RESEARCH ARTICLE

Reduction in Length of Stay and Morphine Use for NAS With the "Eat, Sleep, Console" Method

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ABSTRACT

OBJECTIVES: To reduce average length of stay (ALOS) in infants with neonatal abstinence syndrome (NAS) transferred to the inpatient floor from the mother-infant unit. Secondarily, we aimed to reduce morphine exposure in these infants.

METHODS: Using quality improvement methodology, we redesigned our approach to NAS on the inpatient floor. Key interventions included transitioning from a modified Finnegan Neonatal Abstinence Scoring System to the "Eat, Sleep, Console" method for withdrawal assessment, reeducation on nonpharmacologic interventions, and adding as-needed morphine as initial pharmacotherapy. Data for infants ≥35 weeks' gestation with confirmed in utero opioid exposure and worsening symptoms of NAS requiring transfer to the inpatient floor were obtained, including ALOS, number of morphine doses, and total morphine amount administered. Infants with conditions requiring nothing by mouth for >12 hours or morphine initiation in the ICU were excluded.

RESULTS: ALOS for infants (baseline $n = 40$; intervention $n = 36$) with NAS transferred to the inpatient floor decreased from 10.3 to 4.9 days. Average morphine administered decreased from 38 to 0.3 doses per infant. No infant in the intervention period required scheduled morphine. The percent of all infants transferred to the floor for NAS requiring any morphine decreased from 92% at baseline to 19% postimplementation. There were no observed adverse events or NAS-related readmissions in the intervention period.

CONCLUSIONS: Transitioning to the Eat, Sleep, Console assessment with re-enforcement of nonpharmacologic care and use of as-needed morphine as initial pharmacotherapy resulted in a notably decreased ALOS and near elimination of postnatal opioid treatment of infants with NAS managed on our inpatient floor.

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Dr Blount was the primary investigator and conceptualized and designed the project, collected and analyzed data, and drafted the initial manuscript; Dr Painter and Ms Freeman assisted with creation of the project protocol and assisted with project management, data analysis, and manuscript drafting and revision; Dr Grossman conceptualized and provided the protocol for the key intervention and assisted with manuscript drafting and revision; Dr Sutton assisted with conceptualization and project design, performed data collection and analysis, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Neonatal abstinence syndrome (NAS) is a clinical diagnosis made when an infant experiences withdrawal symptoms after birth because of in utero opioid exposure. Increased opioid use and abuse has resulted in a rising incidence of NAS nationally, recently estimated to affect 6.0 infants per 1000 hospital births.[1,2] Historically, approaches to management of infants with NAS have been focused on a combination of nonpharmacologic and pharmacologic treatment, typically in the NICU.[3] A growing body of research supports a collaborative approach to care that includes maintaining the maternal-infant dyad ("rooming in") and increased nonpharmacologic interventions including skin-to-skin placement, swaddling, and limiting stimulation.[2,4–6] Additionally, a protocol-driven approach to infants with NAS can be used to minimize variability in care, shorten average length of stay (ALOS), and improve patient outcomes.[7–11] The most commonly used tool in evaluation of infants with NAS is the modified Finnegan Neonatal Abstinence Scoring System (FNASS).[12] However, FNASS has notable limitations as an assessment tool, including challenges with internal consistency and lack of rigorous validation.[13] As a result, many groups have recently departed from strict FNASS-based approaches to NAS evaluation.[4,7,14] One novel method for withdrawal assessment, known as the "Eat, Sleep, Console" (ESC) method, relies on a structured assessment of newborn feeding, sleep duration between feedings, and ability to be consoled to inform management of withdrawal rather than FNASS scoring.[7,14,15]

Previous improvement efforts at our institution resulted in a protocol-based approach to infants with NAS that used FNASS scores for assessment, emphasized maintaining the maternal-infant dyad during treatment, and incorporated nonpharmacologic treatments for withdrawal. The ALOS for infants with NAS at our institution decreased over a 4-year period from 22 to 10 days by 2017 after the implementation of these measures. These improvements successfully reduced our ALOS to below the national average of 16 days[16] and resulted in a reduction in the percentage of all infants with confirmed in utero opioid exposure treated with pharmacotherapy at our institution to 30%.

However, our team felt that further opportunities for improvements existed. Infants with elevated FNASS scores in the mother-infant unit (MIU) were transferred to the inpatient floor for initiation of morphine therapy including methodical weans that continued even when FNASS scores were consistently low. FNASS scoring itself was a source of frustration for providers given the perception of poor interrater reliability and that performing the assessment involves disturbing the infant and potentially exacerbating withdrawal. In this setting, with the recent publication of alternative methods for assessment,[4,7,14] we began to note a preference among our provider group away from strict adherence to FNASS-based management. Additionally, we treat a large maternal population managed with medication-assisted treatment (MAT), which we do not administer after maternal discharge. Infants requiring prolonged hospitalization thus resulted in mother-infant dyad separation because mothers left the bedside to continue their own treatment.

To further improve care for infants with NAS on the inpatient floor, we undertook a quality improvement initiative. We primarily aimed to reduce the ALOS for infants with NAS transferred to the inpatient floor by 50% in a 6-month period. We additionally aimed to reduce the percent of infants with NAS receiving treatment with morphine by 50% and the total amount of morphine received by those infants treated with morphine by 50%.

METHODS

Setting

Our institution is a tertiary-care academic medical center with multiple subhospitals. Our MIU admits 3700 infants annually, including ~100 infants per year with known in utero opioid exposure. Newborn infants admitted to our MIU room in with mothers to minimize dyad separation. Our institution is a regional referral center for women incarcerated at the time of delivery and also collaborates with a large residential treatment facility for women with substance use disorder. As a result, the majority of our infants with NAS are born to mothers receiving MAT, most commonly with buprenorphine.

Healthy, inborn infants who are ≥35 weeks' gestation and ≥1.8 kg are admitted to couplet care on the MIU. Infants born to mothers with previous substance use or imprisonment at time of delivery as well as those with known opioid exposure undergo urine and meconium toxicology screening. Infants in the MIU are managed with nonpharmacologic interventions and are monitored for withdrawal by using the FNASS every 2 to 4 hours (determined by score) beginning at 12 hours of life. Infants with 2 consecutive scores ≥12 or 3 consecutive scores ≥8 are transferred from the MIU to the inpatient floor in the adjoined children's hospital for initiation of morphine therapy with cardiorespiratory monitoring because our MIU does not have licensing for monitored infant beds. For infants with tobacco and long-acting opioid exposure, we generally do not transfer before 36 hours of life and attribute earlier symptoms to tobacco withdrawal. Mothers accompany infants after transfer when medically possible. If the mother is unable to discharge, the infant is transferred alone and the mother visits as medically able because no nursing care is provided for the mother on the pediatric floor. If conditions aside from NAS require NICU transfer in an opioid-exposed infant, the infant is monitored and treated for NAS in the NICU with an approach that differs from that used in the MIU and on the inpatient floor.

In our baseline period, once an infant was transferred to the inpatient floor, morphine was initiated at 0.03 mg/kg every 4 hours with FNASS scores every 2 to 4 hours as above. If necessary, morphine was increased by 10% to 20% increments until 2 consecutive FNASS scores were ≤8. Morphine dosage was decreased daily by 10% of the peak dose until at roughly 0.02 mg/kg per dose, then dose frequency was spaced consecutively to every 6, 8, or 12 hours and then finally to every 24 hours before discontinuation. Care teams convened on daily rounds to review the FNASS scores and clinical status. Infants

were maintained on cardiorespiratory monitoring during morphine treatment and had vital signs monitored every 2 to 4 hours depending on the FNASS score that was dictated. Infants were typically discharged within 24 hours of the last morphine dose.

Intervention

We developed a 5-member multidisciplinary task force including physicians (hospitalist and residents), a newborn nursery provider, and a pediatric pharmacist to review the care of infants with NAS on the inpatient floor in June 2017. We obtained baseline data, completed a key driver diagram (Supplemental Fig 5), and implemented 2 key interventions that were approved by stakeholders on the inpatient floor. First, we implemented as-needed (PRN) dosing of morphine at our previous starting treatment dose (0.03 mg/kg) for infants with NAS symptoms not controlled by nonpharmacologic interventions. Dosing was repeated if the infant continued to meet the pharmacotherapy threshold at the 4-hour mark or at any point moving forward. If scheduled morphine was needed on the basis of multiple PRN doses, we allowed weaning by 10% of the peak dose up to 3 times per day when appropriate. We discontinued scheduled morphine at dosing of 0.02 mg/kg every 4 hours with no change in dosing interval and transitioned back to PRN dosing after discontinuation of scheduled morphine. Second, we replaced the use of FNASS scores for monitoring infants with NAS for withdrawal with the ESC method as described by Grossman et al.[7,14] Specifically, nurses assessed if the infant fed 1 oz or had an adequate breastfeeding session, slept at least 1 hour between feedings, and consoled within 10 minutes when crying. The interventions were included in a new protocol that reemphasized nonpharmacologic interventions as the standard treatment of NAS (including reducing environmental stimulation, pacifier use, swaddling, and increasing caloric density of formula) (Fig 1). Infants not receiving morphine were not placed on cardiorespiratory monitors and had vital signs obtained once per shift with blood pressure measurements once per day. We created a guideline for providers with specific instructions on how to enter orders for ESC and the need for the provider to assess, at the bedside, any infant not meeting ESC criteria for potential intervention.

Planning the Intervention and Implementation

As we approached implementation, we hosted a session for nurses and hospitalists covering recent articles describing new approaches to the management of infants with NAS. Two weeks before implementation, we presented the new ESC approach to the floor nurses for feedback and discussion. One week before implementation, the new protocol and treatment guidelines were posted on the resident and hospitalist Web repository and introduced at resident morning report. The protocol was also sent to residents leading the ward teams at the start of each new resident rotation block. We did not change our approach for infants in the MIU or the NICU; therefore, infants continued to receive FNASS scores in these settings. The threshold for transfer to the

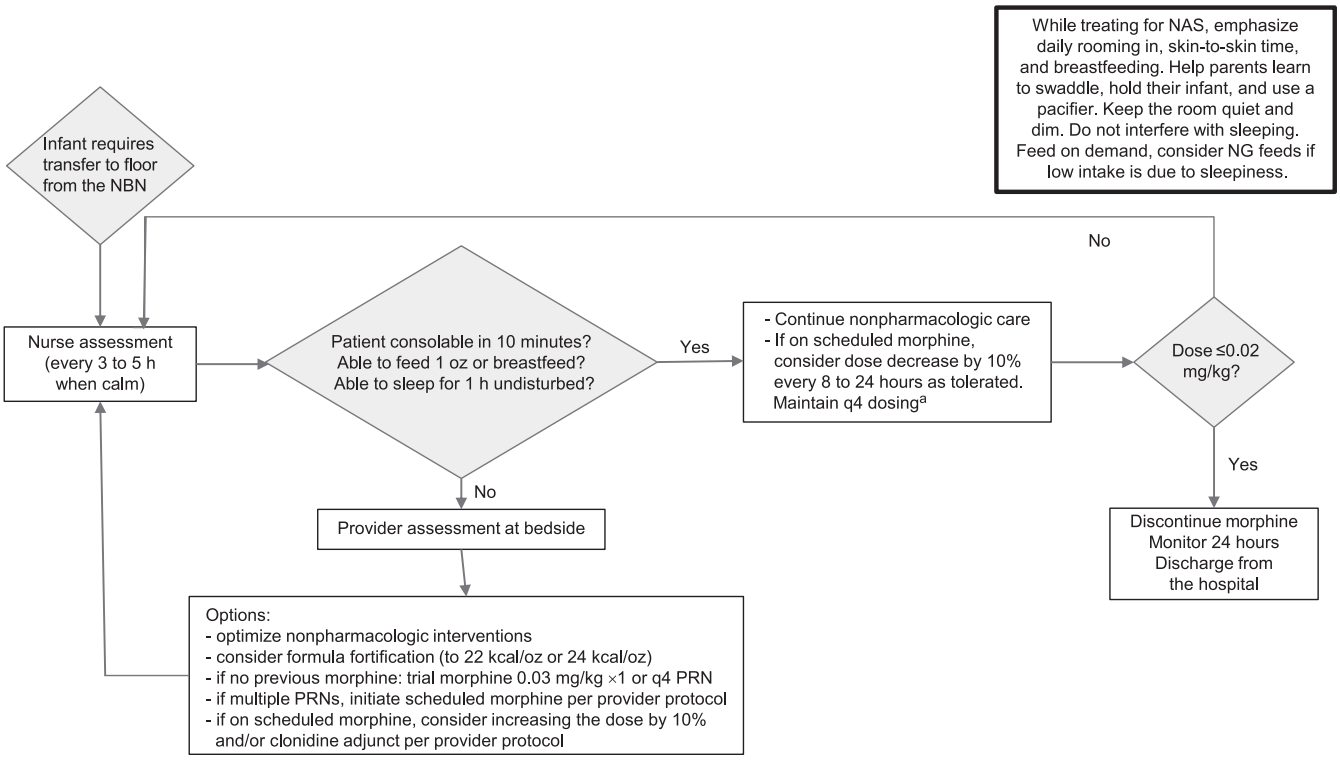

FIGURE 1 New provider protocol and floor management for patients with NAS on the inpatient floor. [a] The medical doctor may choose to wean more rapidly if clinically indicated. NBN, newborn nursery; NG, nasogastric; q4, every 4 hours.

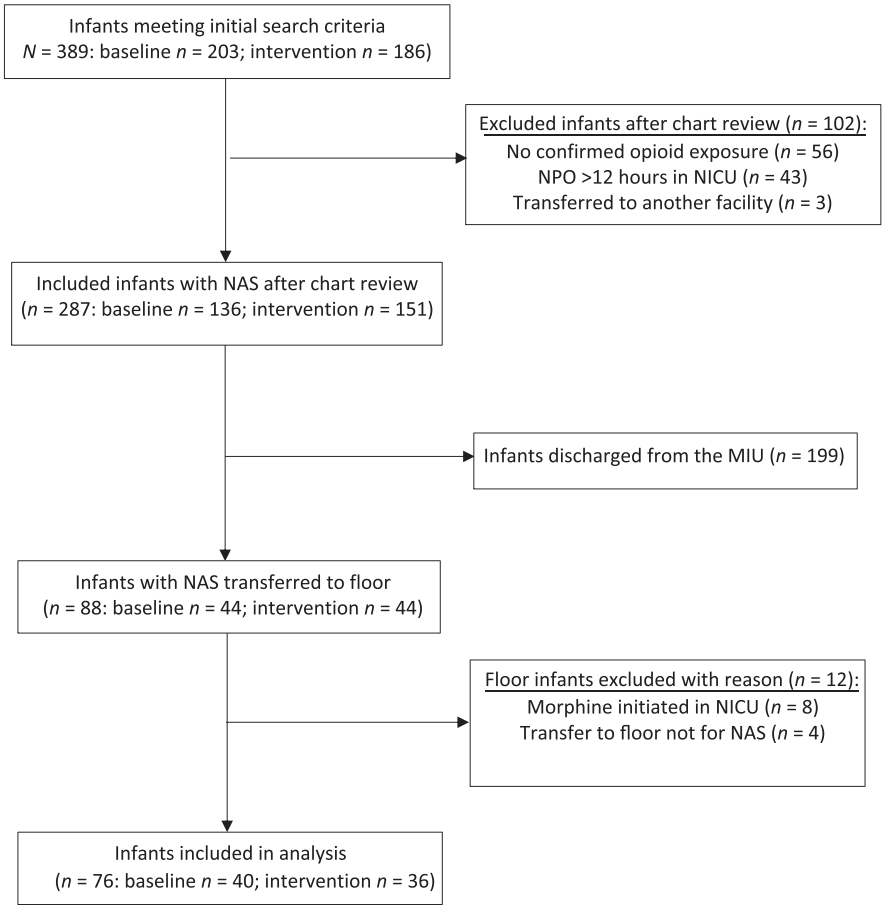

FIGURE 2 Flowchart for inclusion or exclusion of infants. NPO, no enteral feedings.

inpatient floor from the MIU was also not changed.

Studying the Intervention

Baseline (June 2016–October 2017) and intervention and sustainment (November 2017–December 2018) data were obtained via weekly automated reports from the electronic medical record (EMR), which identified infants who were ≥35 weeks' gestation, ≥1.8 kg, and had at least 1 FNASS score documented. Manual chart review was then performed to confirm inclusion of only those infants with documented third-trimester opioid exposure either by positive maternal or infant drug screening or maternal prescription. Included infants in the analysis were confirmed to have documented scores in the MIU of 2 FNASS scores ≥12 or 3 scores ≥8 before transfer, signaling worsening withdrawal. We excluded infants transferred for ongoing observation without elevated FNASS scores, infants with NAS initiated on morphine while admitted to the NICU for another condition (hypoglycemia, respiratory insufficiency), and infants who had risk for NAS but were unable to have enteral feedings for >12 hours related to respiratory status, given the potential impact of nonfeeding status on withdrawal symptoms.

Data extracted from the EMR reports included length of stay (hours), total number of morphine doses during hospitalization (count), total amount of morphine received during hospitalization (milligrams per kilogram), and percent of infants with NAS treated with morphine. Additionally, patient characteristics, including birth weight, discharge weight, gestational age, maternal race, and payer, were extracted. During the manual chart review to confirm inclusion criteria, other patient factors were manually extracted, including documentation of breastfeeding attempt, primary opioid exposure, and maternal polypharmacy use, including tobacco. Infant charts, including care team notes, were manually reviewed for balancing and safety measures as below.

Measures and Data Analysis

Our primary outcome measure was ALOS for infants with NAS transferred to the inpatient floor. We identified infants by any documented FNASS score to ensure that all infants known to have opioid exposure were included in the initial data set for potential inclusion. This method reduced the likelihood of missing data that can occur when relying on provider coding. ALOS was defined as the time from birth to either the time of discharge or the time of discontinuation of the ESC protocol for infants with resolved NAS who were medically cleared but awaiting placement determination. As secondary outcomes, we measured the number of morphine doses and the cumulative dose of morphine received per infant with NAS on the inpatient floor. Balancing measures included adverse events (ie, desaturation, apnea, seizure, or need for NICU transfer from the floor), percent weight change from birth to discharge, and 30-day readmission or emergency department presentation to our network of hospitals. Data were monitored by using statistical process control charts appropriate for each measure to assess improvement over time in key aims. Standard Shewhart rules were used for the interpretation and determination of special cause variation (primarily 8 consecutive points on the same side of the centerline).

Ethical Considerations and Human Subjects Protection

Our institutional review board reviewed this internal improvement project and determined that it did not meet the regulatory criteria for research involving human subjects and that ongoing oversight was not required. No interventions involved comparison of therapies, and subjects were not randomly assigned. No personal health data were shared outside of the investigator team.

RESULTS

A total of 389 infants (baseline $n = 203$; intervention $n = 186$) were identified by the automated EMR report as having at least 1 FNASS score during newborn hospitalization. After manual chart review, 76 infants (baseline $n = 40$; intervention $n = 36$) with escalating NAS symptoms requiring transfer to the inpatient floor met criteria for inclusion in the final analysis (Fig 2). Characteristics of included infants with NAS during baseline and intervention periods are summarized in Table 1. Of note, >80% of included infants were born to mothers on MAT, with buprenorphine being the most common medication. The only measured difference noted between the groups was increased rate of maternal tobacco use in the intervention cohort ($P = .03$).

The ALOS for infants with NAS transferred to the inpatient floor decreased from a baseline of 10.3 days to 4.9 days during the intervention period (Fig 3). The percent of infants treated with morphine on the floor decreased from 92% at baseline to 19% postintervention. Overall, only 9% of all infants with in utero opioid exposure at our institution (including those discharged from the MIU) received any pharmacotherapy postintervention. There was a substantial decrease in the average number of morphine doses from 38 doses per infant to 0.3 doses per infant (Fig 4). The average total morphine dosage per infant treated with morphine decreased from 1.1 to 0.03 mg/kg per infant. In the intervention period, 0 infants received scheduled morphine dosing and only 1 infant received multiple doses (3) of PRN morphine.

Special cause variation was achieved with reduction in mean in November 2017, essentially at the outset of implementation, for each outcome measure. Of note, there were many points of special cause variation in the number of doses per infant noted both above and below the upper and lower control limits at baseline in Fig 3. This variation improved postintervention.

There were no NAS-attributable 30-day readmissions or emergency department visits in the baseline or intervention periods. One infant in the baseline group had a desaturation attributed to a dosing error in oral morphine. There were no adverse events documented in the intervention period. Percent change from birth weight at discharge did reveal special cause variation from an average of 3% below birth weight at baseline (average age ~10 days old) to 5% below birth weight in the intervention period (average age ~5 days old).

TABLE 1 Characteristics of Included Infants With NAS

	Preintervention ($n = 40$)	Postintervention ($n = 36$)	P
Gest age, wk	39 2/7	39 0/7	.540
Birth wt, kg	3.21	3.04	.142
Any breastfeeding, *n* (%)	21 (53)	24 (67)	.203
Maternal race, *n* (%)			
White	33 (83)	31 (86)	.664
African American	4 (10)	3 (8)	.801
Other	3 (7)	2 (6)	.731
Sex, *n* (%)			
Male	21 (53)	16 (44)	.481
Insurance, *n* (%)			
Medicaid	38 (95)	34 (94)	.914
Maternal opioid, *n* (%)			
Buprenorphine	26 (65)	18 (50)	.182
Methadone	8 (20)	13 (36)	.114
Other[a]	6 (15)	5 (14)	.890
Other[b] exposures, *n* (%)			
Tobacco	25 (63)	30 (83)	.035[c]
Polypharmacy	32 (80)	33 (91)	.136

[a] Any other opioid besides buprenorphine or methadone.
[b] Additional relevant exposure history.
[c] Statistically significant.

DISCUSSION

Changing our approach to the management of infants with NAS on the inpatient floor reduced ALOS and decreased morphine use. Implementation of the ESC method and PRN dosing of morphine with re-enforcement of nonpharmacologic therapies, including formula fortification, led to near elimination of pharmacotherapy use and resulted in >50% further reduction in ALOS for infants with NAS managed on our floor. Importantly, we did not observe an increase in readmission rate or in adverse events, although these events were rare at baseline. Infants at discharge had a further 2% decrease in weight relative to birth weight. Given that infants were discharged an average of 5 days earlier and typically before 1 week of life, this change in weight is likely not clinically significant but is instead a reflection of discharge occurring at a younger postnatal age. Of note, we did observe an increase in tobacco use among mothers in the intervention period (Table 1), although if anything, this difference would be expected to be more likely to exacerbate NAS rather than improve outcomes. Overall, demographics and characteristics are provided to offer some guidance on the populations, but small numbers limit interpretability of comparative statistics, and this study was completed as a quality improvement intervention and not a controlled trial.

The number of morphine doses per infant at baseline had a wide range (0–106 doses) and significant variability, including multiple points outside of the control limits (Fig 4). This variation was markedly improved postimplementation. We suspect variation is related to differences in provider decisions to escalate or wean morphine dosing on the basis of the previous protocol. Additionally,

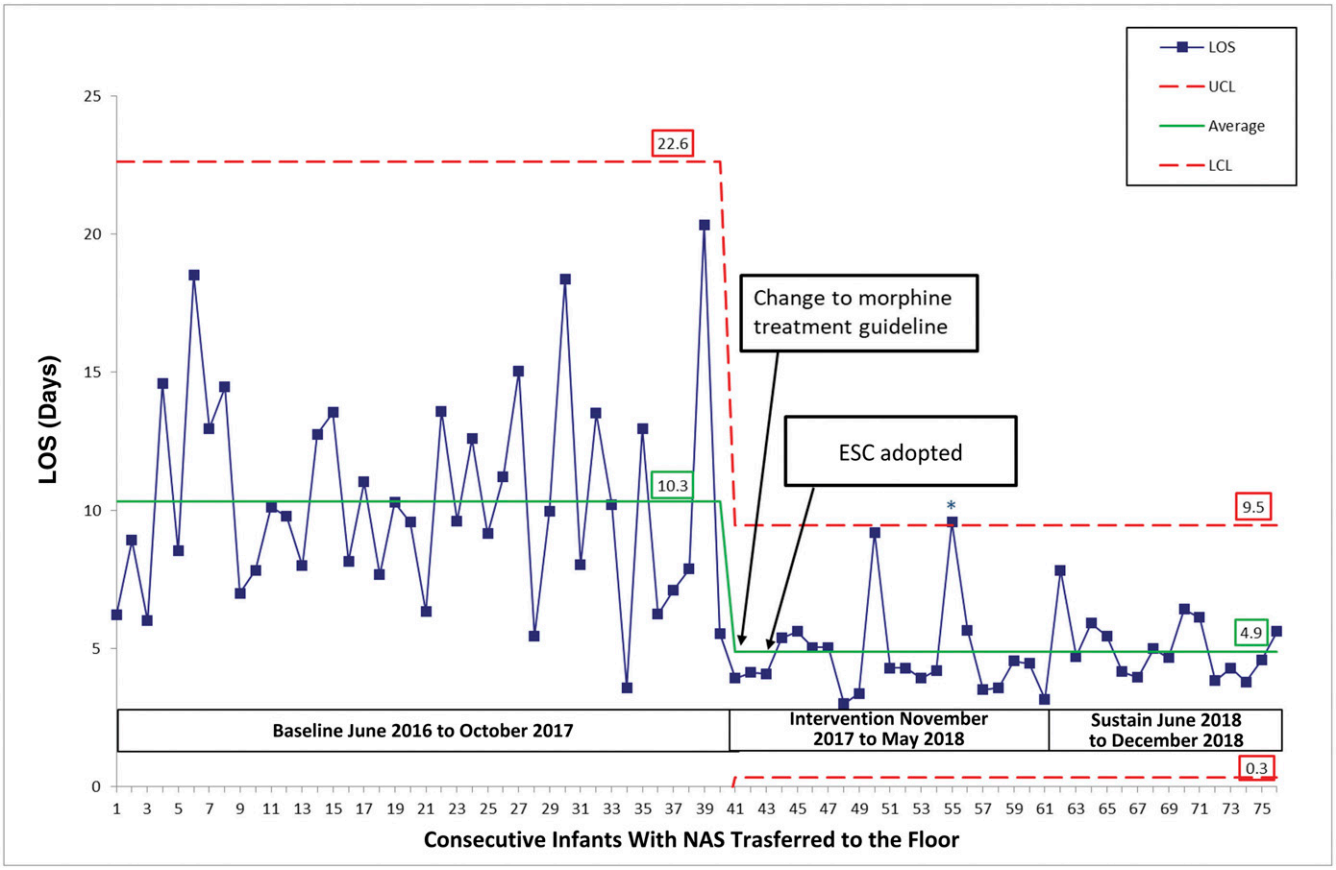

FIGURE 3 Statistical process control chart for length of stay (LOS) for infants with NAS transferred to the inpatient floor. The LOS for consecutive neonates with NAS transferred to the inpatient floor from June 2016 to December 2018. The data source is from a business objects report in Epic by documented FNASS score in newborn hospitalization. LCL, lower control limit; UCL, upper control limit.

after the publication of the ESC method[7] we noted multiple patients who received less pharmacotherapy despite having FNASS scores meeting criteria for treatment per baseline protocol. We suspect that the publication of ESC may have resulted in individual providers to deviate from a strictly FNASS-based treatment approach before a change of the treatment protocol, although we cannot be certain.

We initially aimed for a 50% reduction in the total cumulative dose of morphine in infants with NAS transferred to the inpatient floor and were able to exceed this goal because of low use of pharmacotherapy overall in the intervention period. Infants treated ($n = 7$) with morphine during the intervention period required only PRN morphine to meet ESC parameters. The 1 infant who received multiple PRN doses of morphine was receiving phototherapy, and thus nonpharmacologic interventions were limited.

We acknowledge that the degree of reduction in morphine use was unexpected. This marked change could elicit criticism that our objective was explicitly to avoid pharmacotherapy, potentially at the expense of infants experiencing withdrawal. However, the new protocol offered PRN dosing and had specific instructions for initiation and weaning of scheduled morphine when required. Treatment decisions were made by the clinical team, supervised by >15 different attending physicians during the intervention period. Chart review of infants during the intervention period supported that infants were consistently meeting ESC protocol criteria or responding to enhanced nonpharmacologic interventions when not meeting parameters and not that providers or staff were avoiding opioid use in infants who were otherwise not functioning well.

By adopting a new ESC-based protocol for evaluating infants with NAS, we were able to achieve a paradigm shift at our institution. This approach incorporates the strengths of previously published approaches in that it is protocol driven, standardized, and allows for continued rooming in while using a more straightforward evaluation of how an infant is tolerating the transition to extrauterine life and managing withdrawal symptoms.[2,4,7,15] Our results support the original publication by using this approach in a different population and location.[7,15] The majority of our infants were exposed to buprenorphine and/or naloxone in utero, rather than methadone, and our standard of care was already to transfer infants with NAS to the inpatient floor, likely contributing to a lower baseline ALOS than reported by Grossman and colleagues.[15] We had previously implemented many improvements, including nonpharmacologic interventions and not admitting otherwise well infants with NAS to the NICU.

This model has worked well at our institution in which transfer from the MIU

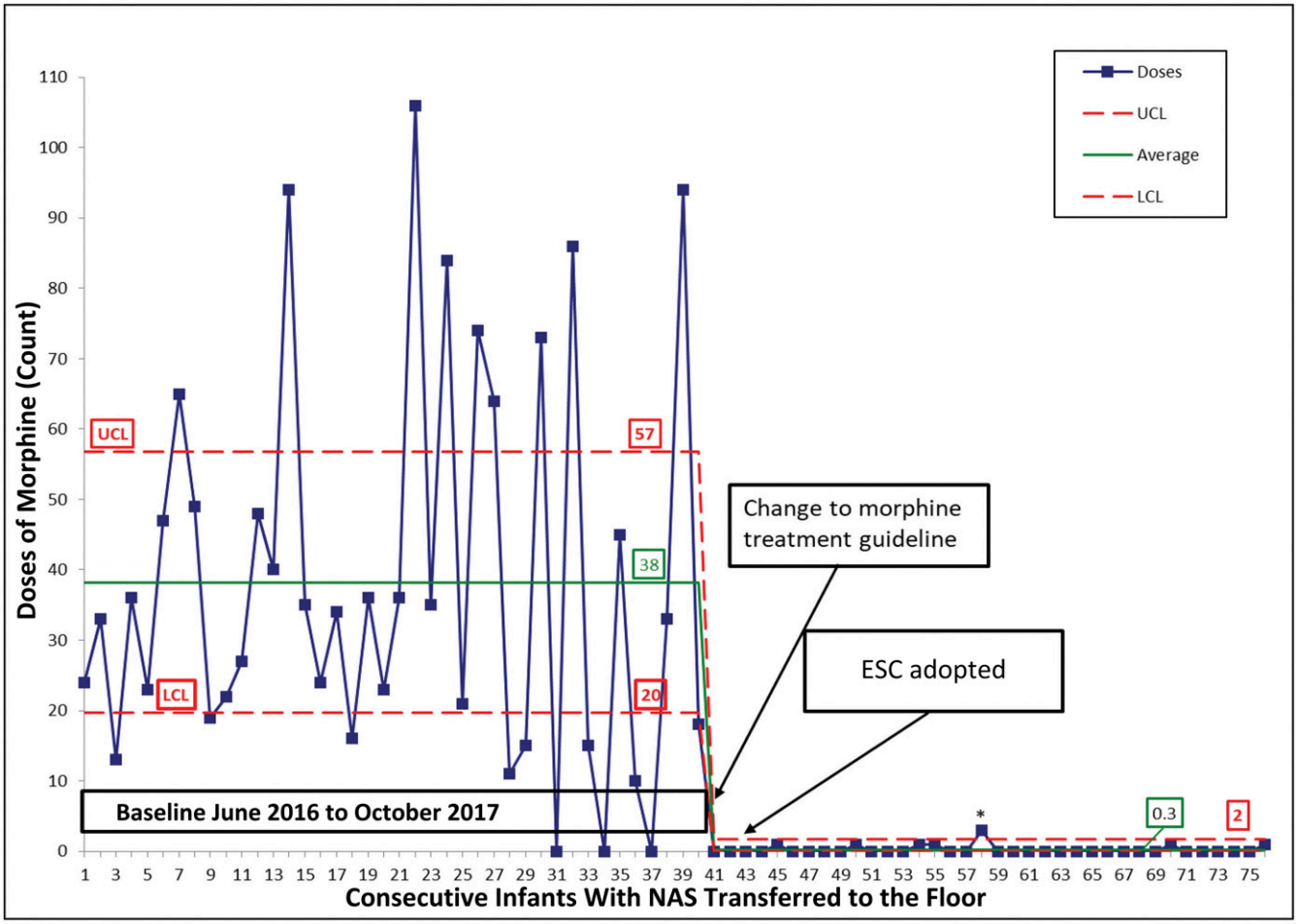

FIGURE 4 Statistical process control chart for number of morphine doses given per neonate with NAS transferred to the inpatient floor. The data source is from a business objects report in Epic by documented FNASS score in newborn hospitalization. LCL, lower control limit; UCL, upper control limit.

to the inpatient floor allows for rooming in and fostering a quieter, dark environment for infants. Although continued opioid use for infants with NAS experiencing withdrawal remains an option for management, the potential long-term effects of prolonged hospitalization and further opioid exposure in a critical period of transition for this at-risk population are not known. Additionally, by minimizing pharmacologic treatment, we were able to decrease vital sign frequency and cardiorespiratory monitoring, thereby promoting a calmer environment in the room for the infant and family. In addition, although not measured directly in our study, the potential impacts on dyad bonding resulting from a shorter hospital stay and reduced opioid exposure are important considerations when weighing the risks and benefits of prolonged, scheduled pharmacotherapy to manage infants who are meeting the basic requirements of postnatal transition.

Our study has several limitations that are worth noting. We report a relatively small sample size, which particularly limits the interpretability of comparative statistics (Table 1). Regarding outcomes, the small sample size, in part, is mitigated by the use of process control charts over time and the extent of the change in outcomes in the population. Given that the implemented interventions occurred in essentially the same time period (2 weeks apart), it is difficult to pinpoint the exact component of this intervention that led to the dramatic change. However, because nonpharmacologic care was already standard, ESC and an option for PRN morphine seem to be the largest drivers of the change.

There were some unique features of our population that may impact the results of a similar approach in different settings. We did not have any baseline readmissions for NAS-related causes, which limits interpretability of having no readmissions, despite halving the ALOS, in the postintervention group given that this is a rare event in our population. We attribute our low rate of readmissions in part to our population of mothers because many are receiving stable MAT perinatally in a supportive residential care environment. Others are incarcerated at the time of delivery, resulting in the infant being placed

in alternative care at discharge. Additionally, buprenorphine was the most common in utero opioid exposure in our infant cohort, which likely improved our outcomes throughout the study given that buprenorphine has been shown to favorably impact NAS severity.[17,18] Although relevant to application elsewhere, there were no detected differences in primary opioid exposure in baseline and intervention groups, and this exposure would not have resulted in the dramatic changes demonstrated.

Importantly, outcomes outside of the initial hospitalization and 30-day postdischarge period (both positive and negative) with the ESC assessment approach compared to FNASS assessments remain largely unknown. An understanding of the impact of various treatment approaches on maternal-infant bonding, neurodevelopment, and adverse events is lacking with this approach (and others) in this population. The independent impacts on infant outcomes of neonatal withdrawal and use of opioids for its treatment are not well understood given a population with heterogenous in utero exposures to substances at baseline. Medium- and long-term postdischarge outcomes including growth and developmental trajectories for infants assessed with FNASS scores versus the ESC method or treated for NAS without pharmacotherapy compared with those that receive pharmacotherapy are also unknown. However, many centers, including ours, use the FNASS for assessment in the MIU and discharge a large percentage of infants with in utero opioid exposure without using pharmacotherapy. Thus, any potential impacts on infant outcomes are not necessarily unique to the ESC approach, although they should be further explored.

Unlike other studies,[4,7,14] we did not collect FNASS data for patients after transfer to the inpatient floor because we felt it sent a mixed message to continue collecting FNASS scores that would not be acted on. We also had concerns about the vigilant and stimulatory environment promoted by FNASS scoring itself. As such, our results are limited only to the historical comparison of the baseline management of similar infants rather than comparison of how the infants during the intervention period would have been managed under our previous approach.

CONCLUSIONS

Our new approach for infants with NAS incorporating the ESC assessment method and PRN morphine improved the management of infants with NAS on our inpatient floor by decreasing ALOS and reducing postnatal opioid exposure without short-term adverse consequences to the infant. Results were achieved in the initial 6-month improvement period and have been sustained without further intervention. Our implemented approach, including the ESC method and further emphasis on nonpharmacologic interventions as equally important to pharmacologic interventions, is simple and can be easily applied at other institutions without rigorous training or validation of competency as required of more detailed scoring systems. One particularly important implication of our study is use of PRN morphine as initial pharmacotherapy. Infants in our population who required morphine needed minimal PRN doses, and under our previous approach, they would have automatically been initiated on scheduled morphine. Because of the success on the inpatient floor, our next steps include expansion of the ESC approach to the MIU to allow for a homogenous assessment tool between units.

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