Research Article

Acute bronchiolitis in regional Queensland: How well are we doing?

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Received on: 23-Jan-2022 Accepted for Publication: 15-Jun-2022

ABSTRACT

Background: Bronchiolitis commonly occurs in infants, with international and national guidelines recommending a requirement for supportive therapy as the trigger for inpatient care, with few, if any investigations. However, investigations and pharmaceutical interventions are still frequently seen.

Aims: The primary objective was to review the management of bronchiolitis in a regional hospital as compared to the Australasian Paediatric Research in Emergency Departments International Collaborative (PREDICT) 2016 guidelines. The secondary aim was to assess the hospital length of stay (LOS), retrieval rates, and mortality.

Methods: A retrospective study was performed with 359 patient encounters between 1 January 2014 and 31 March 2018. The interventions of interest included blood tests, chest X-rays, nasopharyngeal aspirates, antibiotics, salbutamol, steroid use and respiratory support. The number, time, and location (Emergency Department, Paediatric ward or Intensive Care Unit) where the interventions occurred were retrieved.

Results: A majority of patients (93.6%, 336/359) received at least one intervention, with a maximum of seven interventions performed. Most interventions occurred on the day of admission with the number of interventions increasing with LOS. Interventions were not targeted at a specific age group. The mean hospital LOS was 2.54 days (Standard Deviation [SD] 2.16) and mean ICU LOS was 3.55 days (SD 1.97). Retrievals were only required for 1.7% (6/359) of patients. There was no mortality.

Conclusion: This study identified that multiple ineffective interventions were still being performed. Targeted efforts are required to intentionally minimise interventions in patients, and further supports provided to minimise hospitalisation in patients with bronchiolitis in the regional setting.

Key Words: bronchiolitis; paediatrics; regional hospital; intervention

INTRODUCTION

Bronchiolitis is a potentially life-threatening respiratory illness that occurs most frequently in the first year of life.[1] Bronchiolitis is associated with acute inflammation, increased mucous production, atelectasis and ventilation perfusion mismatch.[2] It is a clinical diagnosis, with symptoms including fever, nasal congestion, cough, tachypnoea, increased respiratory effort, widespread crackles, wheeze and difficulty feeding.[3]

In Australia, approximately 13,500 children with bronchiolitis are admitted to hospital annually; accounting for 56% of admissions of all infants aged below twelve months in 2000/01.[4] Bronchiolitis and pneumonia, were the predominant conditions requiring aeromedical retrieval service in the Northern Territory, a remote region in Australia.[5]

There is a lack of effective interventions available to improve the outcome of critically ill infants with bronchiolitis.[6,7] Cochrane systematic reviews revealed no conclusive evidence for the use of antibiotics,[8] leukotriene inhibitors,[9] steam inhalation,[10] bronchodilators[11] or glucocorticoids[12] in managing infants with bronchiolitis. While continuous positive airway pressure (CPAP) improved tachypnoea, there was no significant reduction noted in the requirement of mechanical ventilation or hospital length of stay (LOS).[13]

A recent randomised controlled trial using high flow nasal cannula (HFNC) in infants with bronchiolitis showed a reduction in treatment escalation compared to standard low flow oxygen therapy, although there was no significant difference in hospital LOS.[14] Supportive therapies including supplemental oxygen and fluid replacement via intravenous or nasogastric routes, remain the mainstay management strategies. Routine interventions such as blood tests, CXRs and antibiotics were not recommended.[15]

High-quality international and Australasian clinical practice guidelines for bronchiolitis now exist.[16-18] However, there is significant variation in clinical practice,[19] where up to 48% of infants admitted to Australasian hospitals received interventions that were not clearly beneficial.[20] Implementation of guidelines have been found to reduce interventions performed.[21]

AIMS

The primary aim of this study was to review the management of bronchiolitis in this regional hospital, compared to established guidelines. The interventions of interest included chest X-rays (CXRs), nasopharyngeal aspirates (NPAs), blood tests, steroids, salbutamol, antibiotics administration and respiratory support.

The secondary objective was to assess the outcomes of patients admitted for bronchiolitis including the hospital LOS, the number of retrievals to a tertiary hospital and mortality in this regional hospital.

METHODS

This is a retrospective, single-centre study at a regional hospital in Queensland, Australia, located approximately 700 km away from the two nearest tertiary paediatric hospitals in the state. The hospital is a referral centre for the surrounding areas; with a population of approximately 250,000. All retrievals to the tertiary paediatric hospitals occur via aeromedical services due to the geographical location. The Emergency Department (ED) and Intensive Care Unit (ICU) are mixed units, caring for both adult and paediatric patients, with the ICU functioning at the level of a high dependency unit for the paediatric patients. There are a maximum of 17 paediatric inpatient beds, divided into single and shared rooms, supported by six general paediatricians. The hospital is mainly staffed by medical staff early in their careers, within five years post-graduation, most with limited paediatric training and/or experience.

All infants up to 12 months of age, admitted for bronchiolitis between 1 January 2014 and 31 March 2018 were identified through the hospital database, as per the International Statistical Classification of Diseases and Related Health Problems (ICD) code, referenced under "J21".[22]

A paper chart review was performed for each patient. Patients with congenital cardiac disease, neuromuscular disorders, immunodeficiencies, malignancies, cystic fibrosis or chronic neonatal lung disease were excluded. Each patient presentation was considered as an encounter. Hence if a patient presented twice during the study period, it was analysed as two separate encounters.

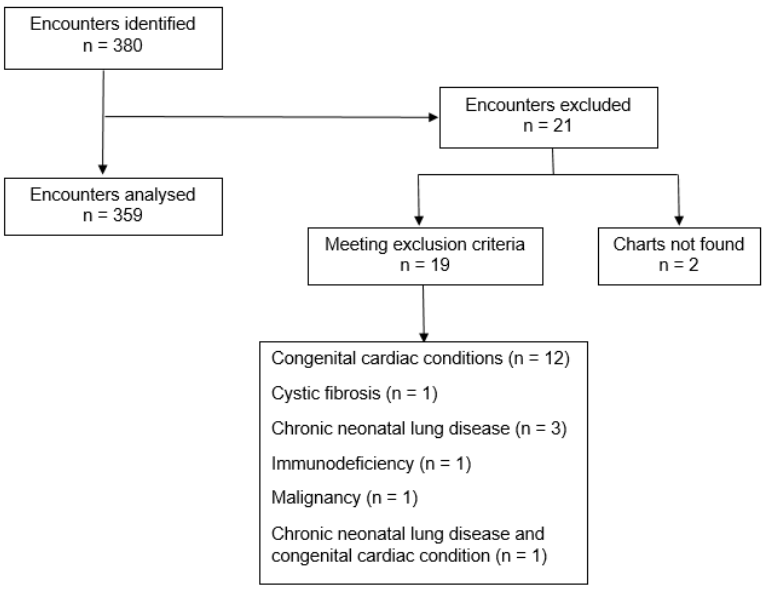
All interventions documented were retrieved; blood tests, CXRs, and NPAs. All therapy documented was retrieved, e.g. antibiotics, salbutamol, steroid use and respiratory support. For each encounter, the number, time, and location where the investigation or intervention occurred [ED, Paediatric ward or ICU] were recorded.
CXR reports were reviewed with IMPAX 6.7.0.4511 (Afga HealthCare Inc.), pathology results were obtained from Auscare (Version 2.4, Pathology Queensland) and ICU admissions were assessed via MetaVision (Version 5.46.44, *i*MD*soft*®).

Data was managed utilising Excel (Microsoft, USA) and analysis performed with SPSS® Statistics 2019 (IBM SPSS®, Australia). Mean values were reported with standard deviation (SD). When comparing proportions, odds ratio (OR) with 95% confidence interval (CI) and χ^2 (chi square) testing was used. Statistical significance was defined as $P < 0.05$.

ETHICS APPROVAL

The study received approval from the Central Queensland Hospital and Health Service Research Ethics Committee (HREC/18/QCQ/13).

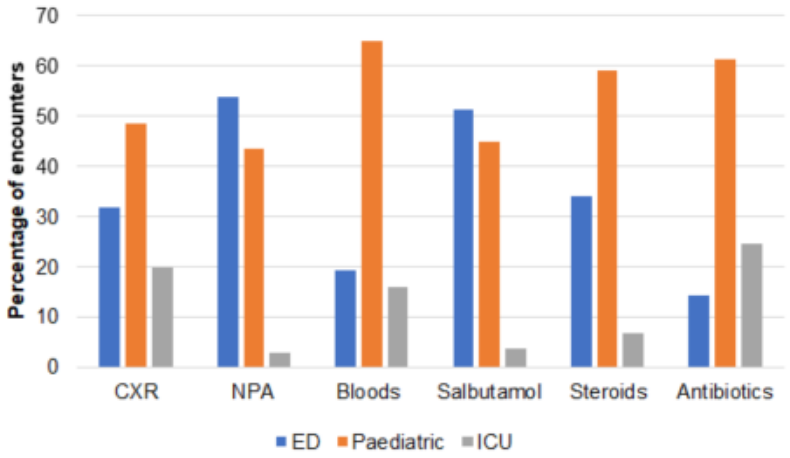
Figure 1: Flow diagram of encounters



RESULTS

A total of 380 encounters were identified throughout the study time frame. 21 encounters were excluded including 19 encounters meeting the exclusion criteria and two paper charts were not found. A total of 359 encounters were then analysed (**Figure 1**). Approximately two thirds of the patients (64.6%; 232/359) were aged less than 6 months old. Most of the patients were of the male gender (66.3%; 238/359). The locations where the interventions occurred were summarised in **Figure 2**.

Figure 2: Interventions performed based on location



Chest X-Rays

A total of 208 CXRs were performed in 163 encounters; 45.4% of admissions had a CXR. Most patients had a single CXR performed (81%; 132/163), while some had two CXRs (12.3%; 20/163), three CXRs (4.9%; 8/163) and four CXRs (1.8%; 3/163). CXRs were performed predominantly on the day of admission (mean 0.76 days, SD 1.563). A higher proportion of patients aged between 7-12 months received at least one CXR compared to patients aged 0-6 months (52%, 66/127 versus 41.8%, 97/232; P = 0.065).

The most common findings were hyperinflation (23.1%; 48/208), streaky changes (20.7%; 43/208), consolidation (15.9%; 33/208), atelectasis (10.1%; 21/208) and one pneumothorax (0.5%; 1/208) was identified. The majority of CXRs were ordered by the Paediatric team (48.6%; 101/208), followed by ED (31.7%; 66/208) and ICU (19.7%; 41/208). Of the patients who had at least one CXR, 36.8% (60/163) were admitted to the ICU.

Nasopharyngeal Aspirates

The NPAs were tested by PCR for eight respiratory viruses, Influenza A, Influenza B, Parainfluenza 1, 2 and 3, Respiratory Syncytial Virus (RSV), Human Metapneumovirus (HMPV) and Adenovirus. A total of 287 NPAs were performed in 284 encounters, where 79.1% of infants admitted had an NPA, and three patients had two tests. RSV was the most frequent positive result (43.6%; 125/287), followed by Adenovirus (7.0%; 20/287),

Parainfluenza (2.9%; 8/287), HMPV (2.9%; 8/287) and Influenza A (0.1%; 2/287). A total of 53.7% (154/287) of NPAs tested negative.

The number of NPAs performed decreased over the study period: - 2014 (90.5%; 76/84), 2015 (89.1%; 41/46), 2016 (93.8%; 90/96), 2017 (60.9%; 67/110), and for the first quarter of 2018 (56.5%; 13/23). NPAs were performed most commonly in ED (53.7%; 154/287), on the Paediatric ward (43.6%; 125/287), and in ICU (2.8%; 8/287). The majority (84.3%; 242/287) were performed on the first day of admission (mean 0.06 days, SD 0.661).

Blood tests

Blood tests were performed in 38.7% (139/359) encounters, with 28 encounters having repeat testing. The infants had blood taken on 176 occasions with varying test combinations of a full blood count (FBC), biochemistry reviewing the electrolytes, namely sodium and potassium levels, urea and creatinine (EUC), liver function tests (LFT) including aspartate transferase (AST), alanine transferase (AST) and bilirubin levels, C-reactive protein (CRP) and/or blood culture.

A total of 36.8% (132/359) had an FBC, and between 17.8% and 30.4% had a combination of EUC and/or LFTs. Blood tests were mostly obtained on the day of admission (mean 0.75 days, SD 1.43). The largest proportion being ordered on the Paediatric ward (64.8%; 114/176), followed by ED (19.3%; 34/176) and ICU (15.9%; 28/176).

Any parameter outside the reference range rendered the blood test abnormal, such as mild electrolyte derangement or lymphopenia. Of these, 48.1% (74/154) of FBCs, 20.3% (27/133) of EUCs and 39.7% (27/68) of LFTs were abnormal. CRP was performed in 35.9% (129/359) of encounters with the mean CRP of 22.6 (SD 40.5) [Reference < 5]. Repeat blood tests were likely collected due to sampling error.

A total of 89 infants had blood cultures performed [24.8%], none with pathogenic organisms. Seven cultures (7.1%, 7/98) were positive from contaminant organisms; six with coagulase negative staphylococcus and one from *Sphingomonas paucimobilis*.

Steroids

Steroids were prescribed in 12.3% (44/359) of encounters, on the day of presentation (mean 0.23 days; SD 0.642). Steroids were administered mostly on the Paediatric ward (59.1%; 26/44), in ED (34.1%; 15/44) and in ICU (6.8%; 3/44). A larger proportion of older infants 7-12 months received steroids, compared to those between 0-6 months (28.3%, 36/127 versus 3.4%, 8/232; P = 0.000). Similarly, for patients in ICU, 8.1% (3/37) of those aged 0-6 months and 29.6% (8/27) of those aged 7-12 months were prescribed steroids (P = 0.024).

Salbutamol

Salbutamol was administered via metered-dose inhaler with spacer or nebulised, in 39% (140/359) of the encounters. Salbutamol was predominantly commenced on the day of admission (mean 0.13 days; SD 0.492). Salbutamol was prescribed in ED for 72 infants (51.4%), on the Paediatric ward for 63 infants (45%), and in ICU for 5 patients (3.6%). A greater proportion of older infants aged 7-12 months received salbutamol compared to the younger patients aged 0-6 months (77.2%, 98/127 versus 18.1%, 42/232; P = 0.000). Of the patients admitted to ICU, 24.3% (9/37) of those aged 0-6 months and 85.2% (23/27) aged 7-12 months received salbutamol (P = 0.000).

Antibiotics

A total of 27.3% (98/359) encounters received antibiotics, with the majority receiving antibiotics via the intravenous route (64.3%; 63/98), oral antibiotics (31.6%; 31/98), intramuscular route (1%; 1/359), and route unknown (3.1%; 3/98). Penicillin or intravenous cefotaxime, a third-generation cephalosporin, was prescribed. Antibiotics were administered on day one of admission (mean 0.67 days, SD 1.139). Antibiotic therapy was mostly commenced on the Paediatric ward (61.2%; 60/98), followed by ICU (24.5; 24/98) and in ED (14.3%; 14/98). There was no significant difference in antibiotic administration between the 0-6 months and 7-12 months groups (28.4%, 66/232 versus 25.2%, 32/127; P = 0.508). A significant correlation was found between any blood test performed and commencement of antibiotics (P = 0.000). An association was also noted between the acquisition of a CXR and the use of antibiotics (OR 8.761; CI 4.984–15.4).

Respiratory support

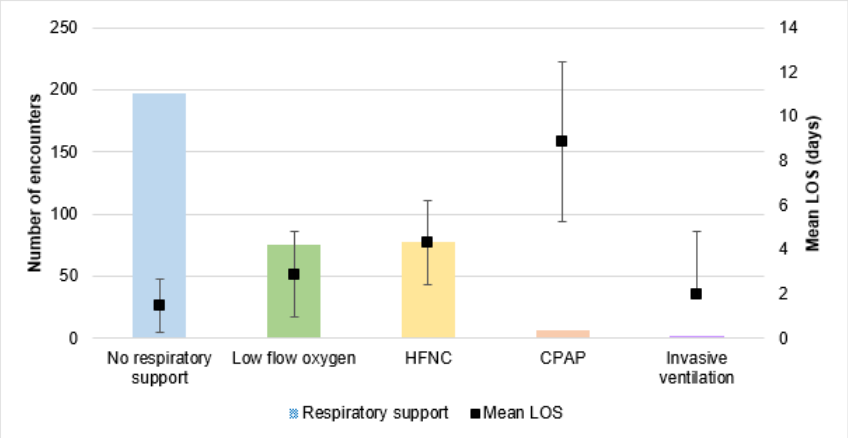
A total of 162 of 359 encounters [45.1%] received respiratory support. The highest form of respiratory support required was documented in a decreasing order from invasive ventilation, CPAP, HFNC to low flow oxygen. A majority received HFNC (48.1%; 78/162) or low flow oxygen (46.3%; 75/162), with a small number requiring CPAP (4.3%; 7/162) or invasive ventilation (1.2%; 2/162). A greater number of patients aged 7-12 months required respiratory support compared to their younger cohort (57.5%, 73/127 versus 38.4%, 89/232; P = 0.000). The LOS of patients on any form of respiratory support was at least double those without respiratory support (mean 3.81 days, SD 2.37 versus mean 1.49 days, SD 1.2; P = 0.000) [**Figure 3**].

In contrast, 197 encounters (54.9%) were admitted without requiring respiratory support. A total of 196 encounters were analysed for geographical information; this was not available for 1 encounter.

Patients admitted without respiratory support were more likely to be younger infants, aged 3 months or less (47.4%; 93/196). A number of patients identified as being from the indigenous background; Aboriginal but not Torres Strait Islander (TSI) [18.9% (37/196)], both Aboriginal and TSI [4.6% (9/196)], and TSI but not Aboriginal [2% (4/196)]. The mean LOS was 1.36 days (SD 1.16). The LOS varied based on distance patients

travelled to the hospital – 8.2% (16/196) were located within 5 km (mean 1 day, SD 1), 55.6% (109/196) between 5-20 km (mean 1.3 days, SD 0.86), 16.3% (32/196) between 20-100 km (mean 1.5 days, SD 1), 10.2% (20/196) between 100-500 km (mean 1.35 days, SD 0.79) and 2% (4/196) living greater than 500 km (mean 5 days, SD 3.67).

Figure 3: Respiratory support and mean hospital LOS



SECONDARY OUTCOMES

Hospital length of stay and Intensive Care Unit admissions

The mean LOS was 2.54 days (SD 2.16), with a maximum admission length of 14 days. There was a total of 64 admissions to the ICU (17.8%; 64/359) with 57.8% (37/64) of admissions for patients aged 0-6 months. The mean ICU LOS was 3.55 days (SD 1.97) and median was 3 days (range 1-11). Patients aged 0-6 months had a mean ICU LOS of 3.95 days (SD 2.3) and patients 7-12 months 3 days (SD 1.12). Patients who were admitted to the ICU were more likely to have a CXR performed (P = 0.000) and to require respiratory support (98.4%; 63/64).

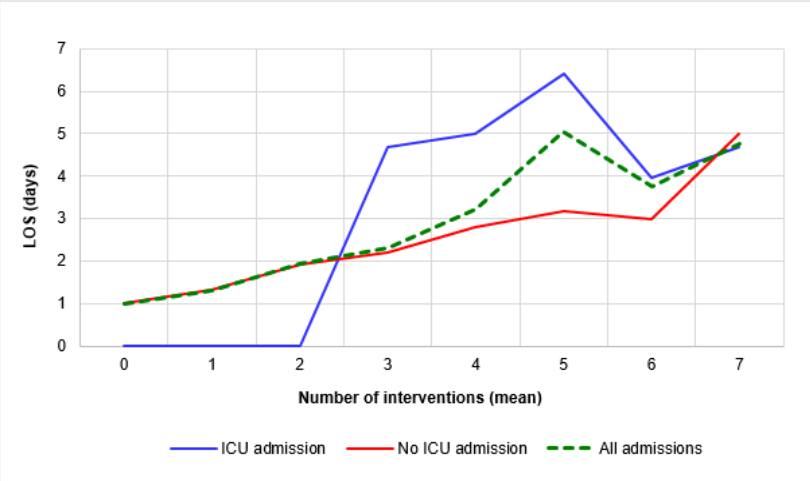
Discharge

Six patients (1.7%; 6/359) were retrieved to a tertiary centre; all other patients were discharged home. There was no patient mortality.

Interventions

Interventions analysed included CXRs, NPAs, any blood test performed, salbutamol, steroids, antibiotics or any form of respiratory support. Each type of intervention performed was considered as one intervention, regardless of the number of repeated episodes. Only 6.4% (23/359) of encounters did not receive any intervention, and 60% (217/359) received between one and three interventions. Patients who were admitted to ICU received at least three interventions. The total number of interventions increased with a greater length of stay, with a peak number of five interventions performed in ICU on day six of admission **(Figure 4).**

Figure 4: Number of interventions based on LOS and admission status



DISCUSSION

The present study identified that patients admitted for bronchiolitis received multiple non-evidence-based interventions in this regional hospital. During the period of this study the current guidelines were – PREDICT 2016,[23] the National Institute for Health and Care Excellence (NICE) 2015 in the United Kingdom,[17] and the American Academy of Pediatrics (AAP) 2014 in the USA[18].

Despite available guidelines, the present study showed that the majority of encounters (93.6%) received at least one intervention. This was significantly higher than a recent multicentre international study, where 30.2% of infants hospitalised for bronchiolitis received non-evidence-based supportive therapies,[24] taking into account the small variance between interventions analysed.

The present study indicated that most CXRs (67.3%) were performed on the day of admission, similar to the findings of an NZ study.[25] CXR findings were also consistent with previous literature.[7] Patients admitted to the ICU received multiple CXRs. While a number of CXRs were performed to determine nasogastric tube and endotracheal tube positions, CXRs were likely repeated to assess patients' progress despite routine CXRs having minimal contribution in improving the management of infants with bronchiolitis.[16]

A majority of the patients also received an NPA during this study. RSV was the most common organism isolated.[26] While an NPA enables organism identification, no clinical benefit was derived from routine testing,[27] apart from having the ability to cohort patients into shared rooms. When this hospital's policy changed in early 2017 where NPAs were modified from routine to clinician guided testing, a decrease of 32.9% in NPA performance was noted between 2016 and 2017.

Approximately a third of patients in the present study had blood tests, despite routine testing not being recommended.[23] Despite higher ICU admission rates in the 0-6-month cohort, blood tests were not targeted to this age group.

Antibiotics were administered to a quarter of patients in the present study. Similar to previous studies, the performance of a CXR or blood test increased the odds of antibiotic prescription.[20] However, it is possible that antibiotics were commenced pre-emptively, while awaiting investigation results, and ceased once the results were reviewed. A larger proportion of blood tests and antibiotic prescriptions conducted in ICU patients were likely due to concerns of clinical severity and/or deterioration. Nevertheless, a systematic review revealed no benefit with antibiotic administration in bronchiolitis on the hospital LOS or readmission rates.[8]

Previous studies reveal that neither glucocorticoids nor bronchodilators improve the patients' hospital LOS or oxygen saturations.[11,12] Steroids were prescribed, largely to the older infants above 6 months old. Infants of all ages received salbutamol, despite those less than 6 months being less likely to respond. It is thought that clinicians administered these interventions to manage wheeze, a common presentation in bronchiolitis, known to be unresponsive.

Patients requiring any form of respiratory support, especially HFNC and CPAP, had increased LOS compared to those who did not, probably due to disease severity. Patients who required CPAP had double the mean LOS compared to those receiving HFNC, differing from the findings of a previous study with similar hospital LOS between both groups.[28] The elevated LOS could be contributed by the cautious wean of CPAP support in this hospital. A small proportion of patients required invasive ventilation (1.2%) compared to 2.3%-18% in previous studies.[29-31] The early retrieval of deteriorating patients to a tertiary paediatric centre most likely negated the occurrence of invasive ventilation in this centre.

To date, there is no literature available specifically for the management of bronchiolitis in a regional setting. Hence, the secondary outcomes of this study were compared to the findings of existing literature. In this centre, the mean hospital LOS of 2.54 days was comparable to 2.4 days in the USA[30] and 3.4 days in New Zealand (NZ).[25] Of interest, 54.9% of encounters were admitted without requiring oxygen support, with a shorter LOS of 1.36 days compared to the entire patient cohort. Approximately 28.6% of these patients lived greater than 20km to the hospital, and 47.4% of these encounters were aged 3 months or less. These patients were more likely admitted for monitoring due to the vulnerability of their age and the distance required for travel, to minimise hospital representations. It is possible that a number of these patients required feeding support, although that aspect was not assessed as a part of this study. Investigations [CXRs and NPAs] were performed in this group, suggesting that they were ordered routinely as part of an admission. Future planning to implement

a hospital in the home programme for close monitoring and feeding support for this subgroup should be considered, including the possibility of onsite family accommodation for patients coming from remote areas.

The median ICU LOS was 3 days, similar to the findings of previous studies with median LOS between 2.1 to 4 days in Paediatric ICUs.[31,32] Approximately 20% of admissions at this centre required the ICU, higher than 5.7% of infants aged between 2-12 months old with bronchiolitis in a multicentre Australasian study.[31] Firstly, the hospital treatment policy of admitting all paediatric patients requiring HFNC to the ICU could have contributed to the higher ICU admission rate. This policy was amended at the end of 2017. As the data collection concluded in March 2018, it was not possible to evaluate the change. In addition, the ICU operated as a closed unit, and the intensivists who predominantly manage adult patients, were likely to be more cautious when managing paediatric patients and having a lower threshold for ICU admissions and intervention performance.

The mean number of interventions also increased concurrently with the hospital LOS, for both the ICU and ward admissions. Given the retrospective nature of this study, it was not possible to determine if the increased LOS contributed to the rise in intervention performance, or if the intervention implementation influenced the LOS. No mortality was recorded during this study, consistent with low mortality rates from bronchiolitis worldwide.[30,33,34]

CONCLUSION

While variation in clinical practice is well described locally and internationally,[20,32,35,36] there are now Australasian guidelines to streamline the management of bronchiolitis.[16] In this regional hospital, in the setting of geographical isolation and staffed by medical personnel of varying clinical experience, many non-evidence-based interventions were performed out of routine and as a precautionary measure.

This study highlights the need for targeted strategies to minimise interventions in managing bronchiolitis in this setting. These include the provision of education regarding the natural history and management of bronchiolitis, as well as the implementation of an evidence based, bronchiolitis specific clinical practice guideline in this hospital, with interval re-evaluation of clinical care. Further consideration should also be made regarding the rationalisation of the hospital admission process and provision of hospital in the home support to minimise hospitalisations in this group of patients.

LIMITATIONS

As this was a retrospective study, data was collected based on documentation in the medical records. As such, it was not completely possible to differentiate the location the intervention was performed on all occasions. In addition, the time of intervention commencement was noted, but not the time of intervention cessation. Hence,

duration of interventions such as steroid or antibiotic administration was not recorded. A small possibility of incorrectly documented ICD classification could have affected the number of admissions.

ACKNOWLEDGEMENT

This study received financial support from the Research Ready Grant Program (RRGP) 2018, a collaboration between Central Queensland Hospital and Health Service (CQHHS), Central Queensland University (CQU) and the University of Queensland (UQ), Australia. We would like to acknowledge Ms Colleen Souifi for her contribution to the data collection and Dr Margaret Harris for her overall contribution to this manuscript.

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