RESEARCH ARTICLES

Decreasing the length of stay for term babies requiring respiratory support: A quality improvement project

AUTHORS

KARINA CLARK BSN[1]
AMANDA BATES BSN, MCP[1]
RENEE MUIRHEAD RN, RM, MN (Advanced Practice)[1]
ANGELA SANT RN, RM, DipEd[1]
PAUL WOODGATE MBBS, FRACP, MClinEpid[1]
LUKE JARDINE MBBS, FRACP, MClinEpid, PhD[1,2]

1. Neonatal Critical Care Unit, Mater Mothers' Hospital, South Brisbane, Queensland, Australia, 4101.
2. Mater School of Clinical Medicine, The University of Queensland, South Brisbane, Queensland, Australia, 4067.

CORRESPONDING AUTHOR

LUKE JARDINE Neonatal Critical Care Unit, Mater Mothers' Hospital, Raymond Terrace, South Brisbane, Queensland, Australia 4101. E: Luke.Jardine@mater.org.au

ABSTRACT

Objective: To decrease the mean length of stay in the neonatal intensive care unit (NICU) for term infants requiring less than 24 hours of continuous positive airway pressure (CPAP).

Background: Term infants with respiratory distress are frequently admitted to the NICU for non-invasive respiratory support with CPAP. The most common cause of respiratory distress in term babies is transient tachypnoea of the newborn (TTN). In term infants with mild to moderate cases of TTN, symptoms typically resolve within 24 hours. However, we observed that many term infants who were admitted with respiratory distress had prolonged admissions to NICU, even after their respiratory distress had resolved.

Study design and methods: Quality improvement methodology was used to undertake this study. We used the Evidence-Based Practice for Improving Quality (EPIQ) framework to conduct a single plan-do-study-act (PDSA) cycle. The principal change idea was developing and implementing a new guideline incorporating a nurse-led decision-making model of care. We chose outcome, process, and balancing measures to determine the risks and benefits of implementing this guideline. Periods pre- and post-implementation of the guideline were selected for comparison.

Results: A total of 69 term infants who required less than 24 hours of CPAP were included in the study (30 pre- and 39 post-). The mean length of stay in NICU significantly decreased from 21.4 to 14.0 hours ($p<0.001$). There were statistically significant decreases in the commencement of intravenous glucose infusions (83.3% to 23.1%, $p<0.001$), the time to enteral milk feed (8.0 to 2.4 hours, $p<0.001$), and the time to first suck feed (13.1 to 9.7 hours, $p = 0.003$). No differences in other project measures were found.

Conclusions: This quality improvement project implemented a guideline that enabled nurse-led decision-making, significantly decreasing the length of stay in the NICU and the use of intravenous glucose infusions. There was no evidence of any adverse outcomes with this approach.

Implications for research, policy and practice: This quality improvement project demonstrated significant benefits after introducing a new guideline that facilitated a nurse-led decision-making model to assist in caring for term babies with respiratory distress treated with CPAP. More research is required to determine whether the observed benefits are maintained over time and if additional PDSA cycles would lead to further improvements. Future studies should consider additional outcome measures such as parental satisfaction and financial costs.

What is already known about this topic

- Term babies with respiratory distress are commonly managed in the neonatal intensive care unit (NICU) with continuous positive airway pressure (CPAP).
- The most common cause of respiratory distress in term babies is transient tachypnoea of the newborn (TTN). Most term babies with mild to moderate TTN require less than 24 hours of CPAP before their respiratory distress resolves.
- NICU admission causes parental stress, may negatively impact parental bonding, and can delay breastfeeding initiation.

What this paper adds

- Nurse-led decision-making guidelines can decrease the length of stay in neonatal intensive care for term babies requiring less than 24 hours of CPAP.
- Nurse-led decision-making guidelines can decrease the time to first enteral feed, decrease the time to first suck feed, and reduce the administration of intravenous glucose infusions for term babies requiring less than 24 hours of CPAP.
- Undertaking a quality improvement project using the EPIQ 10-step framework can significantly improve patient and family outcomes within the NICU.

Keywords: Quality improvement, Term infant, Respiratory distress, Nurse-led

OBJECTIVE

To decrease the mean length of stay in the neonatal intensive care unit (NICU) for term infants requiring less than 24 hours of continuous positive airway pressure (CPAP).

BACKGROUND

Respiratory distress occurs in up to seven per cent of infants born at term.[1] There is an extensive list of possible causes of respiratory distress, including transient tachypnoea of the newborn (TTN), surfactant deficiency, air leak syndromes, infection, aspiration syndromes, congenital anomalies of the lungs/airways/heart, genetic abnormalities, metabolic conditions, and neurological conditions.[1,2] The most common cause of respiratory distress is TTN, which is caused by the delayed reabsorption and clearance of alveolar fluid, making the lung less compliant.[3] Most infants with mild to moderate TTN have a resolution of their symptoms within 12 to 24 hours.[3] Continuous positive airway pressure (CPAP) is often used to treat TTN; the proposed benefit is that it helps to overcome poor lung compliance by holding the airway open, maintaining functional residual capacity. CPAP may also promote the reabsorption of alveolar lung fluid.[4] Anecdotally, we observed that many term infants who were treated with CPAP for TTN had prolonged lengths of stay in our Neonatal Intensive Care Unit (NICU). A preliminary audit of 10 consecutive admissions of term infants who were commenced on CPAP revealed that the mean length of stay in our NICU was 20.6 hours. Neonatal Intensive Care admission causes considerable stress for parents, may negatively impact parental attachment and can delay breastfeeding initiation.[5]

The Mater Mothers' Hospital NICU is a 79-bed (47 intensive care, 32 special care) quaternary neonatal unit located in South Brisbane, Queensland, Australia. In our neonatal unit, the standard practice for term infants with mild to moderate respiratory distress is to commence CPAP at a pressure of eight cm of water. Before undertaking this project, if the bedside nurse assessed that the respiratory distress had resolved, they would need to contact a medical officer or nurse practitioner to review the patient and decide if the CPAP could be ceased. Our preliminary audit noted variations in how clinicians ordered the CPAP to be ceased. Some clinicians would first decrease the CPAP to a lower level (e.g., five to six cm), whereas others preferred to stop treatment at eight cm. Variations in the initiation of intravenous (IV) glucose infusions, the commencement of enteral feeds, the choice of expressed breast milk (EBM)/or formula (after parental consent), and the duration of observation in the NICU post-cessation of CPAP were also noted. Some clinicians would defer the transfer of an infant back to their mother in the postnatal ward until two successive suck feeds had been successful. Unit policy for infants admitted with respiratory distress requires six-hourly blood glucose monitoring for the first 24 hours. The unit policy does not allow any infant on CPAP to attempt breast or bottle feeding; however, gastric tube feeding with either EBM or formula can be commenced in babies with respiratory distress. Many clinicians routinely ordered intravenous glucose infusions and did not start enteral nutrition until signs and symptoms of respiratory distress resolved. Some clinicians would start early enteral feeding via a gastric tube and only commence intravenous fluids if the infant

was hypoglycaemic. After the preliminary audit, variation in clinical practices was most likely the predominant contributing factor to the prolonged length of stay.

Quality improvement (QI) has been suggested as one of the leading reasons for improved outcomes in Neonatal Intensive Care.[6] There is no universal definition of QI.[7] One definition is "A deliberate, systematic activity that engages people in planning, implementing change and measuring outcomes".[8] Quality improvement has its own distinct science and methodology that incorporates cycles of information gathering, collaboration in determining and implementing suggestions for improvement, and monitoring the results of the implemented changes. The Evidence-based Practice for Improving Quality (EPIQ) workshop was developed by the Canadian Neonatal Network and incorporates plan-do-study-act (PDSA) cycles and numerous other accepted educational concepts and tools into its QI methodology.[8] The EPIQ workshop is a four to six-hour course that uses an easy-to-follow 10-step program, enabling participants to work in teams whilst acquiring the basic skills and knowledge in QI.[8] The project team included one master EPIQ facilitator and two accredited EPIQ facilitators. Therefore, a QI project was undertaken using the EPIQ methodology to decrease the length of NICU stay by four hours (approximately 20%) for term infants with respiratory distress who require less than 24 hours of CPAP. The aim was to achieve this reduction within six months.

STUDY DESIGN AND METHODS

A single PDSA cycle was conducted using the tools and processes taught in the Evidenced-based Practice for Improving Quality (EPIQ) workshop.[8] The SQUIRE 2.0 guidelines for reporting quality improvement projects were utilised for this study, and the relevant components of their 18-point checklist were incorporated into this QI project.[9]

The underlying problem was the perceived unnecessary duration of NICU admission for a term infant with respiratory distress who required less than 24 hours of CPAP. The project team comprised neonatal nurses, clinical nurse consultants, nurse educators, managers, and neonatologists. The team first met to discuss this project in March 2021.

The team developed a process map to outline the current admission and discharge processes for term infants commenced on CPAP for respiratory distress. Possible factors contributing to increased length of stay were brainstormed and change ideas addressing the identified factors were incorporated into a Driver diagram (see Figure 1).

Three potential change ideas most likely to have the highest impact were discussed using the EPIQ feasibility tool.[8] The project team ultimately chose "Develop guideline which facilitates nurse-led decision-making" (see Figure 1) as the principal change idea to implement. This change would predominantly remove the bedside nurse needing the baby reviewed by a medical officer or neonatal nurse practitioner before CPAP could be ceased. The guideline was intended to provide a straightforward decision-making algorithm that would empower bedside nurses to make clinical decisions in the best interest of their patients. Before deciding on the change idea, the team worked through the guidelines' components, focusing on steps to facilitate nurse-led decision-making. The guideline underwent several revisions by the project team. Attempts were initially made to incorporate a feeding pathway; ultimately, these attempts were dropped, and we referred to our existing hypoglycaemia and enteral nutrition guidelines. The project team's final version was sent for wider review by NICU staff and approval per the standard hospital policy. After review, the gestational age to which the guideline would be applied was lowered from 37 to 35 weeks to ensure consistency with other pre-existing hospital guidelines. Despite this change to the guideline, the project team elected to continue with their pre-determined 37-week cut-off for data collection to exclude the possible confounder of prematurity increasing the length of stay. The approved guideline is provided in Appendix 1.

Determining how to measure the effectiveness of a QI project is an essential step in the project.[8] The outcome, balancing, and process measures to assess the benefits, risks, and compliance with the implemented change idea (see Table 1) were pre-determined before introducing the guideline into clinical care. Several team members expressed concerns that not starting IV glucose infusions may increase the number of infants experiencing an episode of hypoglycaemia; therefore, a decision was made to include this as a balancing measure. Another concern was that following our existing hypoglycaemia pathway would increase the amount of formula use and inadvertently lead to a decrease in breastfeeding rates because there would be less need for breast milk. Therefore, we also included the number of infants exclusively formula feeding at discharge as a balancing measure. We thought early infant discharge from

TABLE 1. PRE-DETERMINED OUTCOME, PROCESS AND BALANCING MEASURES

Outcome measures	Process measures	Balancing measures
Total time in NICU (hours)	Number (percentage) of infants receiving IV glucose infusions	Number (percentage) of infants with hypoglycaemia (blood glucose level <2.6 mmol/L) during NICU admission
Time in NICU on CPAP (hours)	Time to first enteral feed (hours)	Maternal length of stay (hours)
Time in NICU post-cessation of CPAP (hours)	Time to first suck feed (hours)	Number (percentage) of infants exclusively formula feeding on discharge from hospital

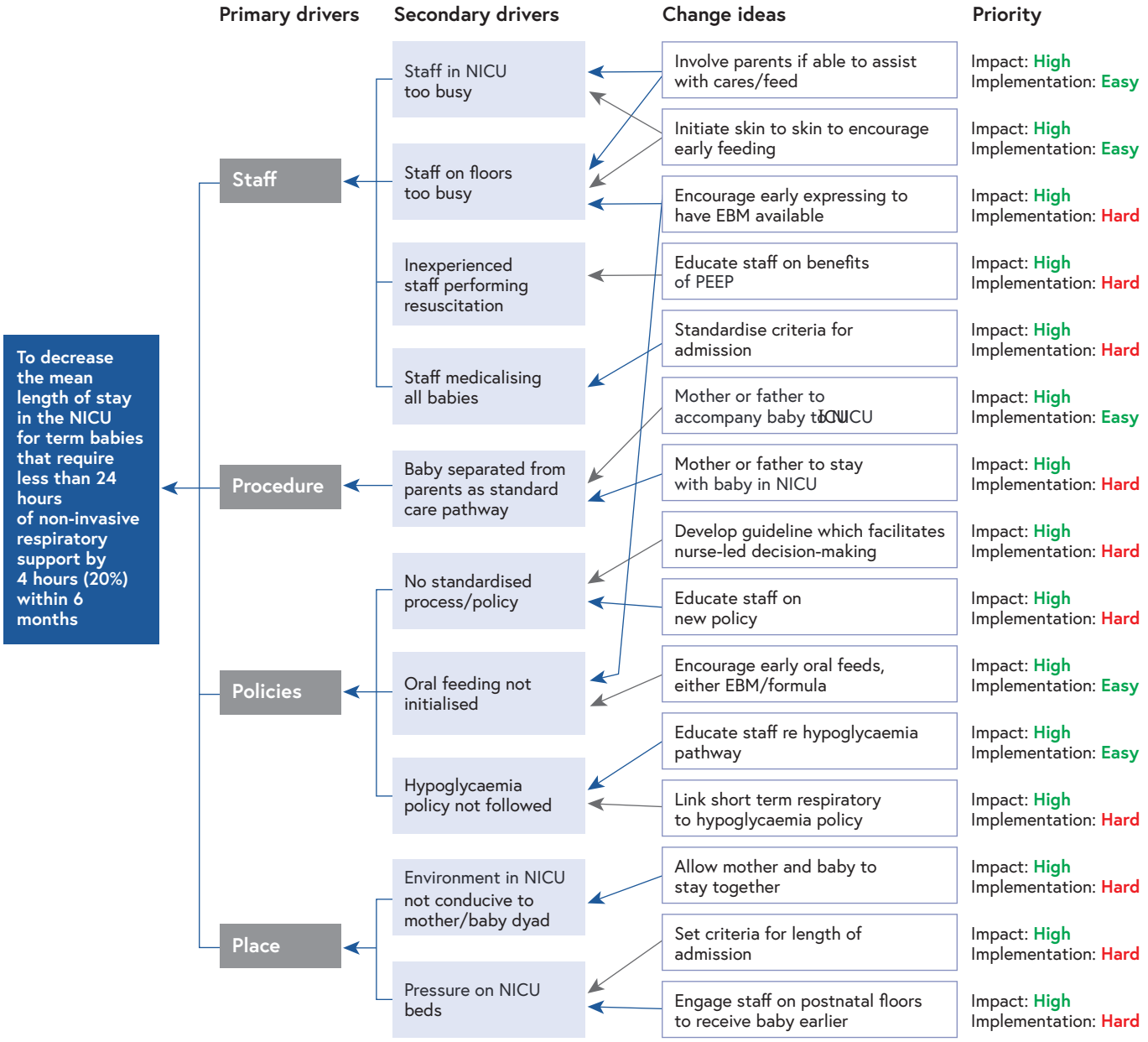

FIGURE 1. DRIVER DIAGRAM

the NICU may also facilitate earlier maternal discharge from the hospital and included this as a balancing measure.

Other collected demographic data included gestational age at birth, mode of delivery, birth weight, and gender. We planned to compare results for two cohorts (pre- and post-implementation of the guideline). All term infants admitted to the NICU who had respiratory distress and were commenced on CPAP were eligible for inclusion. Subsequently, we excluded term infants who received more than 24 hours of CPAP because of the increased likelihood that they might have had another cause of respiratory distress other than TTN. Data were extracted from our neonatal database. Missing data were obtained by directly searching individual patient records. Critical milestones for the project are summarised in Table 2.

TABLE 2. PROJECT MILESTONES

Milestone	Date
First meeting	17/03/2021
Process Mapping completed	28/04/2021
Driver Diagram completed	11/05/2021
Change idea determined	26/05/2021
Guideline developed and sent for approval	27/10/2021
Guideline approved	03/11/2021
"Non-invasive respiratory support (short term) for babies born greater than 35 weeks – work instruction" released.	15/11/2021

This study met the requirements of the National Health and Medical Research Council's Ethical Considerations in Quality Assurance and Evaluation Activities 2014.[10] This study was reviewed by the Mater Human Research Ethics Committee (HREC) and given an exemption. Informed consent was not required.

STATISTICAL METHODS

Summary statistics for normally distributed data are reported as means and standard deviation (SD). Summary statistics for categorical data are reported as numbers and percentages. Paired Student t-tests assessed comparisons between groups for normally distributed data. The Mann-Whitney U test was used to assess comparisons between groups for non-parametric data. Categorical data were compared for statistically significant differences using the Kruskal-Wallis test. All statistical tests were done using Addinsoft (2023) XLSTAT statistical and data analysis solution Boston, USA.[11] We chose to present the primary outcome (length of stay in NICU) in a control chart. A control chart is a graphical display of individual results over time; it is essentially a run chart that incorporates statistical measures, such as control limits, to identify data variability visually. We defined our upper and lower control limits as three standard deviations above or below the mean. The control chart was developed using QI Macros for Excel (2023).[12]

RESULTS

Pre-implementation data were retrospectively collected on consecutive patients from January 1st to February 22nd, 2021. Post-implementation data were retrospectively collected on consecutive patients from November 22nd, 2021, to February 6th, 2022. Patient demographics for each cohort were similar, with no statistically significant differences found between groups (see Table 3).

The primary outcome measure was the total length of stay in NICU; this significantly decreased from a mean of 21.4 hours to 14.0 hours ($p<0.001$) (see Table 4). The total length of stay in the NICU was divided into the time spent on CPAP and the time off CPAP. As demonstrated in Table 4, there was no statistical difference in how long an infant needed CPAP, with the reduced length of stay being due to a significant decrease in the time spent post-cessation of CPAP in the NICU. A control chart for the total length of NICU stay pre- and post-implementation of the guideline is presented in Figure 2.

After implementing the guideline, the mean length of stay decreased, and the control chart's upper and lower control limits narrowed. The narrowing of the control limits signifies less variability in the individual data points and implies more consistent management practices in the post-implementation period.

TABLE 3. PATIENT DEMOGRAPHICS

Demographic	Measurement	Pre-implementation (*N* = 30)	Post- implementation (*N* = 39)	*p*-value
Gestational age at birth (weeks)	Mean (SD)	39.3 (1.3)	38.8 (1.09)	0.20†
Birth weight (grams)	Mean (SD)	3437 (466)	3379 (376)	0.57*
Spontaneous vaginal delivery	N (%)	13 (43.3%)	23 (59.0%)	0.20#
Male gender	N (%)	11 (36.7%)	16 (41.0%)	0.72#

N = number, % = percentage, SD = Standard Deviation, † = Mann-Whitney U, * = Student's t-test, # = Kruskal-Wallis

TABLE 4. PROJECT MEASURES RESULTS

Project measure	Measurement	Pre-implementation (*N* = 30)	Post- implementation (*N* = 39)	*p*-value
Total time in NICU (hours)	Mean (SD)	21.4 (10.6)	14.0 (12.6)	<0.001†
Time in NICU on CPAP (hours)	Mean (SD)	8.5 (6.1)	6.7 (5.3)	0.17†
Time in NICU post-cessation of CPAP (hours)	Mean (SD)	12.9 (9.5)	7.3 (11.6)	<0.001†
Received IV glucose	N (%)	25 (83.3%)	9 (23.1%)	<0.001#
Time to first enteral feed (hours)	Mean (SD)	8.0 (7.1)	2.4 (2.3)	<0.001†
Time to first suck feed (hours)	Mean (SD)	13.1 (8.5)	9.7 (11.9)	0.003†
Hypoglycaemia	N (%)	4 (13.3%)	2 (5.1%)	0.23#
Formula only on discharge	N (%)	2 (6.7%)	3 (7.7)	0.87#
Maternal length of stay (hours)	Mean (SD)	73.3 (25.3)	72.4 (37.4)	0.33†

N = number, NICU = Neonatal Intensive Care Unit, CPAP = Continuous Positive Airway Pressure, SD = Standard Deviation, IV = intravenous, † = Mann-Whitney U, * = Student's t-test, # = Kruskal-Wallis

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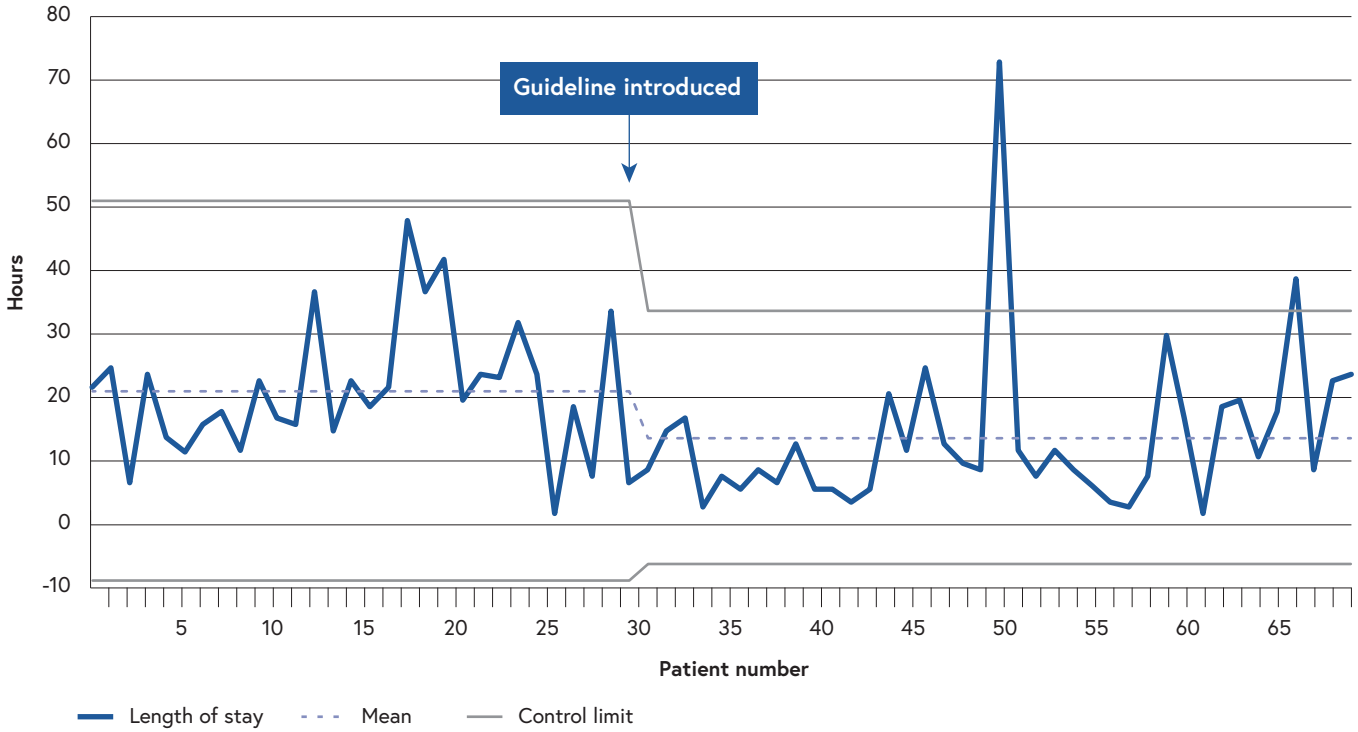

FIGURE 2. CONTROL CHART: LENGTH OF STAY IN NEONATAL INTENSIVE CARE UNIT

The control chart clearly demonstrates an outlier above the upper control limit in the post-implementation guideline group (see Figure 2). This patient stayed for an additional 73 hours in the NICU after their CPAP was ceased. Excluding this patient from analysis (assuming there was another reason for the prolonged length of stay besides respiratory distress) further reduces the mean total length of stay in NICU to 12.5 hours (a decrease of almost 9 hours).

In the pre-implementation period, 83.3% of infants were commenced on IV glucose infusions, as opposed to a statistically significant reduction of 23.1% in the post-implementation period ($p<0.001$) (see Table 4). The new guideline advised clinicians to follow the pre-existing hypoglycaemia policy (see Appendix 1). The hypoglycaemia policy incorporates several measures that should be attempted (e.g. breastfeeding, glucose gel, complementary feed with formula) before recommending that an IV glucose infusion be commenced. Statistically significant reductions were found in the number of infants receiving IV glucose infusions ($p<0.001$) as well as the time to first enteral feed ($p<0.001$) and the time to first suck feed ($p = 0.003$) in the post-implementation group (see Table 4). Reassuringly, no significant differences in the number of babies having hypoglycaemic episodes or being discharged on exclusive formula feeding were observed between the groups (see Table 4). Another potential benefit identified was a possible decrease in the maternal length of stay; however, no significant change was observed (see Table 4).

DISCUSSION

This single-cycle QI project demonstrated that the introduction of a guideline which facilitated nurse-led decision-making led to a significant reduction in the NICU length of stay post-cessation of CPAP for term infants who required less than 24 hours of non-invasive respiratory support. Nurse-led, protocolised decision-making for adjusting mechanical ventilation has been reported in paediatric and adult intensive care; however, we could not identify comparable studies conducted in NICU to compare our findings with.[13-15] Nurse-led decision making for cessation of CPAP within the NICU has not been reported. However, there are several other clinical scenarios in which Nurse-led decision making can be successful, including newborn resuscitation, breastfeeding, infant follow-up, and pain management.[16-19] There is growing evidence for using QI projects to improve patient outcomes within NICU.[20-25] We aimed to reduce the mean length of stay by four hours but achieved a seven-hour reduction. The guideline (see Appendix 1) stated that patients could be discharged to the postnatal ward if they remained stable off respiratory support for at least one hour. However, the mean duration of stay post-cessation of CPAP was still 7.3 hours, and there was a wide variation (standard deviation of 11.6 hours). A limitation of this study is that individual cases were not audited to determine why infants stayed in the NICU after the cessation of their respiratory support. The underlying causes of the respiratory distress and/or additional co-morbidities could increase the length of stay. In an attempt

to control the underlying cause of the respiratory distress and target those babies with presumed TTN, we chose to only include term infants who needed less than 24 hours of CPAP in our study. However, other causes of respiratory distress may resolve within 24 hours, and it is known that in severe cases of TTN, symptoms can take up to 72 hours to resolve.[3] Arguably, this may also be a strength of the study in that the implementation of this guideline resulted in a decreased length of stay, irrespective of the underlying cause of respiratory distress. Unfortunately, data were not collected on how many term infants were tried off CPAP but subsequently failed, or on the total number of attempts at ceasing CPAP on each baby.

Whilst the length of stay post-cessation of CPAP was significantly shorter ($p<0.001$), the overall maternal length of stay was similar between the groups. The standard deviation for the maternal length of stay in both pre- and post-implementation groups is large (see Table 4). A limitation of this project is that the mothers' charts were not audited to examine factors that may have contributed to their overall length of stay. There was a notable difference in spontaneous vaginal delivery (SVD) rate between groups (43.3% in the pre-implementation versus 59% in the post-); however, this did not reach statistical significance. It would be expected that mother's post-caesarean section would require a more extended stay; therefore, the pre-implementation group would have a longer mean length of stay. Despite not impacting the maternal length of stay, implementation of this guideline resulted in a significantly shorter total duration of NICU admission ($p<0.001$). This may have the additional benefit of improving parental-infant bonding and parent satisfaction; however, no attempt was made to collect data on these critical outcomes. While a cost-benefit analysis was not undertaken, the decreased overall length of stay of the infant in the NICU may have implications for nursing workforce-related expenditure in the future.

The initial aim was to complete this project within six months; however, it took approximately eight months from the first meeting to the final version of the guideline being released (see Table 2). Despite not meeting the original timeline, this was a notable achievement given the COVID-19 pandemic, which compromised the NICU workforce and ability to undertake research during that time.

Due to the study design incorporating pre- and post-implementation cohorts, a limitation of this study is that it is impossible to determine if any other practice changes (apart from the implemented guideline) may have impacted upon the results. Another limitation of this project is that only one PDSA cycle was completed. Due to the success of this single cycle and other clinical priorities, quality improvement work within the unit changed focus. There is a plan to re-audit in the future to see if the benefits have been maintained and determine if further change ideas and PDSA cycles need implementation (see Figure 1).

A particular strength of the study was the collaboration of a motivated multidisciplinary team that consisted of clinicians, educators, and administrators. Using a structured and systematic approach incorporating the ten steps taught in the EPIQ course developed a change idea that was explicitly targeted towards our environment. It has previously been demonstrated that using change guidelines from another unit is ineffective for improving outcomes compared to undertaking a quality improvement project within that particular service.[26] Undertaking the same QI project in a different clinical environment may result in entirely different change ideas, project measures and results. This is one of the significant benefits of this methodology, resulting in solutions considered most appropriate for the setting undertaking the QI project. However, it is also one of the limitations in that the results of our project will not be generalisable to other settings.

CONCLUSIONS

This quality improvement project led to a significantly decreased length of stay in the NICU ($p<0.001$). Additionally, there were significant decreases in the number of babies being commenced on intravenous glucose infusions ($p<0.001$), the time to initiation of first enteral feed ($p<0.001$), and the time to first suck feed ($p = 0.003$). Notably, there was no associated increase in the incidence of infants having episodes of hypoglycaemia and no increase in the number of infants being exclusively formula-fed on discharge. Implementing this guideline has increased the opportunity for infant-parent bonding by enabling earlier discharge from the NICU.

IMPLICATIONS FOR RESEARCH, POLICY AND PRACTICE

This project highlights the significant benefits of nurse-led decision-making models of care. More research is required to determine whether the observed benefits are maintained over time and if further PDSA cycles would lead to further improvements. Future studies should consider outcome measures such as parental satisfaction and financial costs.

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