technique improves caregivers' understanding and application of health information (i.e., Can you tell me what you can do if your child has a fever?) (Hamline et al., 2018; Kornburger et al., 2013).

Children's recovery experiences in this study as well as previous studies were individualized and depended on the occurrence of unexpected health issues (Ford et al., 2012; Pinto et al., 2010, 2015). Caregiver interviews post-discharge and examination of medical records, a total of 11 of the 31 observed patients experienced delayed recovery due to unexpected health issues within 30 days post-hospital discharge. The most common problems were pain and respiratory distress, which is similar to previous studies (Ford et al., 2012; Pinto et al., 2015). As a result, seven children in this study had unplanned ED visits, which is higher than an American study (Weiss et al., 2017). Nearly 1 in 10 children in this study experienced unplanned hospital readmission, compared to two earlier studies (3.9%; 6.7% respectively) (Parikh et al., 2018; Weiss et al., 2017).

Commonalities of the three unplanned hospital readmissions in this study related to primary caregivers with limited English language proficiency and not being present at discharge when transition information was provided. Language limitations and underuse of professional interpreter service have been found to result in loss of information or inaccurate translation of information from caregivers present at discharge to primary caregivers at home (Gallagher et al., 2013; Glick et al., 2017). This impact is confirmed by recent studies suggesting that professional interpretation services were not arranged for 31% of families with language limitation. Language limitations are associated with high risks of ED presentations and lower comprehension of transition information (Gutman et al., 2018; Samuels-Kalow et al., 2017).

Practice implications

Inclusion of education on transition information and discharge planning/process is required for junior and casual staff to ensure consistency of information delivery. Nursing staff need to conduct readiness for discharge assessments. Future research is needed to determine the reliability and appropriateness of validated instruments, namely 'Readiness for hospital discharge scale', 'Quality of discharge teaching scale' and 'Post-discharge coping difficulty scale' in Western Australian (Lerret, 2009; Lerret et al., 2014, 2015; Lerret & Weiss, 2011; Weiss et al., 2017).

Importantly for primary caregivers, who speak a language other than English and with limited English proficiency, interpreter services should be arranged throughout the hospital stay and especially when transitions information occurs. It is essential to assess caregivers' comprehension of information using teach-back before discharging patients.

Limitations

This study was conducted at a single center using a sample size of 31. This study did not observe the entire hospitalization period of each child to capture how the discharge plan was formulated. This means that there were probably several opportunities for preparation for discharge, including the delivery of transition information throughout the hospital stay that we did not observe. A further limitation is the lack of observations and interviews with other healthcare providers, especially social workers, who might have been involved in the discussion of the discharge plan, ongoing continuity of care and social support. Given the study limitations, cautions should be taken into consideration when applying results to other healthcare settings.

Conclusion

This study is the first published research to objectively observe and examine content and delivery of hospital-to-home transition information in a Western Australian pediatric setting. This study provided valuable insights into nurse-caregiver communication of transition information on the day of discharge. The study affirmed the complexity of transitioning pediatric patients from hospital to home and the impact of inconsistent content and delivery of information has on caregivers' perception of readiness for discharge and their recovery discharge experience. Unplanned ED visits post-discharge may be avoidable with improvements in content, individualized information and greater consistency in the delivery of information.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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Chapter 5

Discussion

5.1 Chapter Overview

Chapter five presents a detailed discussion of the main findings based on Study Objectives 3 to 6. Where appropriate, reference is made to relevant literature and research to enrich the discussion and allow results to be placed in context. Study Objectives 1 and 2 were addressed and discussed in Chapter Two, *Exploring the Literature*. To avoid duplications, this chapter provides an integrated summary of the discussion utilising the following four key points: (1) Comparing the main research outcomes with previous research and literature; (2) Identifying study methodological limitations; (3) Formulating recommendations for clinical practice, education, policy, and future research. The main findings of this study are summarised in Table 5.1.

5.2 Comparison of Research Outcomes

5.2.1 Study Objective 3

Examine the prevalence and characteristics of all-cause unplanned hospital readmissions at a tertiary children's hospital in WA from 2010 to 2014.

Phase 1 Stage 1 presented as **Publication 4** (Table 5.1) addressed this objective. A retrospective descriptive study was undertaken using an administrative inpatient dataset from a tertiary children's hospital in WA between 2010 and 2014. The main outcomes measures of this publication included 5-year prevalence of 30-day all-cause same-hospital unplanned readmissions calculated using both discharge-based analysis and patient-based analysis, time interval between the paediatric readmission and the index admission and principal index admission diagnoses associated with frequent paediatric readmissions.

Table 5.1

Summary of Main Research Outcomes in relation to each Study Objective

Research Outcomes	Main findings
Objective 1: To comprehensively review research-based evidence related to the transition of care at discharge for paediatric patients	
Publication 1 *Journal of Clinical Nursing* 52 Citations per *Scopus*	61 studies were reviewed Six main themes: Timing of transition; Perceptions of the transition; Preparation for the transition; Patients' outcomes post-transition; Barriers to the transition; and Facilitating factors to the transition 67 studies were reviewed
Thesis Section 2.3	Discharging a paediatric patient is a multifaceted and challenging process Hospital-to-home transition information is commonly offered shortly before the patient leaves the hospital. Therefore, caregivers are less likely to have time to fully comprehend the information and/or seek clarification of their child's care needs at home. The content of transition information is not tailored for individual needs Caregivers had mixed feelings about readiness for discharge. Assessing the level of readiness for discharge is not a routine procedure in all hospitals
Objective 2: To systematically examine predictive models for UHRs and to investigate and assess the characteristics of each model	
Publication 2 *BMJ Open* 115 Citations per *Scopus*	60 studies with 73 unique predictive models were reviewed A wide-range reported c-statistic (0.21–0.88) Predictive models for medical condition-related UHR have consistent moderate discrimination ability (c-statistic ≥ 0.7) Most cited predictors: comorbidities, length of stay and previous admissions
Publication 3 *BMJ Open* 6 Citations per *Scopus*	44 studies were reviewed Most cited predictors: Comorbidity', 'public health insurance'; 'longer LOS' and 'patients<12 months or between 13–18 years'
Thesis Section 2.6	63 studies were reviewed Most cited predictors: comorbidity, age of the patient at index admission/procedure, complications during the index admission, and severity of illness

Research Outcomes	Main findings
Objective 3: To examine the prevalence and characteristics of all-cause UHRs at a tertiary children's hospital in WA from 2010 to 2014	
Publication 4 *Australian Health Review* 4 Citations per *Scopus*	30-day UHR rate: 3.03% discharge-base analysis and 4.55% patient-based analysis 51% UHR occurred by Day 5 post-discharge Time intervals from discharge date to readmission date varied for diagnosis-specific readmissions of paediatric patients
Objective 4: To identify risk factors associated with 30-day all-cause unplanned hospital readmission at a tertiary children's hospital in WA based on an administrative inpatient dataset	
Publication 5 *Journal of Paediatric and Child Health* 2 Citations per *Scopus*	7 significant risk factors: Age ≥ 13 years old; utilising private insurance as an inpatient; with greater social-economic advantage; admitted on Friday; discharged on Friday/Saturday/Sunday;≥ 4 diagnoses at the index admission; LOS ≥ 15 days or longer. The AUC = 0.645
Objective 5: To assess whether adding clinical information and written discharge documentation variables improve prediction of 30-day same hospital unplanned readmission compared to administrative information using machine learning analyses	
Publication 6 *Australian Health Review*	The inclusion of written discharge documentation variables significantly improved readmission predictions compared with models based on administrative and/or clinical variables in standard logistic regression analysis The highest prediction accuracy was obtained using a gradient boosted tree model (c-statistic 0.654), followed closely by random forest and elastic net modelling approaches Predictive factors: Patients' social history (legal custody or Department for Child Protection), language spoken at home other than English, completeness of nursing admission and discharge planning documentation, and timing of issuing discharge summary
Objective 6: To observe and describe nurse-caregiver communication of paediatric hospital-to-home transition information	
Publication 7 *Journal of Pediatric Nursing*	6 common components of verbally delivered hospital-to-home transition information Duration of nurse-caregiver communication and the approach to deliver transition information was primarily depended on nurses' experience and speciality area Caregivers were overwhelmed with the amount of information; others felt the information was inadequate and/or inconsistent Some caregivers perceived their child was not ready for discharge and felt uncertain about providing care at home 8 caregivers reported delayed recovery post-discharge from unexpected health issues 7 presented to the Emergency Department within 2–19 days post-discharge, of which 3 were readmitted Primary caregivers of 3 readmitted patients all had limited English proficiency and were not present when the transition information was provided

The prevalence of 30-day all-cause same-hospital readmissions to the participating children's hospital in this study was 3.03% (discharge-based analysis) and 4.55% (patient-based analysis). Three previous studies examining discharge-based analysis of 30-day all-cause readmissions identified rates ranging from 6.5% to 10.3% (Auger & Davis, 2015; Berry et al., 2013; Wijlaars et al., 2016). Five studies examining patient-based analysis readmission rates varied from 3.4% to 18.7% (Beck et al., 2006; Coller et al., 2013; Ehwerhemuepha et al., 2020; Khan et al., 2015; Pérez-Moreno et al., 2019). Two studies examining readmissions based on both discharge and patient analyses found a rates of 6.5% (Toomey et al., 2016) and 8.8% (Braddock et al., 2015).

Thirty-day readmission is the most common measurement reported in the literature (Zhou, Roberts, et al., 2019). Some studies have used 7-day readmission (Braddock et al., 2015; Ehwerhemuepha et al., 2020; Pershad et al., 2020; Roth et al., 2016; Topal et al., 2014). This study found that 52% of readmissions occurred within the first 5 days post-hospital discharge, 73.6% in the first 10 days and 86.1% in the first 15 days. These findings are similar to those of Berry et al. (2013) who reported 39% of all-cause readmissions occurred in the first 7 days post-hospital discharge and that 61.6% occurred in the first 14 days. This study also found using 30-day readmission measurement was not an appropriate measure for all diagnoses associated hospital readmissions. This finding aligns with the Australian Independent Hospital Pricing Authority's emphasis in establishing appropriate readmission measures against specific health conditions (Bureau of Health Information, 2015; Independent Hospital Pricing Authority (IHPA), 2016).

The top 10 principal index admission diagnoses associated with frequent unplanned readmissions in this study are sleep disorders (obstructive sleep apnoea syndrome requiring tonsillectomy and/or adenoidectomy), acute appendicitis (requiring appendectomy), acute bronchiolitis, abnormalities of breathing (wheezing, mouth breathing), viral infection of unspecified site, chronic diseases of tonsils and adenoids (requiring tonsillectomy and/or adenoidectomy), fracture of forearm, abdominal and pelvic pain, asthma, encounter for other aftercare and medical care (i.e. chemotherapy). This result is consistent with those found by Berry et al (2013) except for one diagnosis, seizure. In addition, this study supports the findings by Berry et al. (2013) that 30-day readmissions are associated with the same diagnosis or complications related to the index admission. The most frequent surgical procedure related to readmission in Western Australia was tonsillectomy and/or adenoidectomy, which is consistent with the findings of this study and also for paediatric population (Government of Western Australia Department of Health, 2015; U.S. Department of Health & Human Services, 2016).

5.2.2 Study Objective 4

Identify risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in WA based on an administrative inpatient dataset.

Phase 1 Stage 2 presented as **Publication 5** (Table 5.1) addressed this objective. The development of a predictive model for paediatric 30-day all-cause same hospital readmission was derived using the same administrative inpatient dataset as in Phase 1 Stage 1. The model development involved identification of seven risk factors with a moderate discriminative ability to predict readmissions. Two of the seven significant predictors are consistent with previous studies, namely comorbidities (Beck et al., 2006; Ehwerhemuepha, Finn, et al., 2018; Markham et al., 2019) and patients older than >13 years old (Coller et al., 2013). In addtion, the weekend effect on unplanned hospital readmission is supported by the findings of this study that Friday and weekend discharge and Friday admission are predictors of readmission (Auger & Davis, 2015; Markham et al., 2019).

Patients with longer LOS in this study were at higher risk of readmission; however, LOS was not significantly associated with readmission in two USA studies (Auger & Davis, 2015; Khan et al., 2015). Comparing the finding of this study to the literature, similar inconsistent predictors of readmissions were identified and include family socio-economic status [advantaged vs. disadvantaged (Wijlaars et al., 2016)] and type of insurance [private (Khan et al., 2015) vs. public (Markham et al., 2019; Toomey et al., 2016)].

Model developed for 30-day all-cause readmission in this study was based on the administrative dataset which had discrimination ability of c-statistics = 0.645. There was one USA study that reported a discriminative model with c-statistics = 0.86 for 365-day all-cause readmissions (Feudtner et al., 2009). Considering the difference in readmission measurement of the two studies, the discriminative model abilities are not comparable.

5.2.3 Study Objective 5

Assess whether adding clinical information and written discharge documentation variables improve prediction of 30-day same hospital unplanned readmission compared to administrative information using machine learning analyses.

Phase 1 Stage 3 presented as **Publication 6** (Table 5.1) addressed this objective. Predictive models were developed using machine learning analyses techniques via a matched case-control retrospective study of patients' medical records, including clinical information and written discharge documentation. Model prediction was improved when adding clinical information and written discharge documentation variables over the model derived from only administrative variables. Eight existing paediatric studies reported predictive model performance (Feudtner et al., 2009; Janjua et al., 2019; Jovanovic et al., 2016; Markham et al., 2019; Minhas et al., 2016; Sacks et al., 2017; Stiglic et al., 2014; Vo et al., 2018; Wolff et al., 2019), of which only two studies extracted and examined both administrative and clinical variables via medical records review (Markham et al., 2019; Sacks et al., 2017).

The highest prediction accuracy in this study was obtained using a gradient boosted tree model (c-statistic = 0.654), followed closely by random forest and elastic net modelling approaches. Three other studies that have applied machine learning to paediatric readmission prediction obtained similar (Wolff et al., 2019) or better performances (Jovanovic et al., 2016; Stiglic et al., 2014).

Four predictors selected in this study were consistent with previous research, namely number of hospitalisations prior to the index admission (Beck et al., 2006; Ehwerhemuepha, Finn, et al., 2018), day of discharge (Auger & Davis, 2015; Markham et al., 2019), LOS (Ehwerhemuepha, Finn, et al., 2018; Feudtner et al., 2009), and comorbidities (Beck et al., 2006; Berry et al., 2011; Ehwerhemuepha, Finn, et al., 2018; Feudtner et al., 2009; Khan et al., 2015; Markham et al., 2019; Wijlaars et al., 2016). Earlier studies identified socio-economic status, a routinely collected administrative variable as a predictor for readmissions (Berry et al., 2011; Feudtner et al., 2009; Khan et al., 2015; Markham et al., 2019; Sills et al., 2017; Wijlaars et al., 2016). This study further extracted patients' significant social history (i.e., under the care of child protection family services) from medical records and found a positive association with readmissions.

Languages other than English was selected by the elastic net and stepwise logistic regression models in this study. Previous studies found an inconclusive relationship between speaking a language other than English and readmissions. In all studies including this study, there were small numbers of cases in the dataset (Coller et al., 2013; Richards et al., 2016; Toomey et al., 2016).

Incomplete *Nursing Admission and Discharge Planning Form* and delay in issuing discharge summaries were identified as predictors for readmissions in this study. Results from previous research with similar focus have been inconsistent (Coller et al., 2013; Feng et al., 2017; Topal et al., 2014). In research by Topal et al. (2014), the absence of written instructional discharge plans for caregivers of children with asthma increased readmission rates while provision of post-discharge follow-up plans in research by Feng et al. (2017) contributed positively to reducing all-cause readmissions.

5.2.4 Study Objective 6

Observe and describe nurse-caregiver communication of paediatric hospital-to-home transition information.

Phase 2 with 5 Stages presented as **Publication 7** (Table 5.1) addressed this objective. A study consisting of multiple stages and sources of qualitative data collection was undertaken. Four key themes to emerge were the components of hospital-to-home transition information, transition information delivery, readiness for discharge, and recovery experience post-hospital discharge.

The most consistently communicated components of hospital-to-home information communicated between nurses and caregivers in this study pertained to pain management, wound management, and hydration/diet. Commonly communicated components in previous studies included transition information restrictions and warning signs for potential complications (Gutman et al., 2018; Holland et al., 2016; Lerret et al., 2014; Unaka, Statile, Haney, et al., 2017), knowing who to contact (Solan et al., 2015), and medication dosage (Gutman et al., 2018; Lerret et al., 2014).

This study, which is similar to others, found the way nurses delivered the transition information varied in terms of length of time spent communicating information (Keatinge et al., 2009; Solan et al., 2015), source of information, consistency of information delivery (Chidume & Pass-Ivy, 2019; Harlan et al., 2010; Keatinge et al., 2009), and approach to communication. Consistent with previous research, nurses and caregivers in this study preferred to commence delivery of transition information communication earlier rather than just prior to leaving the ward. Some nurses and caregivers suggested breaking the information into sections would be more helpful (Keatinge et al., 2009; Solan et al., 2015).

This study confirmed the findings of previous studies that hospital-to-home transition information provided at the time of discharge was too generalised, with some caregivers identifying unmet information needs, such as not knowing or understanding what signs and symptoms to expect during the recovery and duration of recovery (Keatinge et al., 2009; Pinto et al., 2015; Pinto et al., 2010).

Readiness for discharge was not formally assessed in this study, which is similar to three earlier studies (Aydon et al., 2018; Gutman et al., 2018; Lerret et al., 2015). Caregivers in all studies were asked whether they 'understood' or 'had any questions' of the transition information provided by nurses prior to discharge. Regardless of the information provided, caregivers expressed concerns over their child's health condition at the time of discharge or that they felt anxious about taking their child home and providing continued care. Those caregivers in this study who did not feel ready to take their child home experienced coping difficulties and low adherence to medication administration post-hospital discharge which is similar to other research (Gutman et al., 2018; Lerret et al., 2015).

Consistent with previous studies, this study also found children's recovery experiences were individualised and depended on the occurrence of unexpected health issues (Ford et al., 2012; Pinto et al., 2015; Pinto et al., 2010). The most common unexpected health issues were pain and respiratory distress. In this study, 22.6% of children had unplanned ED visits, and 9.7% were readmitted, which is higher than American studies (14.4% and 6.7% respectively) (Parikh et al., 2018; Weiss et al., 2017).

Primary caregivers of the three patients who experienced readmissions in this study were not present at the time of discharge when transition information was delivered, and all three had limited English proficiency. This finding is consistent with recent study findings which identified that families with LEP who did not use professional interpreter services were associated with high risks of ED presentations and lower comprehension of transition information (Gutman et al., 2018; Samuels-Kalow et al., 2017).

5.3 Study Methodological Limitations

A mixed-methods sequential explanatory research design was employed to address the aim and objectives of this study. The study consisted of Phase 1, a 3-stage retrospective quantitative examination of an inpatient dataset, and Phase 2, a 5-stage prospective qualitative analysis of information gathered from both nurses and caregivers. This section summarises four methodological limitations of this study.

5.3.1 Single hospital inpatient dataset

Phase 1 of this study accessed and analysed an inpatient dataset from the only tertiary children’s hospital in WA. Paediatric wards do exist in metropolitan and/or peripheral general hospitals but not were not included in this study. As a result, this study did not captured paediatric patients, who (1) had index admissions at the participating hospital but subsequently were readmitted to paediatric wards of other hospitals; (2) had their index admission to other hospitals and were then readmitted to the same hospital; or (3) had the index admission to other hospitals but were then readmitted to the participating hospital with complications associated with the index admission. As a result, the reported readmission rate in this study is limited to the same hospital readmissions.

5.3.2 Sample size

A sample size of 940 randomised and matched patients was involved in Phase 1 Stage 3 of this study. Difficulties accessing patients' medical records and the costs involved in terms of time and money to extract specific clinical information (vital signs, imaging/laboratory tests results, etc.) and written discharge documentation (not only the discharge summary but also last entries made by physicians, nurses and allied healthcare providers) limited the sample size. The randomisation and matching of the sample size using age, gender, principal diagnosis of index admission, and proportion of patients with the principal diagnosis in the initial dataset ensured the representativeness of the population in this study was maximised.

5.3.3 Caregivers' response rate

Of the 23 caregivers who initially consented to participate in post discharge interviews, only 11 of that total accepted the invitation to be involved in a phone interview two to four weeks following their child's discharge from the participating children's hospital. Caregivers' of the three children who experienced an unplanned readmission declined the interview as they were very disappointed and too stressed to be interviewed. Insights into what issues their child experienced post-discharge and their perceptions on usefulness of the verbal and written hospital-to-home transition information remains unknown. In addition, how transition information was exchanged at home from father (caregiver present at discharge) to mother (primary caregiver for the child at home) remains unknown.

5.3.4 Limited direct clinical observations

Direct clinical observation of nurse-caregiver communication of transition information, was limited to the time period prior to discharging the patient. The study did not observe the entire hospitalisation period of each child to capture how the transition plan was formulated. This means that there were probably several opportunities to prepare for transition, including delivery of transition information throughout the hospital stay which were not observe. A further limitation is the lack of engagement with other healthcare providers, who might have been involved in discussing the transition plan, ongoing continuity of care and social support.

5.4 Recommendations

The results of this study provide evidence to support the need for significant changes in clinical practice, through improved educational contents, and delivery of transition information, via stakeholders and policy changes, and through future research. These changes, detailed below, will improve quality and safety outcomes for paediatric patients and caregivers and reduce unnecessary and costly UHR.

5.4.1 Recommendations for clinical practice

The overarching recommendation for clinical practice to flow from this research centres on the need to develop and implement an evidence-based, comprehensive transition framework in clinical practice. The framework would assist to improve individualised transition planning and consistency of transition information delivery from healthcare providers to caregivers. Embedded within the framework are the six key components identified from this research as per below:

1. Inclusion of specific information in transition plans for patients, especially those who are admitted with one of the top ten index admission diagnoses associated with frequent UHRs, are at higher risk of readmission based on age ($\geq$13 years), the number of admitting diagnosis (>1), day of admission (Friday), day of discharge (Friday and Weekends), and length of hospitalisation (>1). Incorporation of these identified significant predictors provides opportunities for the implementation of individualised transition plan and comprehensive transition information with the aim to reduce the readmission rate (Centers for Medicare & Medicaid Services, 2013; Health & Social Care Information Centre, 2011; Jencks et al., 2009).

2. Identification of designated staff members who are responsible to coordinate the transition process from the time of admission and throughout hospitalisation until the follow-up appointment. Patients with a significant social history may also require a designated hospital-based social worker to assess and provide social needs for the family. The social worker should also collaborate with other healthcare providers to implement a transition planning process to ensure continuity of care at home post-discharge (Heenan & Birrell, 2019).

3. Incorporate a validated readiness for discharge assessment tool into the transition framework. It is critical that nurses conduct a readiness for discharge assessment of patients and their primary caregivers to determine individual needs and to facilitate transitioning from hospital to home. This will assist in reducing unplanned readmissions caused by early/premature discharge (Weiss & Piacentine, 2006).

4. Ensure interpreter services are available for families with language barriers throughout hospitalisation and specifically when communicating hospital-to-home transition information. Nurses also need to plan and schedule a suitable time with the primary caregiver/s to communicate the transition information based on individual need (Keatinge et al., 2009; Solan et al., 2015).
5. Utilise the "teach-back" technique to provide hospital-to-home transition information, especially for caregivers with language deficiencies. “Teach-back" technique improves healthcare providers-caregiver communication and increased caregivers' understanding and retention of health information (Hamline et al., 2018; Kornburger et al., 2013).
6. Complete and distribute hospital discharge summaries to primary carers/family's general practitioner before sending patients home from the ward (Choudhry et al., 2016; Hoyer et al., 2016). Discharge summary offers detailed hospitalisation information when patients/caregivers seek medical advice following hospital discharge. This may assist to prevent unnecessary ED visits or unplanned readmissions.

5.4.2 Recommendation for education

The content of hospital-to-home transition information delivery heavily depends on nurses' years of working experience and speciality area of practice. It is essential to include education on transition information and discharge planning/process in ward orientation programs for junior and casual staff to ensure consistency of information content and delivery (Chidume & Pass-Ivy, 2019).

5.4.3 Recommendation for stakeholders and policy

Electronic medical record-keeping has not been implemented at the participating children's hospital. This means it is difficult to access data and information to inform changes clinical care which could improve patient outcomes. A comprehensive electronic medical record system is warranted to allow easy access to clinical information and written discharge documentation information.

5.4.4 Recommendations for Future Research

Five key recommendations for future research emerged from this in-depth examination of unplanned hospital readmissions and nurse-caregiver communication.

1. Publication 4 and Publication 5 propose a study incorporating WA linkage data to capture unplanned hospital readmissions to the same or a different hospital across the breadth of WA. This will provide opportunity to compile a comprehensive dataset which will enable identification of all paediatric unplanned readmissions in WA.
2. Publication 4 urges further investigation and implementation of prevention strategies to address the findings that 52% of unplanned readmissions occurring in the first 5 days following discharge, especially when the readmission occurs on the date of discharge.
3. Publication 4 recommends future studies examining the appropriateness of establishing readmission measurements against specific diagnosis for paediatric patients. This will provide accurate prevalence data and cost of readmissions (Donzé et al., 2013; Kansagara et al., 2011), which in turn will assist to improve efficiencies in resource utilisation within the WA healthcare system (Independent Hospital Pricing Authority (IHPA), 2016).
4. Publication 6 suggests a larger sample size to leverage further the benefit of machine learning approaches in the development of predictive models for unplanned paediatric readmissions, as a highly constrained approach was used to prevent overfitting.
5. Publication 7 recommends the examination of the reliability of the readiness for discharge assessment instruments, namely 'Readiness for hospital discharge scale', 'Quality of discharge teaching scale' and 'Post-discharge coping difficulty scale' in the WA healthcare context (Lerret, 2009; Lerret & Weiss, 2011; Lerret et al., 2014; Lerret et al., 2015; Weiss et al., 2017). Identification of a suitable tool for use in clinical practice is essential.

Chapter 6

Conclusion

This thesis presents a mixed-methods sequential explanatory study investigating paediatric unplanned hospital readmission to a tertiary children's hospital in WA with the aim to develop predictive models and examine hospital-to-home transition information communication at the time of discharge. A summary of the main research outcomes derived from the two-phase/eight-stage study with considerations on how the findings address the overall aim is provided. The thesis concludes with the presentation of knowledge translation activities and impact of research outcomes.

6.1 Conclusion

The overall aim of this study and the identified six research objectives have been met by multiple extensive literature analyses and a mixed-method sequential explanatory research study. Study Objectives 1 and 2 were met and presented in Chapter Two, consisting of three peer-reviewed journal publications and two theses sections. The outcomes of the comprehensive literature analyses identified the limited research evidence and clear need to examine paediatric transition experience at discharge and all-cause unplanned hospital readmissions risk factors in Australia. In addition, the literature analyses identified the need for a mixed-methods research approach to collect quantitative and qualitative data.

Study Objectives 3 to 6 were achieved by conducting a mixed-methods sequential explanatory study. The study involved two phases and eight stages of data collection from diverse sources and use of a wide range of analytic methods to maximise the study rigour. The research findings of the study were presented as four peer-reviewed journal publications in Chapter Four. Triangulation of the quantitative and qualitative data confirmed that transitioning a paediatric patient from hospital to home is a multifaceted and challenging process. The outcomes also confirmed the complexity of deriving predictive models for paediatric unplanned hospital readmissions.

Identifying predictors associated with paediatric readmission from Phase 1 of the study will facilitate healthcare providers to recognise and target children at higher risk of unplanned readmission as a result of their index admission. These identified readmission predictors need to be incorporated into the preparation and delivery of hospital-to-home transition information to reduce or prevent adverse events post-hospital discharge, such as unplanned ED visit and/or readmissions.

Phase 2 provided opportunity to gain insights into nurse-caregiver communication of hospital-to-home transition information at the time of discharge and during the recovery. These outcomes will inform the development of an evidence-based, comprehensive transition framework. Key components of the framework include specific transition information for patients at higher risk of UHRs, identification of designated staff who are responsible for early commencement of transition process, implementation of a validated discharge readiness assessment tool, provision of interpreter services for families with language barriers, utilisation of "teach-back" technique when communicating transition information, and completion and distribution of hospital discharge summaries. Use of the framework in clinical practice by healthcare providers will assist to improve individualised transition planning and consistency of transition information delivery between healthcare providers and caregivers.

This study also recommends inclusion of a comprehensive educational plan on the importance of hospital-to-home transition information and discharge planning/process in ward orientation programs for junior and casual staff to ensure consistency of information delivery. Ensuring tertiary hospitals have comprehensive electronic medical record systems is also recommended to facilitate access to clinical and written discharge documentation information. Analysis of patients' data would in turn to inform changes in clinical practice and improve patient health outcomes.

The outcomes of this research have identified key areas for future research. Urgent research is needed to examine one of the significant outcomes of this study that more than half of the UHRs occurred within five days post-discharge. In addition, this study also recommends further investigation of the appropriateness of establishing readmission measurements against specific diagnosis for paediatric patients. This will provide accurate data on UHR rates and the associated cost of readmissions, which in turn will improve resource utilisation within the WA healthcare system.

Future research examining WA linkage data including UHRs to the same or a different hospital across the breadth of WA is recommended. This will provide opportunity to capture true prevalence of paediatric unplanned readmissions in WA.

The outcome of this study will contribute to improving the quality and safety of paediatric hospital to home transition, and as a result, to reduce unplanned paediatric hospital readmissions.

6.2 Knowledge Translation Activities and Impact

6.2.1 Literature review – Publication 1

Publication 1 is published in the *Journal of Clinical Nursing* and has been cited 52 times by 2 August 2021 as per the *Scopus* (Appendix D.1). An updated literature review using the same search strategy was conducted, and the results were presented at the Australian College of Children and Young Peoples Nurses 2018 International Conference, Perth (Appendix D.2).

Zhou, H., Roberts, P., Dhaliwal, S.S., & Della, P. (2016). Transitioning adolescent and young adults with chronic disease and/or disabilities from paediatric to adult care services – An integrative review. Journal of Clinical Nursing, 25, 3113–3130. http://doi.org/10.1111/jocn.13326

Zhou, H., Della, R.P., & Roberts, P.A. (2018). An updated integrative review on transiting adolescents and young adults with chronic illness and/or disabilities from paediatric to adult healthcare services. Oral presentation in October 2018 at *The Australian College of Children and Young Peoples Nurses 2018 International Conference*, Perth, WA.

6.2.2 Literature review – Publication 2

Publication 2 is published in the *BMJ Open* and has been cited 115 times by 2 August 2021 as per the *Scopus* (Appendix D.1). Publication 2 was also cited in the report entitled "*Submission to the Independent Hospital Pricing Authority Discussion Paper on the Pricing Framework for Australian Public Hospital Services 2017–18*" by Professor Antony Scott and Associate Professor Jongsay Yong from the Melbourne Institute of Applied Economic and Social Research, The University of Melbourne. The report can be accessed via the web link https://www.ihpa.gov.au/sites/g/files/net636/f/Documents/melbourne_institute_of_applied_economic_and_social_research.pdf

Zhou, H., Della, P., Roberts, P., Goh, L., &Dhaliwal, S.S. (2016). Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review. BMJ Open, 6:e011060. http://doi.org/10.1136/bmjopen-2016-011060

6.2.3 Literature review – Publication 3

Publication 3 is published in the *BMJ Open* and has been cited six times by 2 August 2021 as per the *Scopus* (Appendix D.1).

Zhou, H., Roberts, P.A., Dhaliwal, S.S., & Della, P.R. (2019). Risk factors associated with paediatric unplanned hospital readmissions: A systematic review. BMJ Open, 9(9:e020554). https://doi.org/10.1136/bmjopen-2017-020554

6.2.4 Phase 1 Stage 1 – Publication 4

Phase 1 Stage 1 is presented as Publication 4 in Chapter Four of the thesis, published in the Australian Health Review and has been cited four times by 2 August 2021 as per *Scopus* (Appendix D.1).

Zhou, H., Della, P., Roberts, P., Porter, P., & Dhaliwal, S. (2019). A 5-year retrospective cohort study of unplanned readmissions in an Australian tertiary paediatric hospital. Australian Health Review. https://doi.org/10.1071/AH18123

6.2.5 Phase 1 Stage 2 – Publication 5

Phase 1 Stage 2 is presented as Publication 5 in Chapter Four of the thesis, published in the *Journal of Paediatrics and Child Health* and has been cited twice by 2 August 2021 as per *Scopus* (Appendix D.1). Publication 5 was recognised by the Wiley publisher as the top downloaded paper 2018–2019 (Appendix D.3).

Zhou, H., Della, Della, P.R., P. Porter, P., & Roberts, P.A. (2020). Risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in Western Australia. *Journal of Paediatrics and Child Health*. https://doi.org/10.1111/jpc.14492

6.2.6 Phase 1 Stage 3 – Publication 6

Phase 1 Stage 3 is presented as Publication 6 in Chapter Four of the thesis, published in the *Australian Health Review*. The results of auditing written discharge documentation of this Phase/Stage 3 was also presented at the 4th West China International Nursing Conference – Chengdu, China in 2019 (Appendix D.4). Additionally, Publication 6 was cited by The Australian on 25th May 2021in an article by Paul Garvey entitled "Language handicaps hospital staff" (D.4).

Zhou, H., Albrecht, M.A., Roberts, Porter, P., & P.A. Della, P. (2021). Using machine learning to predict paediatric 30-day unplanned hospital readmissions: A case-control retrospective analysis of medical records, including written discharge documentation. *Australian Health Review*. https://doi.org/10.1071/AH20062

Zhou, H., Della, R.P., & Roberts, P.A. (2019). A retrospective analysis on discharge documentation at a tertiary paediatric hospital of Western Australia. Oral presentation in September 2019 at *The 4th West China International Nursing Conference*, Chengdu, China.

6.2.7 Phase 2 with 5 Stages – Publication 7

Phase 2 with 5 Stages is presented as Publication 7 in Chapter Four of the thesis, published in the *Journal of Pediatric Nursing*. Publication 7 was also cited by The Australian on 25th May 2021in an article by Paul Garvey entitled "Language handicaps hospital staff" (Appendix D.5).

Zhou, H., Roberts, P.A., & Della, P.R. (2021). Nurse-caregiver communication of hospital-to-home transition information at a tertiary pediatric hospital in Western Australia: A multi-stage qualitative descriptive study. *Journal of Pediatirc Nursing, 60*, 83–91. https://doi.org/10.1016/j.pedn.2021.02.017

6.2.8 Phase 1 & Phase 2 – Research Outcomes

The research outcomes of both Phase 1 and Phase 2 was presented at the International Council of Nurses (ICN) Congress, Singapore in June 2019 (Appendix D.6).

Zhou, H., & Della, R.P. (2019). Improving the effectiveness and efficiency of paediatric discharge planning: linking a series of research studies. Oral presentation in June 2019 at *The International Council of Nurses (ICN) Congress*, Singapore.

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APPENDICES

Appendix A

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Mon 12/04/2021 3:14 PM

Heald, Janelle (Services, Clayton Wgtn Rd) <Janelle.Heald@csiro.au>

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Appendix B

Data Collection Instruments: Restrospective Dataset Audit, Direct Clinical Observation & Semi-structured Interview

B.1 Data Extraction Form – Administrative Dataset Audit (Phase 1/Stage 1 & 2)

Data Collection Form – Administrative Inpatient Dataset

Index hospital admission

1. Age (round to the nearest month or in Days) _____Years and___Months /or____Days
2. Gender Male □ Female □
3. Race/Ethnicity if applicable ______________________
4. State/Territory of residence WA □ Non-WA □
5. Post Code/Suburb of home address_________________
6. Medicare Card Yes □ No □
7. Private Insurance Card Yes □ No □
8. Healthcare Card Yes □ No □
9. GP Contact Yes □ No □
10. Source of referral transport Private/Public transport □ Ambulance □ Aeromedical Service □
11. Number of admissions in the last year prior to this admission _______
12. Number of Emergency Department visits in the last year prior to this admission _____
13. Number of outpatients appointment in the last year prior to this admission_______
14. The date and time of initial admission (DD/MM/YYYY; HH:MM)____________
15. Care type provided Acute care □ Other types of care □
16. Interpreter requirement Yes □ No □
17. Admission mode Elective admission □ Emergency admission □ Referred from GP/peripheral hospitals □
18. The admitting principal diagnosis of the initial admission______________
19. Number of Co-diagnosis____________
20. The discharge principal diagnosis of the initial admission______________
21. The date and time of discharge from the initial admission (DD/MM/YYYY; HH:MM)

22. The discharge disposition (Home □; Home with Post-Acute Care Service □; Transferred to another facility □)

23. Length of Stay (Days)__________

24. Significant social history (i.e., under the care of Child Protection Unit CPU)__________

25. ICU stay   Yes □   No□

26. General anaesthetic Yes □   No□

<u>30-Day Unplanned Hospital Readmission (If applicable)</u>

27. The date and time of readmission (DD/MM/YYYY; HH:MM)_________

28. The date of discharge of the readmission (DD/MM/YYYY)___________

29. Admission mode (i.e., Elective admission □; Emergency admission □; Referred from GP/peripheral hospitals □)

30. The admitting principal diagnosis___________

31. The discharge principal diagnosis____________

32. The discharge disposition   Home □ Home with Post-Acute Care Service □
    Transferred to another facility □

33. Length of Stay (Days)_______________

B.2 Data Extraction Form – Medical Records Audit (Phase 1/Stage 3)

Data Collection Form – Medical Records

Index hospital admission – Clinical Variables

1. Admission weight
2. Significant social history
3. History of allergies
4. Significant social history (i.e., under the care of Child Protection Unit CPU)
5. Language other than English Yes □ No □
6. Interpreter required Yes □ No □
7. Language spoken at home____________
8. Significant vital signs Yes □ No □
9. Significant laboratory result Yes □ No □
10. Significant imaging result Yes □ No □
11. Main treatment/management___________________

Index hospital admission – Written Discharge Documentation Variables

12. Delay of issuing discharge summary (Date of issue – Data of discharge)________Day/s
13. Completeness of Nursing Admission Form Yes □ No □
14. Completeness of Nursing Discharge Planning Form Yes □ No □
15. Progress note or Operation sheet Last Entry by **Physician** Yes □ No □
16. Progress note or Clinical Pathway Last Entry by **Nurse** Yes □ No □
17. Progress note Last Entry by **Allied healthcare provider** Yes □ No □
18. Discharge information given by **Physician** from the initial admission

    No □ Written advice (information sheet) □

    Evidence of oral advice given (from the progress notes) □

19. Discharge information given by **Nurse** from the initial admission

No □ Written advice (information sheet) □

Evidence of oral advice given (from the progress notes) □

20. Discharge information given by **Allied health provider** from the initial admission

No □ Written advice (information sheet) □

Evidence of oral advice given (from the progress notes) □

21. Discharge medication information given by P**hysician** from the initial admission

No □ Written advice (information sheet) □

Evidence of oral advice given (from the progress notes) □

22. Discharge medication information given by **Nurse** from the initial admission

No □ Written advice (information sheet) □

Evidence of oral advice given (from the progress notes) □

23. Discharge medication information given by **Allied healthcare provider** from the initial admission

Written advice (information sheet) □

Evidence of oral advice given (from the progress notes) □

24. Follow up or referral discussed by **Physician**

Written appointment □

Evidence of oral advice given (from the progress notes) □

25. Follow up or referral discussed by **Nurse**

Written appointment □

Evidence of oral advice given (from the progress notes) □

26. Consistency of written discharge information documented among healthcare providers

Yes □ No □

30-Day unplanned Emergency Department Presentation and/or Unplanned Hospital Readmission (For Patients with UHRs)

27. The date and time of unplanned Emergency Department visit (DD/MM/YYYY; HH:MM)
28. Main presenting problems
29. Treatment/management
30. Emergency Department Discharge date and time ((DD/MM/YYYY; HH:MM)
31. The date and time of readmission (DD/MM/YYYY; HH:MM)
32. The date of discharge of the readmission (DD/MM/YYYY)
33. The admitting principal diagnosis
34. The discharge principal diagnosis

B.3 Direct Clinical Observation Checklist (Phase 2/Stage 1)

Direct Clinical Observation Checklist

Study ID_____

Date of Observation (DD/MM/YY):				
Time of Observation (Start – HH:MM):				
Time of Observation (Finish – HH:MM):				
Ward/Site:				
Communication at Discharge	**Yes**	**No**	**N/A**	**Notes**
Develops rapport				
Greets patients with names				
Introduces self(HCPs) and role				
Wears staff ID with name clearly showing				
Warm, friendly opening				
Empathic towards patients/caregivers' situation				
Acknowledges patients/caregivers' views and feelings				
Displays appropriate non-verbal behavior				
Demonstrates active listening skills (i.e., paraphrasing, clarifying)				
Maintains eye contact if culturally appropriate				
Demonstrates respect and interest on patients				
Attends to patients' physical comfort and privacy				
Not intrusive of patients/caregivers' space				
Appropriate posture, position & movement				
Appropriate vocal cues (rate, volume, intonation)				
Demonstrates appropriate confidence				
Uses appropriate language				
Understandable vocabulary				
Avoids medical jargon				
Avoids confronting language				
Appropriate uses of open-ended questions to explore patients/caregivers' feeling & problems				
Checks for understanding				
Involves the patients and caregivers				
Shares thinking to encourage involvement				
Explains rationale for questions or physical examinations				
Encourage patients/caregivers to express their concerns over readiness to be discharged				
Provides quality of discharge information				
Information on how to care the child at home after being discharged				
Information on the medication required after being discharged				
Information on a child's daily activities (i.e., eating, bathing, schooling, sporting) after being discharged				
Information on when/where to seek medical attention after being discharged				
Information on the use of equipment required after being discharged				
Provides written information of the above				

Venue (1) Ward-Patient room (2) Recovery – OT (3) Corridor

Surrounding area

(1) Single room

a. Quiet Noisy
b. If noisy Intermittent Continuous
c. Noise source= TV/Electronic Games Medical monitor Conversation
d. Noise level= Low Mod High
e. Action taken= No Yes____

(2) Shared room of two patients

a. Quiet Noisy
b. If noisy Intermittent Continuous
c. Noise source= TV/Electronic Games Medical monitor Conversation
d. Noise level= Low Mod High
e. Action taken= No Yes____

(3) Shared room of four patients

a. Quiet Noisy
b. If noisy Intermittent Continuous
c. Noise source= TV/Electronic Games Medical monitor Conversation
d. Noise level= Low Mod High
e. Action taken= No Yes____

(4) Corridor

a. Quiet Noisy
b. If noisy Intermittent Continuous
c. Noise source= Staff/Ward activity Conversation of other caregiver/s
d. Noise level= Low Mod High
e. Action taken= No Yes____

(5) **Recovery - OT**

a. Quiet Noisy
b. If noisy Intermittent Continuous
c. Noise source=Staff/Ward activity Conversation of other caregiver/s
d. Noise level = Low Mod High
e. Action taken= No Yes____

Noise level:

Low (D/C conversation uninterrupted)
Mod (D/C conversation intermittently interrupted & Needs to raise voices)
High (D/Conversation frequently interrupted & Needs to 'shut down' the noise)

Patient's physical position

(1) Lying in bed
(2) Sitting up in bed
(3) Sitting up in chair next to bed
(4) Corridor
(5) Others________________________________

Caregiver/s' Physical position location

(1) Lying in bed with patient
(2) Sitting at bed side
(3) Sitting in the chair next to patient
(4) Corridor
(5) Others________________________________

Physician/Team's physical position

(1) Standing next to bed
(2) Standing at the end of bed
(3) Corridor
(4) Others________________________________

Distance from Physician/Team to Patient and Caregiver/s

(1) $\leq$ 50cm
(2) 51cm – 100cm
(3) > 100cm

Diagram if Applicable

B.4 Interview Guide – Caregivers: Immediately Post Discharge, 2–4 Weeks Post Discharge (Phase 2/Stage 2 & 4)

Interview Guide

Semi-structured Interviews with Caregivers Immediately Post-discharge & 2-4 Weeks Post-discharge

Introduction

Hi, and thank you for meeting me today. My name is Jo, and I am a research officer from School of Nursing and Midwifery, Curtin University. I am inviting you to participate in a study, which is part of a research project to help us to understand your experience when your child is discharged from PMH to home or community health services. I am particularly interested in understanding how helpful or unhelpful you found communication with the healthcare providers at discharge.

Objective

The objective of this interview is to identify the key issues for patient safety through patients' and carers' reports of their experiences in transitioning from acute to primary care immediately following discharge.

Consent and Ground Rules

[*The envelopes containing the copy of the consent form and reimbursement of $20 for time, inconvenience and cost of parking should be given out at the beginning of the interview*]

We will start by going over a Participant Information sheet and a Consent Form that describe the project. Please sign the consent form if you agree to take part. I will keep the signed copy and you will keep a copy for your records. Feel free to ask me questions if you don't understand something. (Phone number and email address of the participant will be obtained with permission for the researcher to contact interview one month later). If you agree to participate, we will have our interview.

Your participation in this interview session is completely up to you. You can choose to take part in as much or as little as you want. Also, there are no right or wrong answers to any of the questions I will ask. Please be as complete and honest as possible in your responses. We are here today to learn about your opinions and thoughts about communication during the discharge process.

We will be tape recording the discussion to make sure we don't miss anything. Your name will not be connected to either your answers to the questions asked or the answers to the written questions. The tapes and papers will be kept safely by us and destroyed once all the information is recorded.

(*Allow participant 5 minutes to read the information sheet and the consent form*; *If participants agree, have them sign and return the forms*)

A copy of this form is in your envelope along with reimbursement of $20 for time, inconvenience and cost of parking. Our phone number is on this consent form, so please feel free to get in touch with us if you have any questions after this interview session. I will be asking you questions so that we can learn your thoughts and about experiences you have had at the discharge process.

Finally, just some housekeeping issues: (offer Tea and coffee prior to the session). The bathrooms are located (indicate location). If you need to use the bathroom during our discussion, feel free to do so. This session will take about 30 to 45 minutes. Please turn off your cell phones. What questions or concerns do you have before we begin?

Part A: Semi-structured interviews with caregivers immediately post- hospital discharge

1. Your child has just been discharged from the hospital. How would you describe your overall experience of the discharge process for your child?

2. Effective communication requires both verbal (speaking) and non-verbal skills (gesture, eye contact).

   2.1 How did you find the nurses' verbal communication skills?
   2.2 How did you find the nurses' non- verbal communication skill?

3. HCPs often use medical words that patients may not understand. Examples of some of these words are anticoagulant, oral hypoglycemic, or hypertension.

   3.1 Did your nurse use words that you were unsure of?
   3.2 If so, did the nurse explain what these words mean in plain language?
   3.3 In what ways do you think this might affect your understanding of your medical condition?
   3.4 In what ways do you think this might affect your understanding of how to provide care to your child when you go home?

4. Has a nurse ever asked you if you understand what she or he has told you?

   Yes No
   4.1 Has a nurse ever asked you to repeat back what she or he told you during the discharge process?
   4.2 If you were speaking to a nurse and did not understand what she or he was telling you, what would you do or say?

5. Describe your experience in talking with the nurses?

6. What involvement did you have in the decision making during your child's hospitalisation/at discharge?

7. What is your child's diagnosis from the explanation provided during hospitalisation?

8. Tell me about how prepared you were to have your child discharged today? (readiness, plan for transport)

9. Could you tell me about how informed you felt with regard to caring for your child health at home?

10. Could you tell me about how informed you felt about when and where to seek medical attention, if your child develops specific symptoms/health problems?

11. Could you please tell me about how informed you felt about the discharge medication to be given to your child at home? (Frequency, dosage, time to be given, possible side effects, and rational of having each medication)
    - 11.1 The name of the medicine
    - 11.2 What the medicine does
    - 11.3 How to take the medicine and for how long
    - 11.4 (if applicable) Any special directions about preparing the medicine
    - 11.5 Any special directions about taking the medicine
    - 11.6 Side effects, harmful effects, if you can take it with another medicine, how to avoid any harmful problems from taking the medicine wrong, or what to do if you have taken the medicine wrong
    - 11.7 Where to keep the medicine

12. Could you please tell me about how informed you felt about the use of any medical equipment for your child at home?

13. Could you please tell me how informed you felt about your child's appropriate daily activities (eating, bathing, schooling, sporting) after discharge from the hospital?

14. Tell me about your understanding with respect to the written instruction/information provided for the care of your child at home (if applicable)?
    - 14.1 Do printed materials tell you what you want to know about your child's care required at home?
    - 14.2 Are the printed materials organized in a way that makes it easy for you to find the information you need?

15. Tell me about how informed you felt about the follow up appointment/referral? (location and date/time)

16. In what way do you think the discharge process, especially the communication practice, can be improved?

17. Any other thoughts you wish to share on your experience at the discharge?

Participants' demographic questionnaire

(Distribute a demographic questionnaire to each participant.)

This is a short information sheet. Please answer as many questions as you wish on this sheet. Do not write your name on it. The purpose of this is to get to know a little bit more about who are in today's interview session. Your name will not be connected with any of your responses. This is just for our information. Please hand it back to me when you are finished.

Participant Profile 1 (Child/Patient)

1. Patient Age: ______year and ______months
2. Gender: Male Female
3. Ethnicity origin
   - African Australian
   - Arab Australian
   - Asian Australian
   - European Australian
   - Indigenous peoples of Australia
   - Oceanian Australian
   - Others
4. Number of siblings (if applicable)________
5. Principal Diagnosis____________
6. Admission Date______________
7. Discharge Date_____________
8. Mode of Discharge
   - Home,
   - Foster home,
   - Community health services
   - Others____________________________

Participants Profile 2 (Caregiver of the patient)

9. Caregiver in presence at discharge

   Father Mother Others___________

10. Primary caregiver at home

    Female Male

11. Age
    - <20
    - 21-25
    - 26-30
    - 31-35
    - 36-40
    - 41-45
    - 46-50
    - >51

12. Educational Background (Highest qualification)
    - No schooling completed
    - Primary school completed
    - Lower secondary school completed
    - Higher secondary school completed
    - Some college credit, no degree
    - Trade/technical/vocational training
    - Bachelor's degree
    - Master's degree
    - Doctorate degree
    - Others

13. Professional or Employment Status
    - Employed for wages
    - Self-employed
    - Out of work and looking for work
    - Out of work but not currently looking for work
    - A homemaker
    - A student
    - Military
    - Retired
    - Unable to work

Interview Conclusion - That's all the questions we have for you today. Thank you very much for your time and your thoughts. This information will be very helpful for us to better understand the communication practice at the discharge process of a paediatric patient's hospitalisation.

Part B: Semi-structured interviews with caregivers 2-4 Weeks post-hospital discharge

Thank you very much for the opportunity to follow up with you in terms of your child's recovery experience!

1. How was your overall experience of looking after your child after being discharged from the hospital?

   Now that your child has been home for a month,

2. What is your view of the discharge information of how to care for your child at home

3. What is your view of the information given about the discharge medication your child had to take at home?

4. What is your view of the information given about the medical equipment for your child at home?

5. How helpful was the information given about your child's expected daily activities (eating, bathing, schooling, sporting) after discharge from the hospital?

6. What is your view of the information about your child's expected daily activities (eating, bathing, schooling, and sporting) after discharge from the hospital?

7. What is your view about the discharge written information/instruction to care for you child at home?
   - 7.1 Did printed materials tell you what you needed to know about your child's care required at home?
   - 7.2 Were the printed materials organized in a way that makes it easy for you to find the information when you needed?

8. Have you taken your child to attend the follow up/referral?
   - 8.1 if no, go to the next question
   - 8.2 if yes, how was your experience?

9. What is your view of the information given about when and where to seek medical attention with regards specific symptoms/health problems?

10. Did you have to take your child to seek medical attention related to the hospitalisation, other than the arranged follow up?
    - 10.1 if no, go to the next question
    - 10.2 if yes, describe in details what happened?

11. Did your child get readmitted to the same hospital as the previous hospitalisation?

    11.1 if no, go to the next question
    11.2 if yes, describe in details what happened?

12. In what way do you think the discharge process, especially the communication practice, can be improved?

13. Any other thoughts you wish to share on your experience at discharge?

Interview Conclusion - That's all the questions we have for you today. Thank you very much for your time and your thoughts. This information will be very helpful for us to better understand the communication practice at discharge, related to paediatric patient's hospitalisation.

B.5 Interview guide – Nurses (Phase 2/Stage 3)

Interview Guide

Semi-structured Interviews with Nurses who has discharged a patient from an inpatient ward of PMH

Introduction

Hi, and thank you for meeting me today. My name is Jo, and I am a research officer at School of Nursing and Midwifery, Curtin University. I am wanting to collect data which is part of a research project to help us to understand your experience when your patient is discharged from PMH to home or community health services. I am particularly interested in understanding how helpful or unhelpful you found communication at discharge.

Objective

The objective of this interview is to identify the key issues for patient safety through HCPs' reports of their experiences in transitioning from acute to primary care immediately following discharge.

Consent and Ground Rules

[*The envelopes containing the copy of the consent form and reimbursement of $20 for time, inconvenience and cost of parking should be given out at the beginning of the interview*.]

I am inviting you to take part in this study so I want to let you know what will happen today during this session if you agree to participate. We will start by going over a Participant Information sheet and a Consent Form that describe the project. If you wish to take part, please sign the consent form. I will keep the signed copy and you will keep a copy for your records. Feel free to ask me questions if you don't understand something. (Phone number and email address of the participant will be obtained with permission for the researcher to contact interview one month later). If you agree to participate, we will have our interview.

Your participation in this interview session is completely up to you. You can choose to take part in as much or as little as you want. Also, there are no right or wrong answers to any of the questions I will ask. Please be as complete and honest as possible in your responses. We are here today to learn about your opinions and thoughts about communication during the discharge process.

We will be tape recording the discussion to make sure we don't miss anything. Your name will not be connected to either your answers to the questions asked or the answers to the written questions. The tapes and papers will be kept safely by us and destroyed once all the information is recorded.

(*Allow participant 5 minutes to read the information sheet and the consent form*; *If participants agree, have them sign and return the forms*)

A copy of this form is in your envelope along with reimbursement of $20 for time, inconvenience and cost of parking. Our phone number is on this consent form, so please feel free to get in touch with us if you have any questions after this interview session. I will be asking you questions so that we can learn your thoughts and about experiences you have had at the discharge process.

Finally, just some housekeeping issues: (offer Tea and coffee prior to the session). The bathrooms are located (indicate location). If you need to use the bathroom during our discussion, feel free to do so. This session will take about 30 to 45 minutes. Please turn off your cell phones. Do you have any questions or concerns before we begin?

Let's get started

Interview questions

1. You've just discharged a patient form the hospital, how did you find the overall discharge process?

2. Effective communication requires both verbal (speaking) and non-verbal skills (gesture, eye contact).

   2.1 How did you find your verbal communication skills?
   2.2 How did you find your non- verbal communication skill?

3. HCPs often use medical words that patients may not understand. Examples of some of these words are anticoagulant, oral hypoglycemic, or hypertension.

   3.2 Do you use complicated words?
   3.2 If so, do you explain what these words mean in plain language?
   3.3 In what ways might this affect patients' and/or parents/primary carers' understanding of their child medical condition?
   3.4 In what ways might this affect their understanding of how to provide continuity care to the child when they go home?

4. How did you encourage patients and/or parents/primary carers to get involved in the conversation with you?

5. How did you involve patients and/or parents/primary carers in the decision making at the discharge process?

6. How well did you explain the diagnosis of the child to patients and/or parents/primary carers?

7. How have you prepared patients and/or parents/primary carers to discharge their child form the hospital today? (Readiness, plan for transport)

8. How did you inform patients and/or parents/primary carers the care required for the child at home?

9. How did you inform patients and/or parents/primary carers when and where to seek medical attention with specific symptoms/health problems?

10. If applicable, how did you explain to the patients and/or parents/primary carers about the discharge medication to be given to your child at home?

    (Frequency, dosage, time to be given, possible side effects, and rational of having each medication)

11. If applicable, how did you explain the use of the medical equipment for the discharged child to use at home?

12. How did you explain about the child's daily activities (eating, bathing, schooling, and sporting) after discharge from the hospital?

13. If applicable, how did you find the quality of written instruction/information to be given to patients and/or parents/primary carers for the care of their child at home (if applicable)?

14. How did you explain the Follow up appointment/referral to patients and/or parents/primary carers?

15. In what way you think the discharge process especially the communication practice can be improved?

16. Any other thoughts you wish to share on your experience at the discharge?

Participant demographic questionnaire

(Distribute a demographic questionnaire to each participant.)
This is a short information sheet. Please answer as many questions as you wish on this sheet. Do not write your name on it. The purpose of this is to get to know a little bit more about who are in today's interview session. Your name will not be connected with any of your responses. This is just for our information. Please hand it back to me when you are finished.

Participants Profile 3 (Nurses)

1. Nurse: Clinical Nurse, Registered Nurse, Enrolled Nurse

2. Allied Health Professionals: Physiotherapist, Pharmacist, Occupational therapist, Dietician, others________________________

3. Specialty in PMH_______________________

4. Highest completed relevant qualification

- Hospital based diploma
- Undergraduate bachelor degree (including Honours)
- Postgraduate certificate/diploma
- Master degree
- Doctorate/Doctor of Philosophy

5. Years of experience in the profession____________

6. Years of experience in PMH___________________

7. Age group (in years)
    - 21-25
    - 26-30
    - 31-35
    - 36-40
    - 41-45
    - 46-50
    - 51-55
    - 56 and Over

Interview Conclusion - That's all the questions we have for you today. Thank you very much for your time and your thoughts. This information will be very helpful for us to better understand the communicative practice at the discharge process of a paediatric patient's hospitalisation.

B.6 Data Extraction Form – Medical Records Audit (Phase 2/Stage 5)

Data Collection Form – Medical Records

Index hospital admission – Clinical Variables

1. Admission weight
2. Significant social history
3. History of allergies
4. Significant social history (i.e., under the care of Child Protection Unit CPU)
5. Language other than English Yes □ No □
6. Interpreter required Yes □ No □
7. Language spoken at home____________
8. Significant vital signs Yes □ No □
9. Significant laboratory result Yes □ No □
10. Significant imaging result Yes □ No □
11. Main treatment/management___________________

Index hospital admission – Written Discharge Documentation Variables

12. Delay of issuing discharge summary (Date of issue – Data of discharge)________Day/s
13. Completeness of Nursing Admission Form Yes □ No □
14. Completeness of Nursing Discharge Planning Form Yes □ No □
15. Progress note or Operation sheet Last Entry by **Physician** Yes □ No □
16. Progress note or Clinical Pathway Last Entry by **Nurse** Yes □ No □
17. Progress note Last Entry by **Allied healthcare provider** Yes □ No □
18. Discharge information given by **Physician** from the initial admission

    No □ Written advice (information sheet) □

    Evidence of oral advice given (from the progress notes) □

19. Discharge information given by **Nurse** from the initial admission

    No □ Written advice (information sheet) □

    Evidence of oral advice given (from the progress notes) □

20. Discharge information given by **Allied health provider** from the initial admission

    No □ Written advice (information sheet) □

    Evidence of oral advice given (from the progress notes) □

21. Discharge medication information given by P**hysician** from the initial admission

    No □ Written advice (information sheet) □

    Evidence of oral advice given (from the progress notes) □

22. Discharge medication information given by **Nurse** from the initial admission

    No □ Written advice (information sheet) □

    Evidence of oral advice given (from the progress notes) □

23. Discharge medication information given by **Allied healthcare provider** from the initial admission

    Written advice (information sheet) □

    Evidence of oral advice given (from the progress notes) □

24. Follow up or referral discussed by **Physician**

    Written appointment □

    Evidence of oral advice given (from the progress notes) □

25. Follow up or referral discussed by **Nurse**

    Written appointment □

    Evidence of oral advice given (from the progress notes) □

26. Consistency of written discharge information documented among healthcare providers

    Yes □ No □

30-Day unplanned Emergency Department Presentation and/or Unplanned Hospital Readmission (If Applicable)

27. The date and time of unplanned Emergency Department visit (DD/MM/YYYY; HH:MM)
28. Main presenting problems
29. Treatment/management
30. Emergency Department Discharge date and time ((DD/MM/YYYY; HH:MM)
31. The date and time of readmission (DD/MM/YYYY; HH:MM)
32. The date of discharge of the readmission (DD/MM/YYYY)
33. The admitting principal diagnosis
34. The discharge principal diagnosis

B.7 Participant Information Sheet – Caregivers (Phase 2/Stage 1)

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service

Transitions of care at discharge for paediatric patients: Communication practice

Direct Clinical Observation of the Discharge Process - Caregivers

Why are we doing the study?

Sometimes children get sick and are required to be readmitted to hospital. This can be due to a number of reasons including you not understanding the information provided and what you have to do when you take your child home. We want to understand the process of discharge in hospital so we can identify what areas can be improved.

What will the study tell us?

The study will provide us with a better understanding of the communication processes between doctors, nurses, allied healthcare professionals, you and your child before your child is discharged from hospital.

Who is carrying out the study?

Jo Zhou, Research Officer, School of Nursing and Midwifery, Curtin University
Clinical Nurse, Ward 8A, PMH

Does my child have to take part?

No, your child does not have to take part. If you and/or your child do not want to take part it will not affect the care your child will receive.

What will you be asked to do if you decide to take part in this study?

- Your interaction with your child and the healthcare providers during your child's discharge process will be observed
- During the observations, audio-recording of all interactions in the discharge process will be carried out using a digital recorder
- The researcher will also take notes of the interactions
- Your background details will also be obtained at the end of the observation

Page **1** of **3**

What does my child need to do to be in the study?

Your child will only be observed along with you and the doctors, nurses, allied healthcare professionals at the discharge process on the ward of PMH

Is there likely to be a benefit to my child?

There is no direct benefit to your child with the current hospitalization; however, the study aims to improve the communication practice at the discharge process to ensure continuity of care in future hospitalization/s.

Is there likely to be a benefit to other people in the future?

We hope this study will result in strategies and recommendations to improve communication between staff and children and carers on discharge thus making discharge information clearer.

What are the possible risks and/or side effects?

There are no expected risks and/or side effects will occur as a result of this study.

What are the possible discomforts and/or inconveniences?

There are no expected discomforts and/or inconveniences as discharge is part of the routine care provided in PMH. However, you and your child will be observed and recorded while discussing your child's care.

There may be an inconvenience as getting your background details filled up may take an extra 10 minutes before you can leave the ward.

Where is your information kept?

The paper copy of the data collected and all documents will be kept in a locked filing cabinet in a secure office at School of Nursing and Midwifery, Curtin University, these will be archived indefinitely. Computer data will not have any identifying names, will be password protected and able to be accessed by the research team only.

What about my privacy?

Information will remain confidential at all times. You and your child will receive a number which will be used on all paperwork. You will also be reassured of the confidentiality of the data and your right to withdraw from the study at any time. Confidential material may be recorded during the observation, i.e., name of your child, but this will not be included in the final transcripts for analysis. All identifiable information will be replaced with a code. The results will be reported in a table so as to protect the identity of the participants.

Page **2** of **3**

Who has approved the study?

Ethics approvals have been obtained from the Human Research Ethics Committee of Princess Margaret Hospital for Children and from Curtin University.

Who to contact for more information about this study:

If you would like any more information about this study, please do not hesitate to contact one of the research team. They are very happy to answer your questions.

Name	Title	Contact Number
Jo Zhou (Research Officer)	Ms	0411389882
Phillip Della (Chief Investigator)	Professor	(08) 92662062

Who to contact if you have any concerns about the organisation or running of the study?

If you have any concerns or complaints regarding this study, you can contact the Director of Medical Services at PMH (Telephone No: (08) 9340 8222). Your concerns will be drawn to the attention of the Ethics Committee who is monitoring the study.

What to do next if you would like your child to take part in this research:

If you would like to take part in this research study, please read and sign the consent form provided.

THANK YOU FOR YOUR TIME

B.8 Participant Consent Form – Caregivers (Phase 2/Stage 1)

FORM OF CONSENT
(For Caregiver)

PLEASE NOTE THAT PARTICIPATION IN RESEARCH STUDIES IS VOLUNTARY AND SUBJECTS CAN WITHDRAW AT ANY TIME WITH NO IMPACT ON CURRENT OR FUTURE CARE.

I .... have read
Given Names Surname

the information explaining the study entitled

Transitions of care at discharge for paediatric patients: Communication practice

Direct Clinical Observation of the Discharge Process

I have read and understood the information given to me. Any questions I have asked have been answered to my satisfaction.

I agree to allow
....
(Full name of participant and relationship of participant to signatory)

to participate in the study.

I understand my child may withdraw from the study at any stage and withdrawal will not interfere with routine care.

I agree that research data gathered from the results of this study may be published, provided that names are not used. I agree to have the interaction of the discharge process audio recorded.

Dated .... day of .... 20 ....

Child's Signature...
(Where appropriate)

Parent or Guardian's Signature ....

I, ... have explained the above to the
(Investigator's full name)

signatories who stated that he/she understood the same.

Signature of the investigator .... Date......................................

B.9 Participant Information Sheet – Nurses (Phase 2/Stage 1)

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service

Transitions of care at discharge for paediatric patients by emphasizing communication practice

Direct Clinical Observation of the Discharge Process - Nurses

Why are we doing the study?

Transitioning patients within and across health care facilities or from hospital to home has been recognized as a complex process. Recent evidences revealed that when poor communication occurs at points of care transition, patients are put at increased risk of adverse events. Paediatric patients are vulnerable during hospitalisation in part due to their high dependence on caregivers, parents and other adults, which means more stakeholders are involved with care and decision-making to negotiate post-transition care to hospital and/or the community on their behalf. The study aims to develop a better understanding on the communicative and interactive processes between health care providers, paediatric patients and their primary carers at discharge from acute to primary care settings

Who is carrying out the study?

Jo Zhou, Research Officer, School of Nursing and Midwifery, Curtin University
Clinical Nurse, Ward 8A, PMH

What will the study tell us?

- The stages in the communicative processes between doctors, nurses, allied healthcare workers, patients and their carers leading to discharge from acute to primary care
- The major risks and risk management strategies in communication during these stages
- How patients and carers are currently involved in decision-making about transitions of care

What will you be asked to do if you decide to take part in this study?

- Your interaction with patients and their parents/primary carers during the patient's discharge process will be observed
- Audio-recording of all interactions in the discharge process will also be carried out using a digital recorder
- Your demographic information will also be obtained at the end of the observation

Page **1** of **3**

Is there likely to be a benefit to the current patients?

There is no direct benefit to the current patients; however, the study aims to inform the communication practice at the discharge process to contribute to continuity of care in future hospitalization/s.

Is there likely to be a benefit to other people in the future?

This project will make a significant contribution to improving paediatric patient safety and reducing the inefficiencies and economic effects of discontinuity in acute to primary sector transitions of care.

What are the possible risks and/or side effects?

There are no foreseen risks and/or side effects as there is no intervention involved in this study.

What are the possible discomforts and/or inconveniences?

There are no foreseen discomforts as discharge is part of the routine care provided in PMH. However, staff might feel uncomfortable as being observed. In order to minimize the presence of the researcher affecting the participant's behaviour, the researcher will be discreet, keep distance from the participants as not to interfere with the normality of the process, but remains sufficiently close to observe the discharge process.

There may also be an inconvenience as completing the demographic form may take an extra 10 minutes before you can resume your work.

Where is your information kept?

All collected data will be entered into computer analysis software, on a Curtin School of Nursing and Midwifery computer using identification numbers only, no names will be used. Access to the stored data will be restricted by a password known only by the research officer and principal investigator. It is expected that the results will be presented at appropriate conferences and will be published in appropriate journals. All data collected will be stored safely in a locked cupboard at the Curtin School of Nursing and Midwifery indefinitely in accordance with NHMRC guideline. After this time, all electronic data will be deleted, and any printed material will be disposed of via the confidential waste service available in the School of Nursing and Midwifery at Curtin University.

What about my privacy?

Confidentiality will be maintained at all times. You will be approached by a researcher with a detailed written information sheet providing a full explanation of the study. You will also be reinsured the confidentiality of the data and the participant's right to withdraw from the study at any time. Confidential material may be recorded during the observation, i.e., name of the participant, but will not be included in the final transcripts for analysis. The potential confidential material will be replaced with a code. The results will be reported in aggregate and tabular form so as to protect the identity of the participants.

Who has approved the study?

Ethics approvals have been obtained from Human Research Ethics Committee of Princess Margaret Hospital for Children and Curtin University.

Who to contact for more information about this study:

If you would like any more information about this study, please do not hesitate to contact one of the research team. They are very happy to answer your questions.

Name	Title	Contact Number
Jo Zhou (Research Officer)	Ms	0411389882
Phillip Della (Chief investigator)	Professor	(08) 92662062

Who to contact if you have any concerns about the organisation or running of the study?

If you have any concerns or complaints regarding this study, you can contact the Director of Medical Services at PMH (Telephone No: (08) 9340 8222). Your concerns will be drawn to the attention of the Ethics Committee who is monitoring the study.

What to do next if you would like your child to take part in this research:

If you would like to take part in this research study, please read and sign the consent form provided.

THANK YOU FOR YOUR TIME

B.10 Participant Consent Form – Nurses (Phase 2/Stage 1)

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service

FORM OF CONSENT
(For Nurses)

PLEASE NOTE THAT PARTICIPATION IN RESEARCH STUDIES IS VOLUNTARY AND SUBJECTS CAN WITHDRAW AT ANY TIME WITH NO IMPACT ON CURRENT OR FUTURE CARE.

I .... have read
Given Names Surname

the information explaining the study entitled

Transitions of care at discharge for paediatric patients: Communication practice

Direct Clinical Observation of the Discharge Process

I have read and understood the information given to me. Any questions I have asked have been answered to my satisfaction.

I understand I may withdraw from the study at any stage and withdrawal will not interfere with routine care.

I agree that research data gathered from the results of this study may be published, provided that names are not used.

I agree to have the interaction of the discharge process audio recorded.

Dated .... day of .... 20 ....

Signature ....

I, ... have explained the above to the
(Investigator's full name)

signatory who stated that he/she understood the same.

Signature ....Date…………………………………

B.11 Participant Information Sheet – Caregivers: Immediately Post Discharge, 2–4 Weeks Post Discharge (Phase 2/Stage 2 & 4)

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service

PARENT INFORMATION SHEET (CAREGIVER)

Transitions of care at discharge for paediatric patients: Communication practice

Semi-structured Interviews with Caregivers Immediately Post-discharge & 2-4 Weeks Post-discharge

Why are we doing the study?

Sometimes children get sick and are required to be readmitted to hospital. This can be due to a number of reasons including you not understanding the information provided and what you have to do when you take your child home. We want to understand the process of discharge in hospital so we can identify what areas can be improved.

What will the study tell us?

The study will provide us with a better understanding of the communication processes between doctors, nurses, allied healthcare professionals, you and your child before your child is discharged from hospital.

Who is carrying out the study?

Jo Zhou, Research Officer, School of Nursing and Midwifery, Curtin University
Clinical Nurse, Ward 8A, PMH

Does my child have to take part?

No, your child does not have to take part. If you and/or your child do not want to take part it will not affect the care your child will receive.

Your child will only participate in the study if (1) over 13 years old and mentally competent; (2) your child is willing to sign the consent form; and (3) you give permission and sign the consent form as well.

What will you be asked to do if you decide to take part in this study?

- You will be asked about your experiences of your child was discharged from PMH, both immediately following discharge and 2-4 weeks after discharge
- The interview will take about 30 to 45 minutes with each participant.
- Audio-recording of the interview will also be carried out using a digital recorder
- Your background details will also be obtained at the end of the interview

What does my child need to do to be in the study?

- If you give permission for your child to be included in the interview, your child will also be asked about experience of being discharged from the hospital to primary care setting.
- Your child will not need to do anything in this study if you do not give permission.

Is there likely to be a benefit to my child?

There is no direct benefit to your child with the current hospitalization; however, the study aims to improve the communication practice at the discharge process to ensure continuity of care in future hospitalization/s.

Is there likely to be a benefit to other people in the future?

We hope this study will result in strategies and recommendations to improve communication between staff and children and carers on discharge thus making discharge information clearer.

What are the possible risks and/or side effects?

There are no expected risks and/or side effects as there is no intervention involved in this study.

What are the possible discomforts and/or inconveniences?

There are no expected discomforts as this is no intervention involved in this study. The interview will be carried out at the participant's preferred location and time. However, there may be an inconvenience as the interview will take about 30 to 45 minutes.

Where is your information kept?

The paper copy of the data collected and all documents will be kept in a locked filing cabinet in a secure office at School of Nursing and Midwifery, Curtin University, these will be archived indefinitely. Computer data will not have any identifying names, will be password protected and able to be accessed by the research team only.

What about my privacy?

Information will remain confidential at all times. You and your child will receive a number which will be used on all paperwork. You will also be reassured of the confidentiality of the data and your right to withdraw from the study at any time. Confidential material may be recorded during the observation, i.e., name of your child, but this will not be included in the final transcripts for analysis. All identifiable information will be replaced with a code. The results will be reported in a table so as to protect the identity of the participants.

Who has approved the study?

Ethics approvals have been obtained from Human Research Ethics Committee of Princess Margaret Hospital for Children and Curtin University.

Who to contact for more information about this study:

If you would like any more information about this study, please do not hesitate to contact one of the research team. They are very happy to answer your questions.

Name	Title	Contact Number
Jo Zhou (Research Officer)	Ms	0411389882
Phillip Della (Chief Investigator)	Professor	(08) 92662062

Who to contact if you have any concerns about the organisation or running of the study?

If you have any concerns or complaints regarding this study, you can contact the Director of Medical Services at PMH (Telephone No: (08) 9340 8222). Your concerns will be drawn to the attention of the Ethics Committee who is monitoring the study.

What to do next if you would like your child to take part in this research:

If you would like to take part in this research study, please read and sign the consent form provided.

THANK YOU FOR YOUR TIME

B.12 Participant Consent Form – Caregivers (Phase 2/Stage 2 & 4)

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service

FORM OF CONSENT
(For Caregivers)

PLEASE NOTE THAT PARTICIPATION IN RESEARCH STUDIES IS VOLUNTARY AND SUBJECTS CAN WITHDRAW AT ANY TIME WITH NO IMPACT ON CURRENT OR FUTURE CARE.

I .... have read
Given Names Surname

the information explaining the study entitled

Transitions of care at discharge for paediatric patients: Communication practice Semi-structured interviews with caregivers immediately post-discharge & 2-4 weeks post-discharge

I have read and understood the information given to me. Any questions I have asked have been answered to my satisfaction.

I agree to allow

....
(full name of participant and relationship of participant to signatory)

to participate in the study.

I understand my child may withdraw from the study at any stage and withdrawal will not interfere with routine care.

I agree that research data gathered from the results of this study may be published, provided that names are not used. I agree to have the interview audio recorded.

Dated .... day/moth of 20……………

Child's Signature ....
(Where appropriate)

Parent or Guardian's Signature ....

I, ... have explained the above to the
(Investigator's full name)

signatories who stated that he/she understood the same.

Signature ....Date..

B.13 Participant Information Sheet – Nurses: Post Discharging Patient from the Ward (Phase 2/Stage 3)

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service

INFORMATION SHEET (NURSES)

Transitions of care at discharge for paediatric patients: Communication practice

Semi-structured interviews with nurses post-discharging an inpatient from PMH

Why are we doing the study?

Transitioning patients within and across health care facilities or from hospital to home has been recognized as a complex process. Recent evidences revealed that when poor communication occurs at points of care transition, patients are put at increased risk of adverse events. Paediatric patients are particularly at high risk as their transitions typically require family members/primary carers to negotiate post-transition care to hospital and/or the community on their behalf. The study aims to develop a better understanding on the communicative and interactive processes between health care providers, paediatric patients and their primary carers at discharge from acute to primary care settings

Who is carrying out the study?

Jo Zhou, Research Officer, School of Nursing and Midwifery, Curtin University
Clinical Nurse, Ward 8A, PMH

What will the study tell us?

The key issues of communicative practice of the discharge process for patient safety will be revealed through patients', carers' and Clinicians' reports of their experiences in transitioning from acute to primary care, both immediately following discharge and one month after discharge

What will you be asked to do if you decide to take part in this study?

- Your experiences with regards discharging a paediatric patient from acute to primary care
- Audio-recording of the interview will also be carried out using a digital recorder
- Your demographic information will also be obtained at the end of the interview

Page **1** of **3**

Is there likely to be a benefit to the current patients?

There is no direct benefit to the current patients, however, the study aims to improve the communication practice at the discharge process to ensure continuity of care in future hospitalization/s.

Is there likely to be a benefit to other people in the future?

This project will make a significant contribution to improving paediatric patient safety and reducing the inefficiencies and economic effects of discontinuity in acute to primary sector transitions of care.

What are the possible risks and/or side effects?

There are no foreseen risks and/or side effects as there is no intervention involved in this study.

What are the possible discomforts and/or inconveniences?

There are no foreseen discomforts as this is no intervention involved in this study. The researcher will conduct the interview at the participant's convenient location and time. However, there may be an inconvenience as the interview will take about 30 to 45 minutes.

Where is your information kept?

All collected data will be entered into computer analysis software, on a Curtin School of Nursing and Midwifery computer using identification numbers only, no names will be used. Access to the stored data will be restricted by a password known only by the research officer and principal investigator. It is expected that the results will be presented at appropriate conferences and will be published in appropriate journals. All data collected will be stored safely in a locked cupboard at the Curtin School of Nursing and Midwifery for seven years in accordance with NHMRC guideline. After this time, all electronic data will be deleted, and any printed material will be disposed of via the confidential waste service available in the School of Nursing and Midwifery at Curtin University.

What about my privacy?

Confidentiality will be maintained at all times. You will be approached by a researcher with a detailed written information sheet providing a full explanation of the study. You will also be reinsured the confidentiality of the data and the participant's right to withdraw from the study at any time. Confidential material may be recorded during the observation, i.e., name of the participant, but will not be included in the final transcripts for analysis. The potential confidential material will be replaced with a code. The results will be reported in aggregate and tabular form so as to protect the identity of the participants.

Who has approved the study?

Ethics approvals have been obtained from Human Research Ethics Committee of Princess Margaret Hospital for Children and Curtin University.

Who to contact for more information about this study:

If you would like any more information about this study, please do not hesitate to contact one of the research team. They are very happy to answer your questions.

Name	Title	Contact Number
Jo Zhou (Research Officer)	Ms	0411389882
Phillip Della (Principal Supervisor)	Professor	(08) 92662062

Who to contact if you have any concerns about the organisation or running of the study?

If you have any concerns or complaints regarding this study, you can contact the Director of Medical Services at PMH (Telephone No: (08) 9340 8222). Your concerns will be drawn to the attention of the Ethics Committee who is monitoring the study.

What to do next if you would like your child to take part in this research:

If you would like to take part in this research study, please read and sign the consent form provided.

THANK YOU FOR YOUR TIME

Page **3** of **3**

B.14 Participant Consent Form – Nurses (Phase 2/Stage 3)

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service

FORM OF CONSENT
(For Nurses)

PLEASE NOTE THAT PARTICIPATION IN RESEARCH STUDIES IS VOLUNTARY AND SUBJECTS CAN WITHDRAW AT ANY TIME WITH NO IMPACT ON CURRENT OR FUTURE CARE.

I .... have read
Given Names Surname

the information explaining the study entitled

Transitions of care at discharge for paediatric patients: Communication practice

Semi-structured interviews with nurses post-discharging an inpatient from PMH

I have read and understood the information given to me. Any questions I have asked have been answered to my satisfaction.

I understand I may withdraw from the study at any stage and withdrawal will not interfere with routine care.

I agree that research data gathered from the results of this study may be published, provided that names are not used.

I agree to have the interview audio recorded.

Dated .... day of .... 20 ....

Signature ....

I, ... have explained the above to the
(Investigator's full name)

signatory who stated that he/she understood the same.

Signature ....Date……………………………………..

Appendix C

Ethics Committees Approval Letters

C.1 Princess Margaret Hosptial for Children

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service
Research Governance Office

Our Ref: 2015015EP

Professor Phillip Della
School of Nursing & Midwifery
Curtin University
GPO Box U1987
Perth WA 6845

Dear Professor Della

HREC REF **2015015EP**
STUDY TITLE **Transitions of care at discharge for paediatric patients: Communication practice**

On behalf of the Child and Adolescent Health Service, I give authorisation for your research project to be conducted at the following site(s):

Princess Margaret Hospital for Children - CAHS

This authorisation is based on the approval from PMH HREC and the review from the Research Governance Office. This authorisation is valid subject to the ongoing approval from the HREC.

This authorisation is based on the ethical approval from the HREC, and on the basis of compliance with the 'Conditions of Authorisation to Conduct a Research Project at Site' (attached) and with the compliance of all reports as required by the Research Governance Office and approving HREC. Non compliance with these requirements could result in the authorisation being withdrawn.

The responsibility for the conduct of this project remains with you as the Principal Investigator at the site.

Yours sincerely

Dr Mark Salmon
Executive Director
Medical Services

08/09/2015

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service
Research Governance Office

CONDITIONS OF SITE AUTHORISATION TO CONDUCT A RESEARCH PROJECT

The following general conditions apply to the research project authorised to be conducted at the site(s) nominated in the accompanying letter. The acceptance of the site authorisation will be deemed to be an acceptance of these conditions by all investigators involved in the research project at the nominated site(s).

1. The responsibility for the conduct of project at a site lies with the nominated Principal Investigator (PI) at that site, all correspondence should be signed by PI.

2. The PI will inform the Research Governance Office (RGO) about any changes to the project. The PI is responsible for submitting any amendments to the approved documents listed on the approval letter, or any new documentation to be used in the project. Any new or amended documentation should be submitted in a timely manner and cannot be implemented at this site until they have received HREC approval for use at site(s).

3. The PI will notify the RGO of their inability to continue as PI at the site(s) and will provide the name and contact information of their replacement.

4. The PI will notify the RGO of any departures of named site investigators. The PI will also notify the RGO if any new site investigators join the project.

5. The PI is responsible for reporting site adverse events, using the standard forms available from the website. Reporting requirements are as per the WA Health Research Governance and Single Ethical Review Standard Operating Procedures. Additional reports, other than those outlined, that are submitted will be returned without acknowledgement.

6. The annual report that is submitted to the HREC should also be submitted to the RGO. This should include the site specific information which should be completed by the site PI.

7. The site has the authority to audit the conduct of any project without notice. Exercise of this authority will only be considered if there are grounds to believe that some irregularity has occurred, if a complaint is received from a third party or the site decides to undertake an audit for Quality Improvement purposes.

8. The site can conduct random monitoring of any project. The PI will be notified if their project has been selected. The PI will be given a copy

Government of **Western Australia**
Department of **Health**
Child and Adolescent Health Service

Our Ref: 2015015EP

Professor Phillip Della
School of Nursing & Midwifery
Curtin University
GPO Box U1987
Perth WA 6845

Dear Professor Della

HUMAN RESEARCH ETHICS COMMITTEE (HREC)

HREC REF **2015015EP**
STUDY TITLE **Transitions of care at discharge for paediatric patients: Communication practice**

The ethics application for the project referenced above was reviewed by the PMH Human Research Ethics Committee (HREC) at its meeting on 19/03/2015. It has been approved and the following documents have been approved for use in this project.

Scientific Protocol Form 4B
Project Protocol Version 3 dated 31 March 2015
Participant Screening Log Version 1 dated 8 April 2015

Approval of this project from PMH HREC is valid to 20/07/2018 and on the basis of compliance with the 'Conditions of HREC Approval for a Research Project' (attached).

Note: If additional sites are recruited prior to the commencement of, or during the research project, the Coordinating Principal Investigator is required to notify the HREC. Notification of withdrawn sites should also be provided to the HREC in a timely fashion.

A copy of this ethical approval letter must be submitted by all site Principal Investigators to the Research Governance Office or equivalent body or individual at each participating institution in a timely manner to enable the institution to authorise the commencement of the project at its site/s.

<u>This letter constitutes ethical approval only.</u>

This project cannot proceed at any site until separate site authorisation has been obtained from the CE, or delegate, of the site under whose auspices the research will be conducted at that site.

The PMH HREC is registered with the Australian Health Ethics Committee and operates according to the NHMRC National Statement on Ethical Conduct in Human Research and International Conference on Harmonisation – Good Clinical Practice.

The HREC's Terms of Reference, Standard Operating Procedures, membership and standard forms are available from http://www.pmh.health.wa.gov.au/development/resources/ethics.htm or from the Ethics Office. Should you have any queries about the HREC's consideration of your project, please contact Ethics Office.

Government of Western Australia
Department of Health
Child and Adolescent Health Service

CONDITIONS OF HREC APPROVAL FOR A RESEARCH PROJECT

The following general conditions apply to the research project approved by the Human Research Ethics Committee (HREC) and acceptance of the approval will be deemed to be an acceptance of these conditions by all investigators involved in the research project:

1. The responsibility for the conduct of projects lies with the Coordinating Principal Investigator (CPI), all correspondence should be signed by CPI.
2. Projects that do not commence within 12 months of the approval date may have their approval withdrawn and the project closed. The CPI must outline why the project approval should stand.
3. The submission of an application for HREC approval will be deemed to indicate that the investigator/s and any sponsor recognises the approving HREC is registered with the National Health and Medical Research Council (NHMRC) and that it complies in all respects with the National Statement on Ethical Conduct in Human Research and all other national and international ethical requirements. **The HREC will not enter into further correspondence on this point.**
4. A list of attendance at a specific meeting is available on request, but no voting records will be provided.
5. The CPI will notify the HREC of his or her inability to continue as CPI and will provide the name and contact information of their replacement. Failure to notify the HREC can result in the project being suspended or approval withdrawn.
6. The CPI will notify the HREC of any departures of named investigators. The CPI will also notify the HREC if any new investigators and/or sites join the project that will utilise the HREC's approval.
7. The CPI will inform the HREC about any changes to the project. The CPI is responsible for submitting any amendments to the approved documents listed on the approval letter, or any new documentation to be used in the project. Any new or amended documentation should be submitted in a timely manner and cannot be implemented at any participating site until they have received HREC approval.
8. The CPI is responsible for reporting adverse events, indicating whether or not the project should continue. Reporting requirements are as per the WA Health Research Governance and Single Ethical Review Standard Operating Procedures. Additional reports other than those outlined that are submitted to the HREC will be returned without acknowledgement. The HREC can request additional reporting requirements as a special condition of a research project.
9. Where a project requires a Data Safety Monitoring Board (DSMB) it is the CPI's responsibility to ensure this is in place before the commencement of the project and the HREC notified of this. All relevant reports from the DSMB should be submitted to HREC.
10. For projects where the site is acting as the sponsor (ie. investigator initiated project) it is the responsibility of the CPI to report serious and unexpected drug/device reactions, as well as other reactions/events to the Therapeutic Goods Administration (TGA). Please refer to TGA website for further information and the relevant forms (see http://www.tga.gov.au/pdf/clinical-trials-guidelines.pdf p71 for medications or p77 for devices).
11. If this project involves the use of an implantable device a properly monitored and up to date system for tracking participants is to be maintained for the life of the device in accordance with the National Statement section 3.3.22 (g).

C.2 Curtin University

MEMORANDUM

Curtin University

To:	Professor Phillip Della School of Nursing and Midwifery
CC:	
From	Professor Peter O'Leary, Chair HREC
Subject	Reciprocal ethics approval Approval number: HR184/2015
Date	17-Sep-15

Office of Research and Development
Human Research Ethics Office

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for your application submitted to the Human Research Ethics Office for the project: 6206
Transition of care at discharge for paediatric patients: Communication practice

Your application has been approved through Curtin University Human Research Ethics Committee (HREC) through a reciprocal approval process with the lead HREC.

The lead HREC for this project has been identified as PMH Human Research Ethics Committee (HREC)

Approval number from the lead HREC is noted as: 2015015EP

Please note the following conditions of approval:

1. Approval is granted from **17-Sep-15** to **20-Jul-18**
2. Research must be conducted as stated in the approved protocol.
3. Any amendments to the approved protocol must be approved by the Ethics Office.
4. An annual progress report must be submitted to the Ethics Office annually, on the anniversary of approval.
5. All adverse events must be reported to the Ethics Office.
6. A completion report must be submitted to the Ethics Office on completion of the project.
7. Data must be stored in accordance with WAUSDA and Curtin University policy.
8. The Ethics Office may conduct a randomly identified audit of a proportion of research projects approved by the HREC.

Should you have any queries about the consideration of your project please contact the Ethics Support Officer for your faculty, or the Ethics Office at hrec@curtin.edu.au or on 9266 2784. All human research ethics forms and guidelines are available on the ethics website.

Yours sincerely

Professor Peter O'Leary
Chair, Human Research Ethics Committee

C.3 Department of Health Western Australia

Government of **Western Australia**
Department of **Health**

HUMAN RESEARCH ETHICS COMMITTEE AHEC EC00422

Postal Address:
Executive Officer
DOHWA HREC
Level 1, C Block
189 Royal Street
EAST PERTH WA 6004

ph: (08) 9222 4278
fax: (08) 9222 4236
e-mail: HREC@health.wa.gov.au
http://www.health.wa.gov.au/healthdata/hrec/

Prof Phillip Della
Head - School of Nursing and Midwifery
Curtin University of Technology
GPO Box U1987
PERTH WA 6102

Dear Prof Della

Project #2015/55 - Transitions of care at discharge for paediatric patients: Communication practice

Date of commencement:	11/11/2015
Date of next annual progress report:	11/11/2016
Research team:	Phillip Della, Joanne Siffleet, Huaqiong (Jo) Zhou, Satvinder Dhaliwal and Pam Roberts
DOH data required:	Yes
Data linkage required:	No
Datasets to be accessed:	Hospital Morbidity Data System Patient Medical Records
Date of ethical review:	14/10/2015 and 11/11/2015
Ethics approval validity:	11/11/2018

I am pleased to advise that the Department of Health WA Human Research Ethics Committee (DOH HREC) has granted **ethical approval** for this project.

This letter constitutes ethics approval only. You will not receive the data requested for your project until the release of the data has also been approved by the data steward.

As Principal Investigator you are responsible for the ethical conduct of the project and the security of the personal health information.

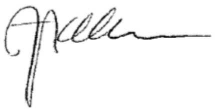
This approval is subject to your continued compliance with your obligations under the Practice Code for the Use of Personal Health Information including the following conditions. You are required to:

1. Report to the DOH HREC anything which might warrant review of ethical approval of the project including;
   - any breaches or complaints and any adverse events affecting the security and confidentiality of the data; and
   - unforeseen events that might affect the continued ethical acceptability of the project.
2. Notify the DOH HREC if the project is discontinued or withdrawn before the expected date of completion and to give reasons for this action.
3. Provide an annual progress report to the DOH HREC and a final report at the completion of the project.
4. Obtain approval from the DOH HREC for;

- any changes or amendments to the research protocol, including methodology, data required, duration of the project and any changes to the approved data storage arrangements;
- any changes of personnel in the research team, and provide a DOH Confidentiality Agreement/Confidentiality Acknowledgement form for any addition to the research team.

We wish you well with your project.

Yours sincerely



Honorary Fellow Judy Allen
Chair
Department of Health WA Human Research Ethics Committee

11 November 2015

DOHWA HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) 'National Statement on Ethical Conduct in Human Research'. Applications are also reviewed for compliance with the Department of Health WA 'Practice Code for use of personal health information'.

Appendix D

Evidence of Knowledge Translation Activities and Impact

D.1 Publications Citations as per *Scopus* at 2 August 2021

Brought to you by Curtin University Library

Scopus Search Sources Lists SciVal ↗

This author profile is generated by Scopus Learn more

Zhou, Huaqiong

Perth Children's Hospital, Perth, Australia Show all author info

56139009500 Connect to ORCID

Edit profile Set alert Potential author matches Export to SciVal

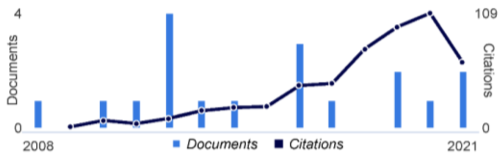
Metrics overview

18 Documents by author

500 Citations by ***472 documents***

8 *h*-index: View *h*-graph

Document & citation trends



18 Documents Cited by 472 Documents

0 Preprints 23 Co-Authors Topics

Analyze author output Citation overview

Most contributed Topics 2016–2020

Hospital Readmission; Liquid Air Cycle Engines; Medicare
3 documents

Pharmacy Students; Teamwork; Health Occupations
1 document

Transition to Adult Care; Patient Transfer; Chronic Conditions
1 document

Article • Open Access
Nurse-caregiver communication of hospital-to-home transition information at a tertiary pediatric hospital in Western Australia: A multi-stage qualitative descriptive study
Zhou, H., Roberts, P.A., Della, P.R.
Journal of Pediatric Nursing, 2021, 60, pp. 83–91
View abstract find it Related documents
0 Cited by

Article • Open Access
Using machine learning to predict paediatric 30-day unplanned hospital readmissions: A case-control retrospective analysis of medical records, including written discharge documentation
Zhou, H., Albrecht, M.A., Roberts, P.A., ...Della, P.R., Della, P.R.
Australian Health Review, 2021, 45(3), pp. 328–337
View abstract find it Related documents
0 Cited by

Article • Open Access
Risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in Western Australia
Zhou, H., Della, P.R., Porter, P., Roberts, P.A.
Journal of Paediatrics and Child Health, 2020, 56(1), pp. 68–75
View abstract find it Related documents
2 Cited by

Review • Open Access
Risk factors associated with paediatric unplanned hospital readmissions: A systematic review
Zhou, H., Roberts, P.A., Dhaliwal, S.S., Della, P.R.
BMJ Open, 2019, 9(1), e020554
View abstract find it Related documents
6 Cited by

Article • Open Access
A 5-year retrospective cohort study of unplanned readmissions in an Australian tertiary paediatric hospital
Zhou, H., Della, P., Roberts, P., Porter, P., Dhaliwal, S.
Australian Health Review, 2019, 43(6), pp. 662–671
View abstract find it Related documents
4 Cited by

Review
Nurse–physician communication – An integrated review
Tan, T.-C., Zhou, H., Kelly, M.
Journal of Clinical Nursing, 2017, 26(23-24), pp. 3974–3989
View abstract find it Related documents
32 Cited by

Review • Open Access
Transitioning adolescent and young adults with chronic disease and/or disabilities from paediatric to adult care services – an integrative review
Zhou, H., Roberts, P., Dhaliwal, S., Della, P.
Journal of Clinical Nursing, 2016, 25(21-22), pp. 3113–3130
View abstract find it Related documents
52 Cited by

Review • Open Access
Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review
Zhou, H., Della, P.R., Roberts, P., Goh, L., Dhaliwal, S.S.
BMJ Open, 2016, 6(6), e011060
View abstract find it Related documents
115 Cited by

Article • Open Access
Demographics and Personality Factors Associated with Burnout among Nurses in a Singapore Tertiary Hospital
Ang, S.Y., Dhaliwal, S.S., Ayre, T.C., ...Zhou, H., Della, P.
BioMed Research International, 2016, 2016, 6960184
View abstract find it Related documents
28 Cited by

Article • Open Access
Family-centered care for hospitalized children aged 0-12 years: A systematic review of qualitative studies
Watts, R., Zhou, H., Shields, L., ...Munns, A., Ngune, I.
JBI Database of Systematic Reviews and Implementation Reports, 2014, 12(7), pp. 204–283
View abstract find it Related documents
18 Cited by

Article
The effectiveness of the Surgical Safety Checklist as a means of communication in the operating room
Michael, R., Delia, P., Zhou, H.
ACORN, 2013, 26(2), pp. 48–52
View abstract find it Related documents
1 Cited by

Review
Effective surgical hand preparation: An integrative research review
Michael, R., Della, P., Zhou, H.
ACORN, 2012, 25(2), pp. 40–46
View abstract find it Related documents
0 Cited by

Article
Family-centred care for hospitalised children aged 0-12 Years: A systematic review of quasi-experimental studies
Shields, L., Zhou, H., Taylor, M., ...Munns, A., Watts, R.
JBI Database of Systematic Reviews and Implementation Reports, 2012, 10(39), pp. 2559–2592
View abstract find it Related documents
21 Cited by

Review
Family-centred care for hospitalised children aged 0-12 years.
Shields, L., Zhou, H., Pratt, J., ...Hunter, J., Pascoe, E.
Cochrane database of systematic reviews (Online), 2012, 10
View abstract find it
121 Cited by

Article
International trends in research publications by perioperative nurses: A comparative analysis of three international perioperative nursing journals
Michael, R., Della, P., Zhou, H.
ACORN, 2012, 25(3), pp. 21–34
View abstract find it Related documents
0 Cited by

Article
Setting the stage for enhancing perioperative nursing research: An evaluation of research publication in the ACORN journal
Della, P., Michael, R., Zhou, H.
ACORN, 2011, 24(4), pp. 30–34
View abstract find it Related documents
1 Cited by

Review
Family-centred care for hospitalized children aged 0-12 Years: A systematic review of qualitative studies
Zhou, H., Shields, L., Watts, R., ...Munns, A., Ngune, I.
JBI Database of Systematic Reviews and Implementation Reports, 2010, 10(57), pp. 3917–3935
find it Related documents
7 Cited by

Review
Association between self-report pain ratings of child and parent, child and nurse and parent and nurse dyads: Meta-analysis
Zhou, H., Roberts, P., Horgan, L.
Journal of Advanced Nursing, 2008, 63(4), pp. 334–342
View abstract find it Related documents
92 Cited by

D.2 Conference Oral Presentation 2018

The Australian College of Children and Young Peoples Nurses 2018 International Conference, Perth, Western Australia

Statement of Attendance

This is to certify that

Ms Huaqiong Zhou

has attended the

ACCYPN 2018 CONFERENCE

25 - 26 October 2018

9.9 CPD Hours

The Conference Program
details all Conference Sessions

8 November 2018

June Colgrave
Conference Chair

Date Issued

D.3 Publication 5: Wiley Certificate – Top Downloaded Paper 2018–2019

WILEY

Journal of Paediatrics and Child Health

Congratulations — your work was one of the top downloaded in recent publication history!

Dear HUAQIONG,

We are excited to share that your research, published in *Journal of Paediatrics and Child Health*, is among the top 10% most downloaded papers!

- **Risk factors associated with 30-day all-cause unplanned hospital readmissions at a tertiary children's hospital in Western Australia**

What this means for you:

- Among work published between January 2018 and December 2019, yours received some of the most downloads in the 12 months following online publication.
- Your research generated immediate impact and helped to raise the visibility of *Journal of Paediatrics and Child Health*.

In recognition of your work, we're pleased to offer you a certificate of achievement.

TOP DOWNLOADED PAPER 2018-2019

CONGRATULATIONS TO

Huaqiong Zhou

whose paper has been recognized as one of the most read in

Journal of Paediatrics and Child Health

WILEY

D.4 Conference Oral Presentation 2019

The 4th West China International Nursing Conference, Chengdu, China

2019第四届华西国际护理学术会议
West China International Nursing Conference

证书
Certification

周华琼 老师：

感谢您参加 2019 年 9 月 19-21 日在成都举办的“2019 年第四届华西国际护理学术会议”，并进行题目为《澳大利亚某儿童医院出院文书的回顾性分析》的大会发言。

特颁此证！

The 2019 West China International Nursing Conference hereby certifies Ms./Mr. ZHOU Huaqiong delivered an oral presentation A retrospective analysis on discharge documentation at a tertiary paediatric hospital of Western Australia

September 19-21, 2019, in Chengdu, China.

四川大学华西护理学院
2019年9月21日

D.5 *The Australian* Newspaper Article: "Language handicaps hospital staff"

isentia

AUTHOR: Paul Garvey SECTION: GENERAL NEWS ARTICLE TYPE: NEWS ITEM AUDIENCE : 94,448
PAGE: 7 PRINTED SIZE: 200.00cm² REGION: National MARKET: Australia ASR: AUD 5,145
WORDS: 461 ITEM ID: 1447239228

25 MAY, 2021

Language handicaps hospital staff

The Australian, Australia

Curtin University

Page 1 of 1

Language handicaps hospital staff

EXCLUSIVE

PAUL GARVEY

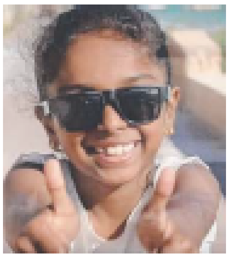
An in-depth study of the Perth Children's Hospital identified problems in staff interaction with parents who spoke languages other than English just months before seven-year-old Aishwarya Aswath died there.

Published in the Journal of Paediatric Nursing in February, the study of 31 patients who were discharged from PCH found three of the patients who had to be subsequently readmitted had parents with limited English proficiency.

The cultural awareness and training of PCH staff has come under scrutiny in recent weeks following the death of Aishwarya in early April.

She waited almost two hours to be admitted, despite her parents making repeated appeals for help, and died of sepsis soon after she saw a doctor.

The incident has brought to the surface lingering tensions between frontline medical staff and hospital administrators amid widespread signs of pressure across the West Australian health system. Doctors and nurses have accused management of ignoring repeated warnings in the months leading up to Aishwarya's death



Aishwarya

that understaffing could lead to tragedy.

Healthcare workers plan a protest outside PCH on Tuesday.

The study by Curtin University's Huaqiong Zhou, Pamela Roberts and Phillip Della, which involved direct clinical observations of the preparation for discharge of 31 patients at the hospital, found interpreter services should be arranged for parents with limited language proficiency throughout their child's hospital stay.

The same trend emerged in a broader study by the same researchers of 940 pediatric patients from WA hospitals, split equally between patients who experienced unplanned readmissions and patients without readmissions. That study found that having a language other than English was a critical factor in whether an unplanned readmission was more likely.

While the studies focused on preparing a patient for discharge and the rates of hospital readmissions, Professor Della said the findings had relevance across the health system. Up to 70 per cent of clinical errors, he said, were linked to communication issues.

"If English is your second language or you don't get a proper interpretation, the rate of error is going to increase," he said.

"If there's a communication problem, then there's a much greater chance of a clinical error."

He noted that the case of Aishwarya had raised multiple issues around both staffing and communication – both of which "go hand-in-hand".

A root cause analysis into Aishwarya's death, released by the girl's family last week, identified a "cascade" of failures that had contributed to the incident.

Among the problems identified by the analysis were communication issues between staff and Aishwarya and her parents, as well as a lack of recognition of "persistent and significant" parental concerns.

Aishwarya's father, Aswath Chavittupara, told media last week that hospital staff had been "rude" and lacked compassion.

"We found the level of humanity they had was very low," Mr Chavittupara said.

D.6 Conference Oral Presentation 2019

The International Council of Nurses (ICN) Congress, Singapore

Singapore
International Council of Nurses
2019 CONGRESS

27 June – 1 July 2019

CERTIFICATE OF PRESENTATION

We hereby confirm that

Phillip Della

has presented the session entitled

C67C Improving the effectiveness and efficiency of paediatric discharge planning: linking a series of research studies

Author(s) :H. Zhou, P. Della

during ICN 2019 Congress in Singapore

Beyond Healthcare to Health

Howard Catton
ICN Chief Executive Officer

SINGAPORE EXHIBITION & CONVENTION BUREAU