

**Home Oxygen therapy for infants and young children with acute
bronchiolitis and other lower respiratory tract infections: The HiTHOx
Program**

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ABSTRACT

Background: Acute lower respiratory tract infection (LRTI) including bronchiolitis, is one of the leading causes of paediatric hospital admissions worldwide. Recent studies have demonstrated that some children with acute bronchiolitis can be successfully managed using home oxygen therapy.

Aim: To report the impact of a Hospital in The Home Oxygen therapy program (HiTHOx) for selected infants and young children with acute bronchiolitis and other LRTI.

Findings: The HiTHOx program appears to be a safe model of care for carefully selected infants and young children with acute bronchiolitis and LRTI that reduces the hospital length of stay.

Conclusions: The HiTHOx program provides an alternative model of care for infants and young children with acute LRTI. Implementation of models of care similar to that of the HiTHOx program in other paediatric health services may have the potential to create additional bed capacity, at the time of year when it is most needed.

Introduction

Acute bronchiolitis is the most common viral lower respiratory tract infection in infants and a leading cause of hospital admissions worldwide (Scottish Intercollegiate Guidelines Network, 2006; Stang et al. 2001; Rosychuk et al. 2011; Corneli et al 2012). Increasing demand for hospital beds has seen the rapid growth of ambulatory care services that aim to reduce the total number of hospitalisations and/or shorten the overall length of hospital stay, while maintaining or improving clinical outcomes for patients.

The management of children with acute bronchiolitis is supportive only (Scottish Intercollegiate Guidelines Network, 2006) and includes supplemental oxygen administered to patients who are hypoxic and intravenous fluids or nasogastric feeds to those unable to feed sufficiently. Oxygen supplementation remains the prime determinant of the length of hospital stay for children with acute bronchiolitis (Unger & Cunningham 2008). A number of recent studies have suggested that home oxygen therapy, for otherwise healthy children with acute bronchiolitis is a reasonable alternative to traditional inpatient management (Bajaj, Turner & Bothner 2006; Tie et al., 2009; Parker, Allen, Stephens, Lalani & Schuh, 2009; Sandweiss, Corneli & Kadish, 2010; Sandweiss, Kadish & Campell, 2012; Corneli et al., 2012).

At Princess Margaret Hospital for Children (PMH), the sole tertiary paediatric hospital in Western Australia (WA), a prospective randomised controlled pilot study was undertaken in 2007, to determine the feasibility and safety of a home oxygen therapy program for children with acute bronchiolitis (Tie et al.,

2009). While the number of subjects recruited in that single bronchiolitis season was relatively small (n=44), the results supported the view that by using carefully considered inclusion and exclusion criteria and providing high quality nursing support for families, children with acute bronchiolitis could be safely managed at home, while continuing to receive supplemental oxygen therapy. This paper describes the Hospital in the Home Oxygen (HiTHOx) Program and reports the outcomes of children managed by the service since its inception.

The HiTHOx Program Initial Pilot Study

In 2003, the State Government of Western Australia appointed the Health Reform Committee to review the Western Australian health system and develop a vision for the future. Health care reforms recommended by the committee in 2004 included the reconfiguration of hospital services, with an increased emphasis on ambulatory services. At PMH, these recommendations led to the establishment of a comprehensive paediatric ambulatory service including the nurse-led Hospital in the Home (HiTH) program in October 2006.

In 2007, the Ambulatory Services team at PMH were recipients of a State Health Research Advisory Council (SHRAC) Research Translation Project (RTP) grant that supports innovative, cost effective health services in WA. In collaboration with the Department of Respiratory Medicine, a randomised controlled pilot study was undertaken to assess the effectiveness of a HiTH led Program managing children with acute bronchiolitis at home, as an alternative to traditional inpatient admission.

The study compared health outcomes of children managed at home to those hospitalised with acute bronchiolitis (Tie et al., 2009). Children were recruited between 1st August 2007 and 30th November 2007. Forty four children, twenty two in each group, were enrolled in the study and randomly assigned to traditional inpatient care (hospital group) or to home oxygen (HiTHOx group).

Children in the HiTHOx group had a significant shorter hospital length of stay (55.2 hours (interquartile range (IQR) 40.3–88.9) when compared to the tradition inpatient group (96.9 h (IQR 71.2–147.2) $p=0.001$). One child from each group required readmission to hospital, with full and uneventful recoveries. While the study was not sufficiently powered to determine the safety of home oxygen therapy for children with acute bronchiolitis, the results were reassuring and supported the continuation of the HiTHOx Program, the first of its kind in Australasia.

The HiTHOx Clinical Program

The PMH HiTH service is an acute care hospital substitution model that allows children to be treated and cared for in their home. It is provided by experienced tertiary paediatric nurses based at PMH with clinical responsibility provided by the child's admitting medical team. The delivery of traditional inpatient services in the out of hospital setting relies on a number of key factors to ensure care is delivered safely. The HiTHOx Program incorporates inclusion and exclusion criteria (Table 1), criteria for readmission (Table 2), a "safety in air" test (Tie et al., 2009) and an oxygen weaning protocol for HiTH staff, to ensure the key outcomes of patient safety and quality care.

Infants and young children admitted with acute bronchiolitis, or other LRTI requiring oxygen, must remain in hospital for at least 12 hours and be stable with no deterioration in clinical status before discharge to the HiTHOx Program. In addition, due to the constraints of having a centrally based HiTH service, the HiTHOx Program is only available for families who reside in the Perth metropolitan area, which is within a 50km radius from the hospital. Parents who are offered the HiTHOx Program have the choice of continuing their child's treatment in hospital or in the home. A "safety in air" test is conducted under supervision on the inpatient ward, to assess the child's ability to cope in room air in the event that their oxygen supply became interrupted in the home. This "safety in air" test involves continuous monitoring of the clinical status of the child and oxygen saturation levels to maintain >80% over 15 minutes in room air (Tie et al., 2009).

Table 1: Inclusion and exclusion criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
<ol style="list-style-type: none"> 1. >2 months of age (corrected gestation) 2. Clinical diagnosis of acute bronchiolitis or other LRTI (e.g. pneumonia) 3. Adequate feeding and hydration (>50% normal feed) 4. Oxygen saturation $\geq 92\%$ on <1 litre/minute nasal cannula oxygen 5. With no signs of deteriorating respiratory status 6. Paediatrician agrees that child is fit for home oxygen therapy regardless of any of the exclusion criteria 	<ol style="list-style-type: none"> 1. Pre-existing cardiac, pulmonary (e.g. BPD), neuromuscular disorders 2. History of apnoea 3. Prematurity <34 weeks (may be less relevant if a child is >12 months) 4. Children requiring >12 hourly beta-2 agonists (children with asthma or bronchial hyper-responsiveness should <u>not</u> receive home oxygen)

Table 2: Criteria for readmission to hospital

Hospital readmission criteria
<ol style="list-style-type: none"> 1. Oxygen requirement increases to >1 litre/minute to maintain oxygen saturation >92%. 2. Apnoeic episode. 3. Feeding < 50% of normal with clinical evidence of dehydration. 4. Parents or treating paediatrician want the child readmitted to hospital.

Following assessment of the family's suitability to the HiTHOx Program, including hazard identification within the home environment, parents receive education including how to observe for signs of deterioration and use of oxygen equipment. Oxygen needs are determined prior to discharge based upon oxygen flow rates and the expected length of time the child will be receiving oxygen. Hospital discharge does *not* occur until confirmation is received by the gas supply company (BOC), that home delivery of oxygen has occurred.

HiTHOx Management

Children and their family are assessed by the HiTH nurse prior to discharge and home visits are scheduled. The first home visit occurs within 12 hours of hospital discharge, and families subsequently receive two nursing visits per day, in addition to a daily telephone call from the HiTH nurse.

HiTH nurses are available to visit any day of the week between 7am and 10pm and are the central point of contact for families regarding the child's condition. Provision of telephone support 24 hours per day ensures families' access to experienced tertiary paediatric nurses at any time. Whilst on the HiTHOx program, the child remains under the care of the admitting medical team. HiTH nurses may contact the medical team to discuss any concerns and facilitate a medical review if required or parents may request an additional visit by HiTH staff if they are concerned.

In the home, low flow oxygen is delivered via nasal cannulae at a maximum rate of 1L/min to maintain oxygen saturations of $\geq 92\%$. At each visit, oxygen flow rates are titrated by the HiTH nurse according to the oxygen weaning protocol. If oxygen saturation levels are greater than 92%, then the oxygen flow rate is reduced, see Table 3.

The nurse remains with the child for at least fifteen minutes following the decrease in oxygen flow rate to assess the clinical condition and ensure oxygen saturation levels are maintained $\geq 92\%$. Supplemental oxygen is discontinued when the child maintains oxygen saturation levels $\geq 92\%$ for a minimum of fifteen minutes in air. Following the next HiTH visit, if oxygen saturation has been maintained then the child is discharged from the program.

Progress to date

One hundred and twelve patients were enrolled in the HiTHOx Program between August 2007 and December 2011 with a total of seven children (6%) readmitted to PMH. Reasons for readmissions included increased oxygen requirements (n=4), dehydration secondary to viral gastroenteritis (n=1), wheezing (n=1) and fever (n=1). All children made a full recovery with no adverse outcomes.

Table 4 represents HiTHOx admissions and readmissions for each year following the pilot study, from 2008 to 2011. Children received on average seven visits from the HiTH nurses from time of hospital discharge to discharge from the HiTHOx Program (Table 5). The average hospital days were three

and average HiTH days were three. The average cost for oxygen supply and delivery costs over three HiTH days was \$187, approximately \$62 per day per patient. In 2011 the average costs per patient day for a hospital bed were \$3000, compared with the average HiTH bed per day at \$900.

Table 3: Oxygen Weaning Protocol

Weaning Protocol
- 1L/min to 750mls/min
- 750 mls/min to 500mls/min
- 500 mls/min to 250mls/min
- 250 mls/min to 125mls/min

Table 4: Admission & Readmission rates

Year	No. of children admitted to HiTHOx	No. of children readmitted to hospital	Percentage of readmission
2007 *	22	1	5%
2008	46	4	9%
2009	16	2	12%
2010	19	0	0%
2011	9	0	0%

* RCT Pilot Study

Table 5: Hospital and HiTH utilisation

Variable	2008 (n=46)	2009 (n=16)	2010 (n=19)	2011 (n=9)
Age, months	9.8 (6.1-16.4)	17.4 (10.5-20.4)	14.4 (9.8-22.8)	11.4 (2-30.3)
Males, n	26	6	10	4
Females, n	20	10	9	5
Hospital days	3 (2-6)	3.5 (2-6)	4 (2-5)	4 (2-5)
HiTH days	3 (2-4)	3 (3-4)	3 (2-4)	4 (3-11)
HiTH visits	7 (6-8)	7 (6-10)	7 (6-9)	9 (7-24)

Data are number for gender and median (interquartile range) for all other variables.

Discussion

The current best practice management for children with acute bronchiolitis involves supportive care only, with supplemental oxygen therapy provided if oxygen saturation levels are less than 93%. Delivery of oxygen therapy traditionally occurs in the inpatient setting and whilst efforts to reduce or shorten hospitalisations for bronchiolitis patients are desirable (Stang et al. 2001), patient safety and outcomes are paramount.

In 2006, Bajaj et al. demonstrated the safe use of home oxygen therapy for children with acute bronchiolitis. This approach was supported by the establishment of inclusion and exclusion criteria as a way to maximize the safety of home discharge with oxygen therapy from an emergency department. The home oxygen protocol we have reported supports the discharge of a low risk population from a tertiary facility to home, following a period of observation of clinical status.

Deciding the level of supportive care required for children with acute LRTI is assisted by a period of observation and assessment. At PMH, patients are required to remain an inpatient for at least 12 hours before discharge to the HiTHOx Program. The period of observation assists in supporting the health care team to combine objective features into their overall clinical judgement regarding the suitability of the patient for home oxygen therapy (Marlais, Evans & Abrahamson, 2011). Unger and Cunningham (2008) found that infants who remained in hospital once feeding difficulties were resolved and

continued to receive supplemental oxygen did not experience deterioration in their condition. Establishment of a home oxygen protocol that recommends patients are observed for a minimum period ensures an early but safe discharge to the program. This period of observation has been reported to range between eight hours (Bajaj et al., 2006; Halstead, Roosevelt, Deakyne & Bajaj, 2012) and 24 hours (Tie et al., 2009).

Several studies have focused on determining predictors of hospitalisation and length of stay (LOS) for children with bronchiolitis (El Radhi et al.1999; Mansbach et al., 2008; Unger & Cunningham, 2008; Parker et al., 2009; Norwood et al., 2010; Marlais et al., 2011; Corneli et al., 2012). Oxygen therapy has been reported as a principal determinant of LOS for infants admitted to hospital with bronchiolitis (Unger & Cunningham, 2008). The most common barrier to discharge reported by Sandweiss et al. (2010) from a 24 hour observation unit for patients with bronchiolitis was hypoxia, suggesting further research in to the use of home oxygen may assist in reducing length of stay. Decreasing length of stay provides additional improvements in service efficiency, including increased availability of hospital beds. Furthermore, bronchiolitis is a disease with a peak incidence in winter, the critical period of bed shortages and so the positive effects of such a program as HiTHOx, would be maximized at a time when the demand for resources are at a peak.

A recent study by Sandweiss et al. (2012) surveyed paediatricians' experiences with home oxygen therapy for bronchiolitis patients and reported protracted periods on oxygen therapy in the home. No clear protocol for

weaning home oxygen was identified with paediatricians acknowledging difficulty in deciding when to stop oxygen. The present work at PMH has incorporated a clear protocol for the HiTH nurses to wean oxygen in a safe and clinically appropriate time frame. Pre-existing infrastructure and interventions from the HiTH program provide the necessary support to promote safe care in the home.

Children with underlying co morbidities have been identified as being at greater risk for severe bronchiolitis (Shay et al., 1999; American Academy Pediatrics, 2006) and during our initial pilot study were deemed out of scope for the HiTHOx Program (Tie et al., 2009). Ongoing delivery of the HiTHOx Program has seen the criteria for inclusion expand, to include children with some pre-existing co-morbidities, allowing more flexibility for paediatricians and families when deciding whether the benefits of home oxygen therapy outweigh the risks for certain patients (Table 1).

Since 2007, patient outcomes at PMH have reflected safety measures and strict criteria used by the HiTH program. Following the pilot study, subsequent years show annual readmission rates ranging from 0% to 12% (Table 4). Patients who were readmitted experienced relapse of respiratory illnesses but did not require advanced airway management with all children making a full recovery. Low enrolment numbers to the program over the most recent years have prompted strategies to promote ambulatory care services, as for these patients it is recognised as a safe, cost effective model of care.

The HiTHOx Program supports a paradigm shift away from hospital admission as the sole mechanism for managing the health needs of infants and young children with acute bronchiolitis and other LRTI who require oxygen therapy. It is evident that this community centric approach yields a benefit by reducing the length of stay. Programs such as HiTHOx and other ambulatory care investments empower families to work collaboratively with health care providers to provide better clinical outcomes for their children. Concerns in relation to levels of appropriate support for families has been highlighted by Sandweiss et al. (2010) and the use of a nurse led HiTH program at PMH supports this process.

Conclusion

Although these studies are small, findings from this study support the safe management of selected children with acute bronchiolitis and other LRTI who require oxygen at home. We believe this programme could be adapted in other westernised countries. Continued research focusing on safely reducing hospitalisations (Pelletier, Mansbach & Camargo, 2006) and evaluation of health care costs is required as well as the impact on families participating in home based care.

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