QUALITY IMPROVEMENT ARTICLE

Quality improvement initiative to impact Golden Hour timeliness using a dedicated delivery team

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OBJECTIVE: Golden Hour (GH) care impacts immediate and long-term outcomes for premature infants. We hypothesized that creation of a dedicated delivery team, the Stork Team, would improve delivery of GH care.
METHODS: A GH quality improvement initiative was created for infants born at <32 weeks and implemented in July 2018. Data were collected from GH checklists and the electronic medical record.
RESULTS: Following Stork Team implementation there was special cause variation noted in the minute of life (MOL) for administration of dextrose containing fluids and antibiotics. Dextrose containing fluid time improved from 111 to 67 MOL, with an increase in the percentage of patients receiving fluids by 60 MOL. Antibiotic administration improved from 180 to 82.5 MOL. GH checklist completion increased from 77% to 98% and time to isolette closure improved from 88 to 62 MOL.
CONCLUSION: Implementation of the Stork Team was associated with improvements in timeliness of GH care.

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INTRODUCTION

Problem description

The Golden Hour (GH) refers to the first 60 min in a preterm infant's life, a critical time period that impacts immediate and long-term outcomes. Typical components of the GH include providing appropriate respiratory support, maintenance of euthermia, establishing intravenous access, initiation of dextrose containing fluids, and antibiotic administration if indicated [1–3]. Successful GH care is a challenging endeavor as many inter-dependent factors contribute to each component and overall GH completion relies on cohesive teamwork for success.

Available knowledge

Appropriate and timely care for preterm infants in the minutes to hours following delivery can have both short and long-term impacts. Abnormal admission temperature has been associated with mortality and major neonatal morbidities [4], and delay in initiation of dextrose containing fluids increases the risk for hypoglycemia. Improving consistency and quality of care delivered in the first hour of life through GH protocols and quality improvement (QI) initiatives can improve the incidence of euthermia on Neonatal Intensive Care Unit (NICU) admission [5–7], decrease rates of hypoglycemia [6, 7] and improve timeliness in fluid and amino acid initiation [6, 8]. Studies have also demonstrated potential impacts on long-term neonatal outcomes following creation of GH initiatives, such as decreased odds of chronic lung disease [5, 9], decreased rates of intraventricular hemorrhage [10], decreased odds of retinopathy of prematurity [5], and decreased rates of late onset sepsis [9]. The benefits demonstrated for both immediate and long-term outcomes highlight the importance of targeted intervention to ensure timely stabilization of premature infants in the first hour of life.

Rationale

A GH QI initiative was implemented in July 2018 for infants born at less than 32 weeks gestation at our academic level III delivery hospital to target improvement in surfactant administration, thermoregulation, and timeliness for initiating fluids and antibiotics, when indicated. Initial Plan-Do-Study Act (PDSA) cycles brought significant and sustained improvements in delivery room surfactant administration (when indicated), but significant improvements were not seen with other GH aims. By early 2020, roughly 18 months following GH project initiation, the majority of infants born at less than 32 weeks still did not have successful completion of most GH tasks prior to sixty minutes of life.

Other institutions have shown improvement in GH care through interventions focusing on improving resuscitation team communication and clearly defined team member roles and responsibilities [1, 5, 6]. We hypothesized that the creation of a dedicated delivery room team would improve team dynamics within the delivery room (DR) and on NICU admission which would lead to improved consistency and timeliness of GH care.

Specific aims

We aimed to improve the minute of life (MOL) that dextrose containing fluids were initiated by 20%, by decreasing from 110 to 88 MOL within six months of implementing the dedicated delivery team. Secondary aims included improving MOL that antibiotics were initiated (when indicated), increasing the percentage of euthermic (36.5 °C to 37.5 °C) infants in the DR from 75% to 80%, and increasing completion of GH checklists from 77% to 100% within 6 months. These aims were chosen based on previously established project aims with the ultimate goal of completing all

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tasks by 60 MOL and maintaining euthermia in the DR and throughout the first hour of life.

METHODS

Context

This QI project took place at a level III neonatal intensive care unit at an academic health center. Defined by the Indiana Perinatal Hospital Standards, a neonatal level III facility has the ability to provide acute and comprehensive NICU care for infants born at less than 32 weeks gestational age or less than 1500 g at birth or have medical or surgical conditions regardless of gestational age [11]. This NICU is staffed by neonatologists, neonatal-perinatal medicine fellows, pediatric and combined internal medicine-pediatrics residents, neonatal advanced practice providers (APP) and medical students as well as NICU nurses and respiratory therapists.

From 2017 through late 2021 all GH deliveries occurred at our level III NICU located within the adult hospital. This unit was an open bay NICU organized into three modules. On November 7, 2021, a new, private room level III NICU was opened within our free-standing children's hospital. Admitted NICU, labor and delivery, and post-partum patients were transferred to this new facility on the opening date, and all subsequent deliveries occurred at this new facility. In anticipation of the move to this new unit, there was a change to in-house attending neonatologist coverage in September of 2021 from a previous home-call system. During the home-call system, the attending neonatologist was not present in the hospital overnight from 5 p.m. to 7 a.m. but would come into the unit for deliveries of infants at <28 weeks gestation, those with complex congenital anomalies, or other acute clinical concerns.

Initial QI efforts aimed at GH metrics in these infants began in July 2018. Baseline data was obtained via chart review back to 2017. Prospective data was collected from July 2018 to July 2019. During this time period, PDSA cycles focused on utilizing a checklist for GH admissions, streamlining umbilical access by educating providers, moving dextrose containing IV fluids to an in-unit pyxis system, and instilling surfactant in the DR for those infants born at less than 28 weeks that were intubated in the DR. After a turnover in project leadership, the GH project was revisited in early 2020 with project aims revised and renewed emphasis given to this study population. The Institute for Healthcare Improvement (IHI) Model for Improvement was used to design and evaluate subsequent interventions [12].

Intervention(s)

A dedicated delivery room team, the Stork Team, was created in February of 2020. This team is comprised of 11 day shift and 10 night shift nurses as well as dedicated respiratory therapists, APPs, neonatal-perinatal medicine fellows, and neonatologists. Prior to the creation of the Stork Team, all but 8 out of a pool of approximately 100 nurses would attend deliveries on a rotating basis. After Stork Team creation, members of the Stork Team were present at all deliveries. Stork Team providers were selected by a team of unit leadership after applying and interviewing for the positions. During Stork Team development, a multidisciplinary stakeholder group evaluated Stork Team impacts on GH care. Due to poor compliance with GH checklist completion and identified need for additional assistance at bedside on admission of GH patients from the DR, these tasks were integrated into the expectations for Stork Team nurses. The Stork Team nurse was made responsible for assisting the admission nurse until all GH tasks were finished, including completion of the GH checklist. Those selected to join the Stork Team received additional training in DR management of high risk neonates which included biyearly simulation training days. During the first 2 years of the Stork Team, each of the simulation sessions featured a GH delivery scenario, which included a review of GH tips and the unit's most recent GH performance.

Prior to March 2020, providers placing umbilical lines would scrub out of the procedure following line securement but prior to connecting umbilical lines to fluids. The admission nurse would then don sterile gloves to connect the umbilical line to fluids. We suspected this was contributing to a delay in initiating dextrose containing fluids and antibiotics so we implemented a change in workflow in March 2020, where the providers placing the umbilical lines would remain sterile and connect the lines to fluids immediately following line securement.

In October 2020, we created GH order sets via the electronic medical record which included pre-selected STAT ordering of medications and fluids. Prior to the creation of these orders sets, the general NICU admission order set did not have any of the medications or fluids pre-selected and when they were selected required an additional step to change the priority to STAT from routine for each medication.

In February 2021, we compiled a set of GH tips for providers, including the recommendation for performing a delivery "pre-brief" to discuss anticipated orders with the care team, reminders to prompt nursing to obtain ampicillin from the pyxis during umbilical line placement, and the recommendation for immediate isolette top closure after fluid initiation.

Study of the intervention(s)

Patients born at <32 weeks gestation from January 1, 2017 through August 31, 2022 were included in the analysis. We divided these infants and analyzed their results in three distinct phases. Phase 1 included infants born in the baseline period from January 2017 through June 2018, prior to implementation of the GH project. Phase 2 infants were those born after GH initiation but prior to Stork Team creation, from July 2018 through January 2020. Phase 3 included infants born following Stork Team implementation in February 2020 through August 2022. Infants that did not survive the delivery room were not included in analysis. Additionally, after November 2021 there were a few infants with select, mainly surgical, congenital anomalies who were stabilized and then immediately admitted to the Level IV NICU in the children's hospital. These infants were also not included in the analysis. The GH Checklist (Supplementary Fig. 1) was filled out in real time by nursing providers. The medical record was reviewed for checklist verification and to obtain missing data points. GH data was analyzed monthly during the study time periods.

Measures

Primary outcome measures included MOL dextrose containing fluids were initiated, MOL antibiotics were initiated (when indicated), proportion of infants with hypoglycemia and proportion of euthermic infants in the delivery room. Dextrose containing fluid and antibiotic start times were noted on the GH checklist by the admission or Stork Team nurse and then converted to time in MOL during data collection. Blood glucose measurements were obtained during central line placement or at time of admission for infants who did not require central line placement. Hypoglycemia was defined as having a blood glucose level of <40 mg/dL. A subset of infants with hypoglycemia were treated with a 2 ml/kg bolus infusion of 10% dextrose solution. Decision to treat hypoglycemia was determined by the care team. The need for and timing of bolus dextrose treatment was noted on the GH checklist. Axillary temperatures were obtained prior to leaving the DR and on admission to the NICU. The goal temperature range was 36.5–37.5 °C and infants with temperatures in this range were classified as euthermic at that time point.

Process measures included GH checklist completion and time to isolette closure. Checklist completion was tracked by comparing unit admission data each month to checklists received to ensure each GH infant had a checklist completed. Time of isolette closure was recorded on the GH checklist as this metric is not recorded in the electronic medical record.

Analysis

Monthly data was evaluated initially via run charts with data subsequently analyzed using X-bar and S control charts. Baseline rates were determined from the time period prior to the GH project (January 2017 through June 2018). We used accepted rules for determining special cause variation in our control charts [13]. Process changes were noted when special cause variation was demonstrated (most commonly noted as 8 or more points below the center line), when the special cause variation could be explained by our interventions, and when this change was persistent over time. QIMacros add-in (KnowWare, Denver, CO) for Microsoft Excel was used to generate control charts, demonstrate process changes, and for statistical analysis tests.

Continuous data was analyzed using one-way analysis of variance (ANOVA) and categorical data was analyzed using chi-square tests. A p value of < 0.05 was considered statistically significant.

Study data were collected and managed using REDCap electronic data capture tools hosted at the Indiana Clinical and Translational Sciences Institute (Indiana CTSI) funded, in part by Grant Numbers UL1TR001108, KL2TR001106, or TL1TR001107 from the National Institutes of Health, National Center for Advancing Translational Sciences, Clinical and Translational Sciences Award and at the Indiana University Pervasive Technology Institute (https://pti.iu.edu/) which supports REDCap with IT infrastructure and consulting resources. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data

Table 1. Baseline characteristics.

	Phase 1[a] Pre-GH project	Phase 2[a] GH project started	Phase 3[a] Stork Team created
Total patients, *n*	181	178	314
Mean gestational age, week	28.25	28.19	28.46
Female, *n* (%)	94 (52%)	101 (57%)	146 (47%)
Day shift (7a-5p), *n* (%)	93 (51%)	79 (44%)	168 (53%)
Cesarean section, *n* (%)	131 (72%)	134 (75%)	235 (75%)

[a]Phase 1 occurred from January 1, 2017 to June 30, 2018; Phase 2 occurred from July 1, 2018 to February 15, 2021; Phase 3 occurred from February 16, 2021 to August 31, 2022.

downloads to common statistical packages; and (4) procedures for importing data from external sources [14].

Ethical considerations

The practices studied in this QI project were all previously established standard of care practices therefore posing no significant ethical concerns. This project was submitted to the Indiana University Institutional Review Board and deemed exempt.

RESULTS

There were 673 infants born at <32 weeks gestation in our NICU from January 1, 2017 to August 31, 2022. Phase 1 included 181 infants born prior to implementation of the GH project. Phase 2 included 178 infants born after GH initiation but prior to Stork Team creation, and phase 3 included 314 infants born following Stork Team implementation. Of note, there were no GH patients born in October 2019.

Baseline characteristics of the infants born across these time periods were similar with regards to gestational age, sex, time of delivery, and mode of delivery (Table 1). ANOVA and chi-square analysis revealed no statistical differences between or within these groups.

We found improvements in all primary outcome and process measures. Compliance with GH checklist completion improved from an average of 77 to 98% completion. There were improvements in timeliness to initiate dextrose containing fluids (Fig. 1) with special cause variation noted for the average time to start dextrose containing fluids corresponding with a process change occurring after Stork Team implementation which also included a narrowing of control limits. The average monthly start time for dextrose containing fluids improved from 111 MOL to 67 MOL following this process change. There was a statistically significant improvement in the percentage of patients receiving dextrose containing fluids by 60 MOL and a statistically significant decrease in patients with admission blood glucose <40 mg/dL in Phase 3 of this initiative (Table 2). There were no statistically significant differences in the rates of hypoglycemia treatment throughout the reported time periods. Time to antibiotic administration improved (Fig. 2) from an average of 180 MOL to 82.5 MOL with special cause variation noted following Stork Team implementation and associated interventions in early 2020.

There was an increase in the proportion of patients who were euthermic in the DR following Stork Team creation and additional interventions, although this was not statistically significant (Table 3). 78% of patients were euthermic in the DR in Phase 3, compared with 75% and 73% in Phase 1 and 2, respectively. The percentage of hypothermic patients remained stable throughout the three project periods, however, the percentage of hyperthermic (temperature 37.6 °C or higher) decreased following GH creation and remained low throughout the project. There was a statistically significant increase in the percentage of infants with recorded axillary DR temperatures throughout the project, with a recorded DR temperature present for 98% of patients in Phase 3 compared with only 60% of patients in Phase 1. Time to isolette closure improved from a median of 88 MOL prior to Stork Team implementation to a median of 62 MOL.

DISCUSSION

Summary

QI methodologies were used to impact Golden Hour care for preterm infants. Over the course of the project there were significant improvements in time to initiation of dextrose containing fluids, hypoglycemia on admission, and time to initiation of antibiotics, when applicable.

Interpretation

The largest and most sustained improvements occurred in the time period after the creation of the dedicated delivery team. There are several potential reasons why this occurred. The Stork Team decreased the potential pool of delivery room providers for high risk infants, increasing the individual team member's exposure to these cases both in the DR and upon admission. There was also an emphasis on establishing a core group of APPs and working towards continual APP coverage within this unit. Having a small, consistent pool of providers has made it easier to streamline the admitting practice for these infants, decrease variation, and more easily disseminate practice changes from subsequent PDSA cycles. Improvements in time to initiate dextrose containing fluids and to administer antibiotics showed a process change immediately following Stork Team implementation, with continued improvements and sustainment noted throughout the remainder of the project. We suspect these sustained improvements were related to continued interventions targeting GH care, including the creation of pre-checked admission order sets for GH patients in October 2020 and bi-yearly education for Stork Team members regarding GH care. We hypothesize that the dedicated and consistent group of providers caring for these patients allowed us to disseminate changes quickly and efficiently.

Despite significant improvements to the timeliness of initiation of dextrose containing fluids and stabilization with isolette top down, hypothermia and hypoglycemia requiring treatment remained a large concern for our population. As this level III delivery hospital services the academic health center, it is an obstetric and neonatal referral center. A large portion of our patients and their mothers have comorbidities, importantly including intrauterine growth restriction which puts infants at increased risk of both hypothermia and hypoglycemia after birth. We suspect the high rates of these comorbidities may have contributed to the lack of improvement in these measures. There was a significant increase in the percentage of GH patients with recorded DR temperatures, from 60% in the baseline period to 98% since Stork Team creation, so the true percentage of patients with an abnormal DR temperature in the baseline period is not known. We suspect that those patients missing DR temperatures may have had abnormal temperatures and that the rates of hypothermia may have been higher than recorded in the baseline period. Additionally, the decision to treat hypoglycemia is at the provider's discretion, creating variability in rates of hypoglycemia treatment. This variability may have made it challenging to detect whether a change existed in rates of hypoglycemia requiring treatment.

While other studies have shown improvement in GH aims following interventions targeting team dynamics in the DR, this

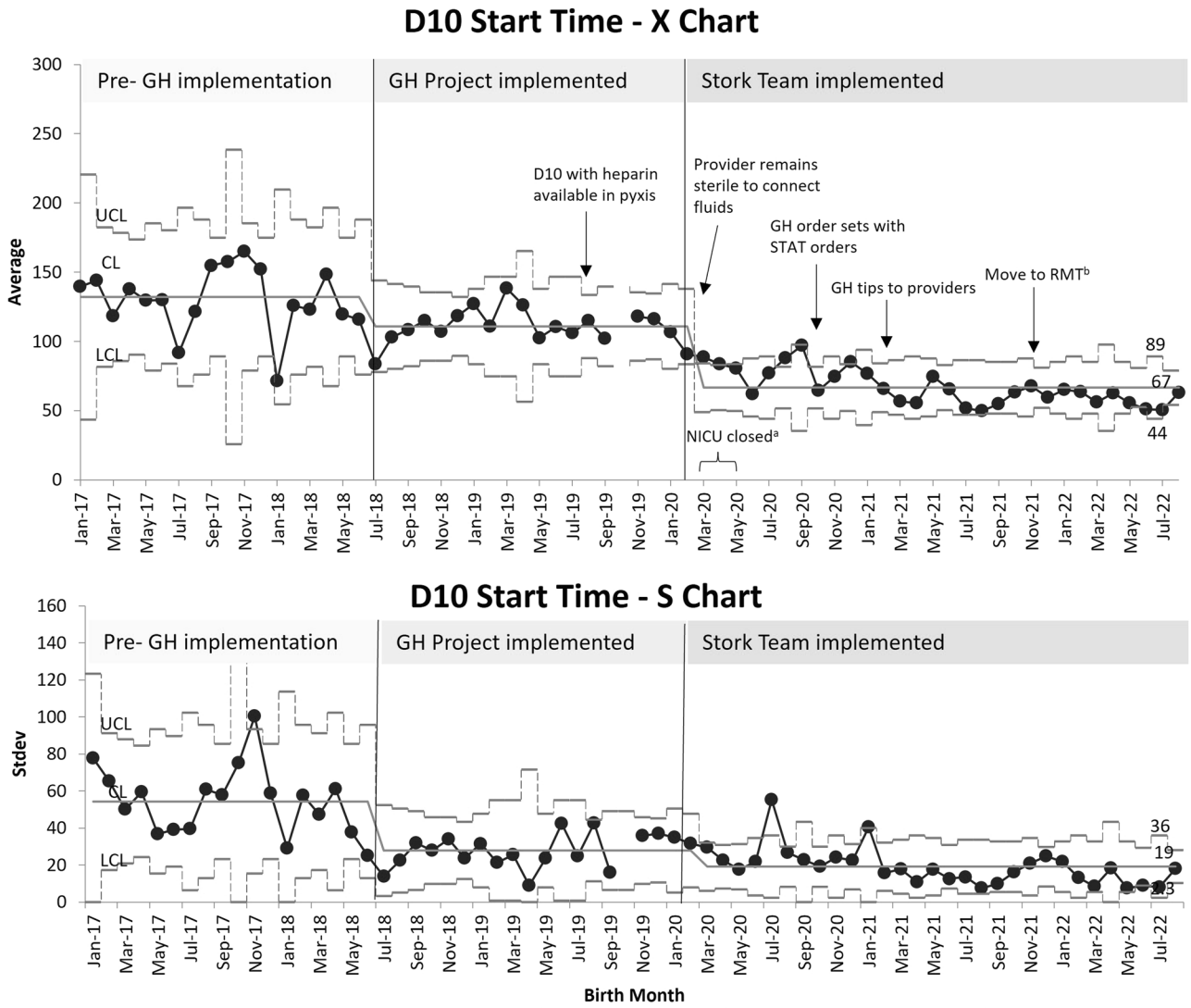

Fig. 1 X bar and S charts for MOL that dextrose containing fluids (D10) were initiated grouped by birth month and annotated with interventions. Time to start D10 decreased from 111 MOL to 67 MOL following Stork Team implementation. There were no GH patients in October 2019.

Table 2. Hypoglycemia results by project phase.

	Phase 1[a] Pre-GH project	Phase 2[a] GH project started	Phase 3[a] Stork Team created	*P* value
Total patients, *n*	181	178	314	–
D10 by 60 MOL, *n* (%)	16 (9%)	2 (1%)	167 (53%)	<0.001
Admit BG < 40, *n* (%)	72 (40%)	74 (43%)	71 (23%)	<0.001
D10 bolus, *n* (%)	54 (29%)	59 (33%)	78 (25%)	0.13

BG blood glucose, *D10* 10% dextrose solution, *MOL* minute of life.
[a]Phase 1 occurred from January 1, 2017 to June 30, 2018; Phase 2 occurred from July 1, 2018 to February 15, 2021; Phase 3 occurred from February 16, 2021 to August 31, 2022.

study is unique in highlighting the significant and sustained improvements following the creation of the Stork Team. One group found decreased compliance with GH interventions following the practice change from a dedicated delivery team to a large pool of delivery providers further highlighting the impact of a dedicated delivery team on GH aims [1]. Ongoing education efforts and feedback to providers on GH metrics likely contributed to the success of this project leading to a culture shift surrounding the preparation, resuscitation, and admission process for these infants.

Several other studies have demonstrated improvement in GH metrics such as initiation of dextrose containing fluids and

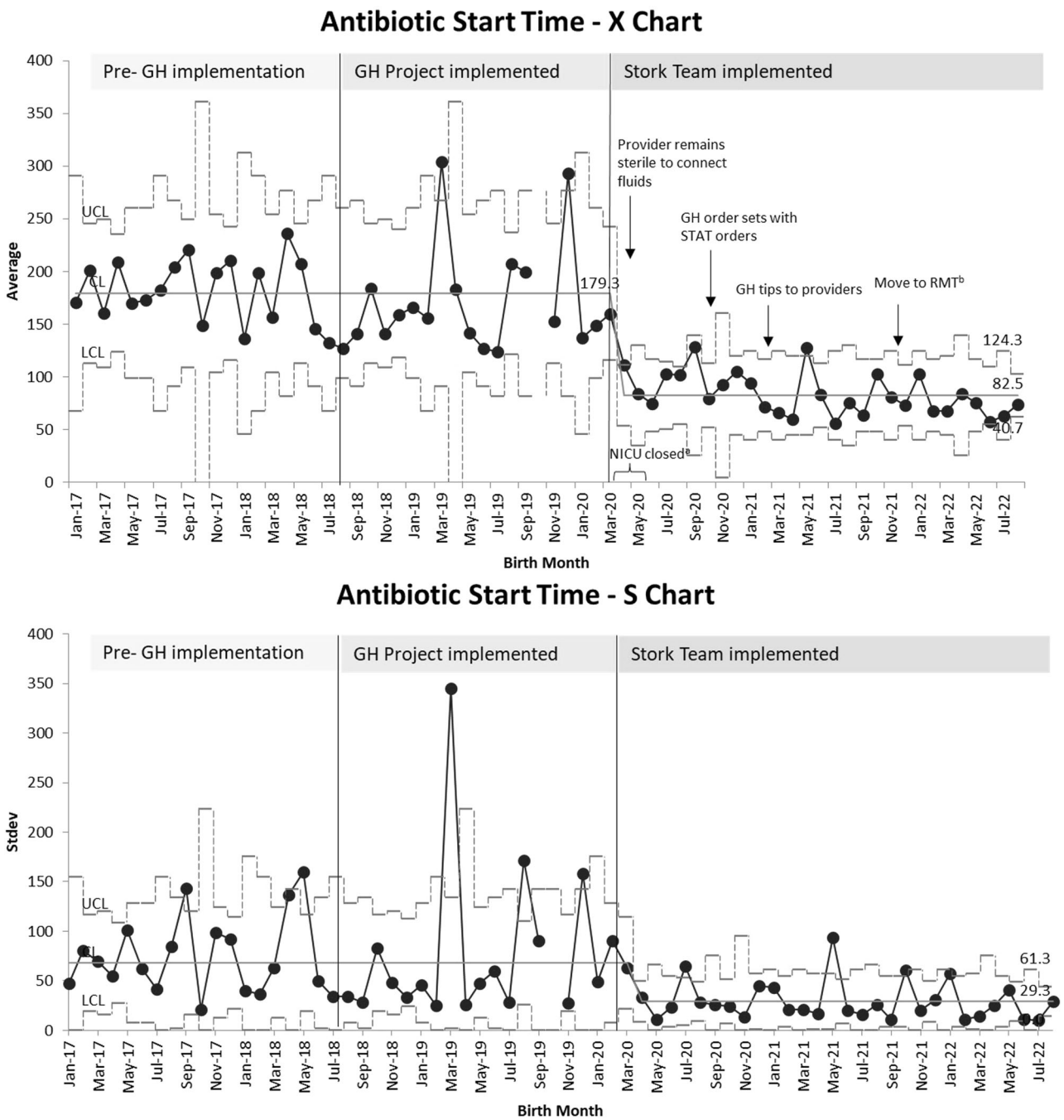

Fig. 2 X bar and S charts for the MOL that antibiotics were initiated grouped by birth month and annotated with interventions. Time to initiate antibiotics decreased from 180 MOL to 82.5 MOL following implementation of the Stork Team. There were no GH patients in October 2019.

completion of initial stabilization with isolette closure [5–8]. However, our study is the first to decrease these metrics to close to one hour of life in a large patient population. Examining two of our key GH stabilization measures, time to initiate dextrose containing fluids and isolette closure time, showed that the average time for completion of each of these tasks was within 67 MOL following Stork Team implementation. Other similar large studies have accomplished these findings by an average of 92 min of life [7], and no other study has detailed a significant impact on GH care following the creation of a dedicated delivery team.

Limitations

There are several limitations to this study. One of the limitations is the impact of the COVID-19 pandemic. The NICU in the study was an open module configuration until November 7, 2021. To provide infection control measures for infants born to COVID-19 positive mothers, these infants were brought to a separate room just outside of the NICU for resuscitation and admission stabilization prior to being transferred to other hospitals that could provide single-bed unit care. The transport of infants from the delivery or operating room to a separate room for resuscitation resulted in

Table 3. Delivery room temperature ranges by project phase.

	Phase 1[a] Pre-GH project	Phase 2[a] GH project started	Phase 3[a] Stork Team created	*P* value
Total patients, *n*	181	178	314	–
DR temp recorded, *n* (%)	108 (60%)	165 (93%)	307 (98%)	<0.001
36.5–37.5 °C, *n* (%)	81 (75%)	121 (73%)	241 (79%)	0.42
36.0–36.4 °C, *n* (%)	13 (12%)	31 (19%)	44 (14%)	0.26
35.9 °C or lower, *n* (%)	2 (2%)	7 (4%)	10 (3%)	0.55
37.6 °C or higher, *n* (%)	12 (11%)	6 (4%)	12 (4%)	0.008

[a]Phase 1 occurred from January 1, 2017 to June 30, 2018; Phase 2 occurred from July 1, 2018 to February 15, 2021; Phase 3 occurred from February 16, 2021 to August 31, 2022.

increased rates of initial DR hypothermia in these infants. Additionally, for a period of time from March 25 to May 12, 2020, the NICU was closed as a part of strategic planning for adult patient surges. During this time, infants were initially stabilized in a converted space within the labor and delivery unit prior to transfer to other NICUs in the city. Another limitation to the study is lack of long-term follow-up for these infants. The initial scope of the study was aimed at affecting these admission measures. Subsequent project steps include trending long-term outcomes such as intraventricular hemorrhage, bronchopulmonary dysplasia, retinopathy of prematurity, and death.

CONCLUSIONS

Through ongoing QI efforts, the GH care for preterm infants born at <32 weeks gestation was prioritized and refined at a busy level III academic NICU. The most significant improvements in the process were noted after the creation of the Stork Team and associated interventions. The findings of our study support previously published work showing improvements in GH care through QI initiatives. After the implementation of the Stork Team our NICU was able to achieve more consistent and timely GH care than previously described in the literature.

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AUTHOR CONTRIBUTIONS

BW and AB conceptualized and designed the study, edited the data collection instruments, collected data, carried out the initial analyses, drafted the initial manuscript, and reviewed and revised the manuscript. JST designed the data collection instruments, coordinated, and supervised data collection, and reviewed and revised the manuscript. JH and AT conceptualized and designed the initial golden hour quality improvement project and original data collection instrument, collected data, and carried out the initial analyses from July 2018 through June 2019, and reviewed and revised the manuscript. IL conceptualized the dedicated delivery team, supervised data collection, and reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

ETHICS APPROVAL

This project was submitted to the Indiana University Institutional Review Board and deemed exempt (IRB #2003758842).

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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