Title

Survival to hospital discharge is equivalent to 30-day survival as a primary survival outcome for out-of-hospital cardiac arrest studies.

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ABSTRACT (250 words)

Aim

The 2015 Utstein guidelines stated that 30-day survival could be used as an alternative to survival to hospital discharge (STHD) as the primary survival outcome in out-of-hospital cardiac arrest (OHCA) studies. We sought to ascertain the equivalence (concordance) of these two survival outcome measures.

Methods

We conducted a population-based retrospective cohort study of OHCA patients who were attended by St John Western Australia (SJ-WA) paramedics in Perth, WA between 1999 and 2018. OHCA patients were included if they received either an attempted resuscitation by SJ-WA or bystander defibrillation; were a resident of WA; and were transported to a hospital emergency department (ED). STHD was determined through hospital record review and 30-day survival via the WA Death Registry and cemetery registration data.

Results

The study cohort comprised a total of 7,953 OHCA patients, predominantly male (70%), with a median (IQR) age of 63 (46-77 years), a presumed cardiac arrest aetiology (78.9%), and the majority occurred in a private residence (66.8%). Survival rates were identical for STHD and 30-day survival, with both being (13.78%, 95% CI: 13.02-14.54%) ($p > 0.99$). The overall concordance between the two survival rates was 99.6%. There were only 30 (0.4%) discordant cases in total: 15 cases with STHD-yes but 30-day survival-no; and 15 cases with STHD-no but 30-day survival-yes.

Conclusion

We found that STHD and 30-day survival were equivalent survival metrics in our OHCA Registry. However, given potential differences in health systems, we suggest that 30-day survival is likely to enable more reliable comparisons across jurisdictions.

Word count (1490/1500)

INTRODUCTION

Standardisation of definitions for reporting survival outcomes after out-of-hospital cardiac arrest (OHCA) is necessary to enable meaningful comparisons between studies and across different jurisdictions.[1-3] The first version of the guidelines for uniform reporting of OHCA data and the "Utstein Style Reporting Template" were produced in 1991 by an International Taskforce of resuscitation experts.[4] Whilst acknowledging that the best outcomes to report might differ between various systems and locations, the Taskforce specified 'discharged alive (yes/no)' and 'alive at 1 year (yes/no)' as core clinical outcomes.[4] Subsequent iterations in 2004[5] and 2015[6] by the International Liaison Committee on Resuscitation (ILCOR)[7] saw 'survival to hospital discharge' (STHD) remain as a core outcome, but 1-year survival became a supplementary outcome. The 2015 Utstein guidelines,[6] for the first time, stated that 30-day survival could be used as an alternative to STHD. However, the equivalence of these two survival outcome measures is not well established.

Whilst the capture of prehospital data for OHCA registries is *relatively* straight forward for many Emergency Medical Services (EMS), especially for those using electronic patient care records, determining in-hospital mortality and longer-term survival outcomes can be more challenging. For example, if ascertainment of STHD requires manual hospital record review (e.g. by a research nurse), the salary costs can be prohibitive, especially in an EMS serving a large number of hospitals.[8] For some jurisdictions, it may be more feasible to ascertain date of death from the local death registry, thereby facilitating determination of 30-day survival. However, this relies on the completeness of the death registry data, since loss to follow-up can introduce bias.[9]

We sought to ascertain the equivalence (concordance) between STHD and 30-day survival as primary survival outcomes for OHCA; and to explore the characteristics of discordant cases. We anticipated that our study results could help inform comparisons of OHCA outcomes between jurisdictions, and more broadly inform registry science.

Methods

Study Design

We conducted a population-based retrospective cohort study of OHCA patients who were attended by EMS in Perth, Western Australia (WA), between 1st January 1999 and 31st December 2018. Patients were included if: they received either an attempted resuscitation by EMS, or bystander defibrillation; were a resident of WA; and were transported to a hospital emergency department (ED). The two outcomes of interest were rates of STHD and 30-day survival.

Study Setting

Perth is the capital city of WA; with an area covering 6,400 square kilometres and an estimated resident population of 2.09 million at 30 June 2019.[10] St John WA (SJ-WA)[11] is the sole EMS provider in WA; and operates a single-tiered advanced life support (ALS) ambulance service, staffed by nationally registered paramedics. Within Perth, OHCA patients who are not declared dead at the scene are transported to one of nine hospital emergency departments (ED).[12]

Data Sources

Data were sourced from the SJ-WA OHCA Registry[13], which is maintained by the Prehospital, Resuscitation and Emergency Care Research Unit (PRECRU) at Curtin University. The OHCA Registry contains detailed information drawn from the SJ-WA patient care records (PCRs) and computer-aided dispatch data; including patient demographics, arrest characteristics, EMS interventions and initial survival status (ROSC, survival to ED). STHD is routinely determined by manual review of the patient's hospital record by a research nurse (NM). Thirty-day survival is primarily ascertained using the WA Death Registry;[14] with both the Metropolitan Cemeteries Board[15] database and the SJ-WA PCR being used as secondary data sources. For patients with a match in the death registry, 30-day survival is based simply on the recorded date of death, relative to the date of the arrest. Where a patient has no match in the death registry they are considered to have survived 30 days if i) there is no indication in the ambulance PCR that the patient died in ED

(i.e. in the presence of the attending paramedics) and ii) the patient does not appear in the WA Metropolitan Cemeteries Board database with a death date recorded within 30 days of their arrest.

Statistical Analysis

Baseline patient characteristics were presented as frequencies and percentages, or medians and interquartile ranges (IQR). Agreement in the overall percentage of the two survival outcome rates (STHD and 30-day survival) was tested using the McNemar test.[16] The characteristics of discordant cases were described for a range of demographic and peri-arrest factors. All statistical analyses were performed using SPSS v26 (IBM Inc., Armonk, NY, USA). Results were considered statistically significant for P values < 0.05.

Ethics

This study was approved by the Human Research Ethics Committee (HREC) of Curtin University (HR128/2013); with separate HREC approvals from each of the metropolitan hospitals for medical record review.

RESULTS

Between 1999 and 2018 there were 27,826 cases of OHCA attended by SJ-WA in Perth, with 12,062 patients receiving an attempted EMS resuscitation or bystander defibrillation. After applying our inclusion/exclusion criteria, 7,953 cases remained (Figure 1). Table 1 shows the baseline characteristics of the study cohort, which had a median (IQR) age of 63 years (46-77), and was predominantly: male (70%), had a presumed cardiac aetiology (78.9%), and occurred in a private residence (66.8%).

The overall percentage survival was identical for STHD and 30-day survival (13.78%, 95% CI: 13.02-14.54%) (McNemar test; $\chi^2 < 0.001$, p = 0.999). There were n=30 discordant cases in total; 15 cases with STHD-yes but 30-day survival-no; and 15 cases with STHD-no but 30-day survival-yes (Supplementary Table 1). Of the 15 discordant cases where STHD-yes and 30-day survival-no, most (11/15) survived at least twice as long as their hospital length of stay; but two patients died on the same day they were discharged (Figure 2a). These n=15 discordant cases (STHD-yes; 30-day survival-no) had a shorter median hospital length of stay (3 days, IQR 0-7 days) compared to the length of stay for all STHD cases overall (9 days, IQR 4-17 days). For the other n=15 discordant cases (STHD-no; 30-day survival-yes), median survival from time of arrest was 39 days (IQR, 31-67), (Figure 2b). Supplementary Table 2 shows the characteristics of both groups of discordant cases. Because of the small numbers involved, no statistical tests about differences between the groups were made.

DISCUSSION

Our population-based cohort study of (n=7,953) OHCA patients transported to ED by EMS over 20 years, showed that survival-to-hospital-discharge (13.78%) and 30-day survival (13.78%) were equivalent. There were only n=30 (0.38%) cases with discordant survival outcomes, i.e. 30 cases with different yes/no values for STHD and 30-day survival. We have established that for our OHCA Registry, it is acceptable to use either metric as the primary survival outcome.

A 2015 systematic review of OHCA randomised controlled studies (n=141) showed that STHD was the most commonly reported survival outcome (73%);[17] with 23% reporting 1-month survival and 16% reporting 1-year survival.[17] More recently, the COSCA initiative (Core Outcome Set for Cardiac Arrest)stated that STHD and survival to 30 days were considered to be better indicators of patient survival than shorter-term outcomes, such as survival to admission.[9] However, the COSCA authors cautioned that STHD is "limited by cultural differences (whether patients are discharged home to die or die predominantly in the hospital) and health system differences (efficiency of

discharge processes; whether long-term care is provided in the hospital or in home care settings)".[9] They suggested that "survival to specific intervals (e.g. 30 days) after arrest can avoid some of these limitations", enabling more robust comparisons across different health systems.[9] Notwithstanding such benefits, some OHCA Registries may not have access to the local death registry, or it may be incomplete. Furthermore, manually reviewing medical records enables the collection of additional clinical information, such as post-resuscitation care and neurological outcomes. As such, each EMS OHCA Registry will need to assess the cost/benefit/feasibility for the two options.

Limitations

Our study has some limitations. Firstly, there is a possibility that OHCA patients discharged from hospital prior to 30-days post-arrest may have died interstate (despite our exclusion of patients known to be non-WA residents). However, we previously showed (in 2009) that only 3/55 (5.5%) of the WA OHCA patients who had STHD subsequently died interstate; none of whom died within 30 days post-arrest.[18] Secondly, a total of 6 cases in the current study cohort were not identified in the WA Death Registry but were identified through the use of the Cemeteries Board database. While this is not a limitation per se, it does show that we could have missed n=6 deaths if we relied solely on the WA Death Registry; a cautionary message for other jurisdictions. We did not report the neurological status of survivors, however we have previously shown that the majority (93%) of OHCA patients in Perth who STHD have a good cerebral performance category score (CPC 1-2) at hospital discharge.[19] Finally, we acknowledge that our results may not be applicable to other OHCA registries with different cultural backgrounds and health systems.

Conclusions

We found that STHD and 30-day survival were equivalent survival metrics in our population-based OHCA Registry. However, given potential differences in health systems, we suggest that 30-day survival is likely to enable more reliable comparisons across jurisdictions.

Conflicts of Interest

Some of the authors are affiliated with St John WA as follows: Paul Bailey (Medical Director); Judith Finn (Adjunct Research Professor & recipient of research funding); Stephen Ball (Adjunct Research Fellow).

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Legends to Figures

Figure 1. Flow diagram of study cohort

Figure 2. Hospital length of stay in days for the n=30 discordant cases

(a) Length of hospital length of stay and days survived post-arrest in patients who survived to hospital discharge but did not survive to 30-days.

(b) Length of survival in patients who survived 30-days but who do not survive to hospital discharge.

Table 1. Study cohort patient characteristics

	N = 7953	
ROSC, n (%)		
Yes	2504	(31.5)
Age, n (%)		
0-17	453	(5.7)
18-39	984	(12.4)
40-64	2672	(33.6)
65-79	2252	(28.3)
≥80	1585	(19.9)
Unknown	7	(0.1)
Sex, n (%)		
Male	5567	(70.0)
Witness status, n (%)		
Unwitnessed	3105	(39.0)
Bystander	3621	(45.5)
EMS	1217	(15.3)
Unknown	10	(0.1)
Arrest location, n (%)		
Private residence	5315	(66.8)
Public	2107	(26.5)
Aged care	531	(6.7)
Initial arrest rhythm		
VF	2823	(35.5)

VT	106	(1.3)
PEA	2458	(30.9)
Asystole	2399	(30.2)
Unknown	167	(2.1)
Bystander CPR, n (%)		
Yes	4148	(52.2)
Bystander AED shock, n (%)		
Yes	183	(2.3)
EMS response time, n (%)		
< 5 minutes	963	(12.1)
5-10 minutes	4190	(52.7)
> 10 minutes	2796	(35.2)
Missing	4	(0.1)
Aetiology, n (%)		
Presumed cardiac	6271	(78.9)
Respiratory	347	(4.4)
Drug overdose	275	(3.5)
Trauma	764	(9.6)
Malignancy	66	(0.8)
Other	230	(2.9)
Arrest year, n (%) [a]		
1999-2003	1127	(14.2)
2004-2008	1388	(17.5)
2009-2013	2286	(28.7)

2014-2018	3152	(39.6)
Hospital length of stay, Median (IQR)		
For STHD (days)	9	(4-17)
For 30-day survivors (days)	9	(4-17)

[a] The Perth population grew from 1.46 million in 2001 to 2.06 million in 2018, representing a 41% increase. (Australian Bureau of statistics. Population Estimates by Local Government Area, 2001 to 2020 [Cited 1st June 2021]. Available from: https://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_ANNUAL_ERP_ASGS2016#)

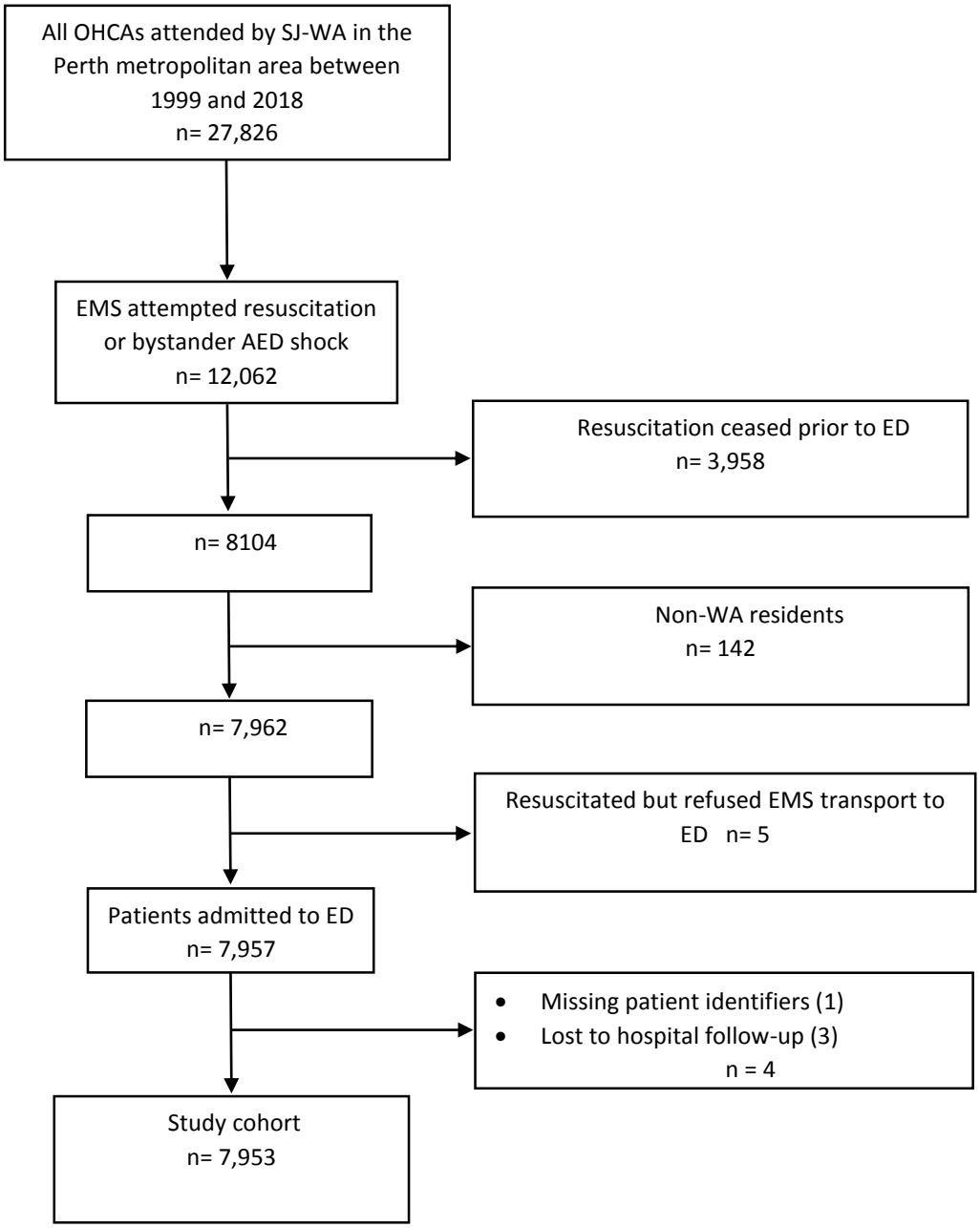


Figure 1. Flow diagram of study cohort

Figure 2a

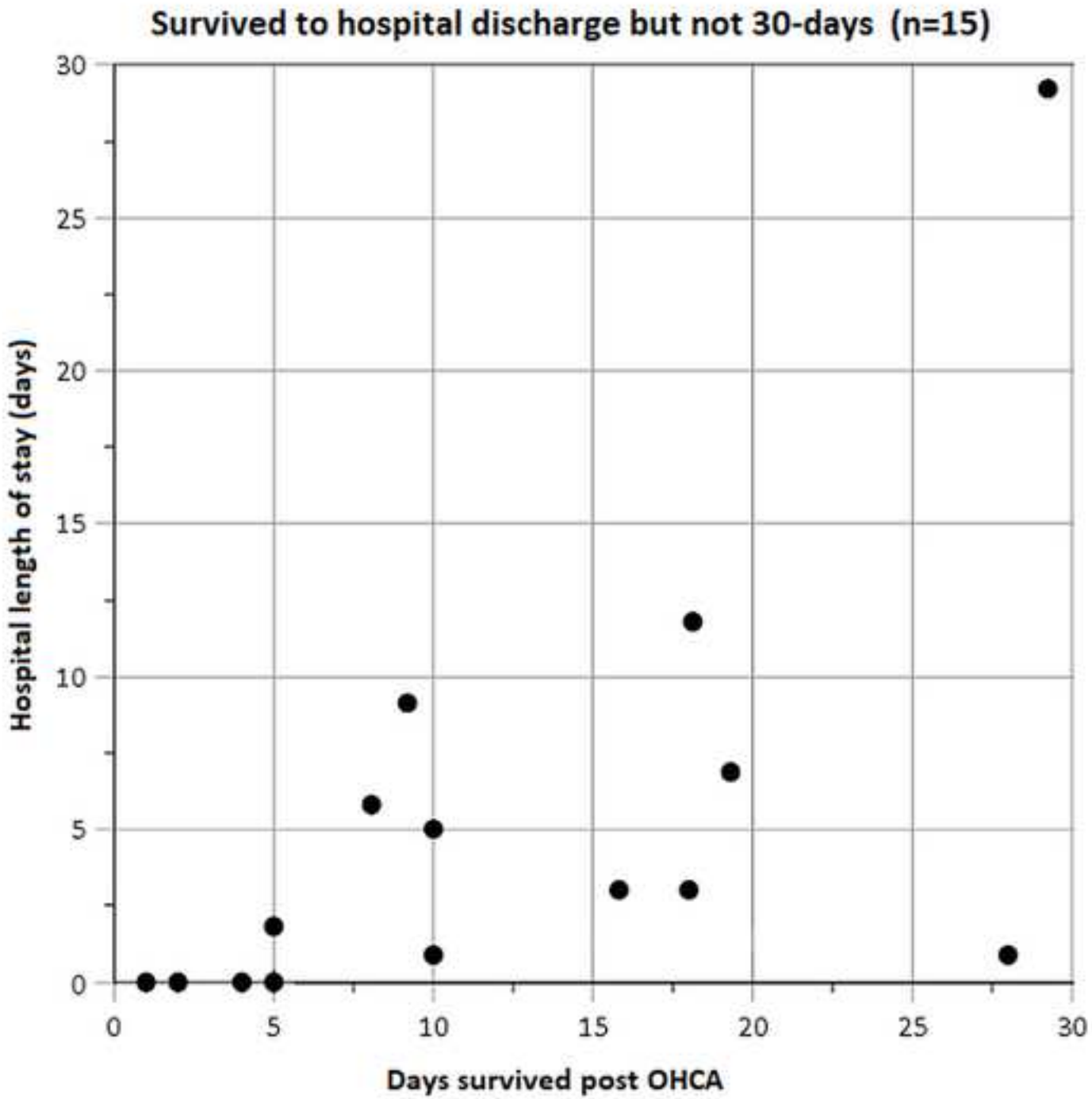
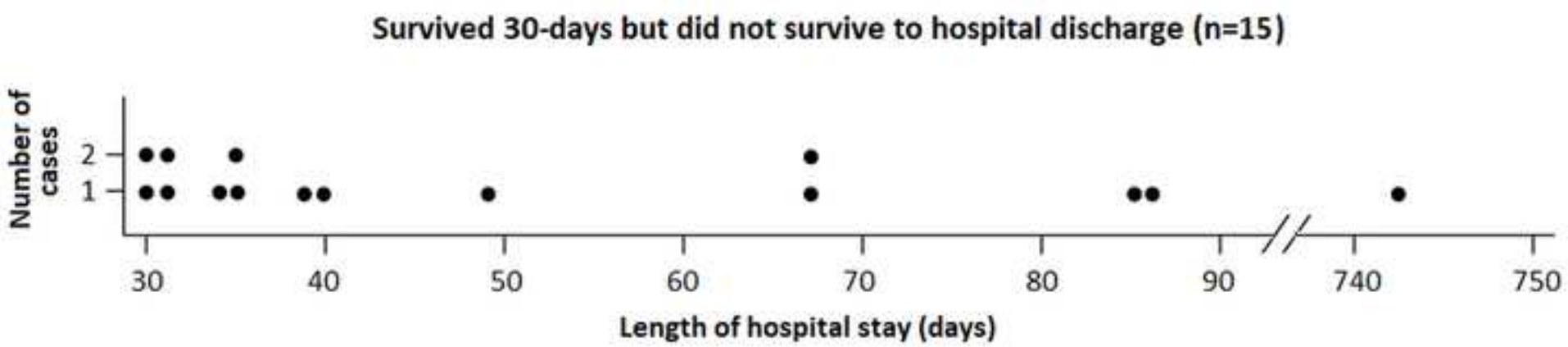


Figure 2b



Conflicts of Interest

Some of the authors are affiliated with St John WA as follows: Paul Bailey (Medical Director); Judith Finn (Adjunct Research Professor & recipient of research funding); Stephen Ball (Adjunct Research Fellow).

CRediT author statement

David Majewski: Conceptualization, Methodology, Validation, Investigation, Data Curation, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration. **Stephen Ball**: Conceptualization, Methodology, Validation, Data Curation, Writing - Review & Editing. **Paul Bailey**: Conceptualization, Writing - Review & Editing, Funding acquisition. **Nicole Mckenzie**: Conceptualization, Methodology, Investigation, Data Curation, Writing - Review & Editing. **Janet Bray**: Conceptualization, Writing - Review & Editing. **Alani Morgan**: Conceptualization, Data Curation, Writing - Review & Editing. **Judith Finn**: Conceptualization, Methodology, Validation, Writing - Original Draft, Writing - Review & Editing, Project administration, Supervision, Funding acquisition.