Improving Outcomes through a Neonatal Abstinence Syndrome Collaborative in Maryland


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Conflict of Interest: The authors declare that they have no conflict of interest.

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Abstract:

Objectives: A statewide Maryland Perinatal Neonatal Quality Collaborative, facilitated by the Maryland Patient Safety Center (MPSC), identified the three specific, measurable, attainable, relevant, and time-limited (SMART) aims to improve outcomes of NAS care: (1) to reduce hospital length of stay (LOS), (2) to reduce interhospital transfers, and (3) to reduce 30-day readmission rates of infants with neonatal abstinence syndrome (NAS).

Study Design: The Maryland collaborative developed a bundle of best practices for care of infants with NAS. MPSC partnered with Vermont Oxford Network (VON) to utilize the VON NAS toolkit and provide its standardized NAS educational curriculum to address the three objectives for participating birthing hospitals. Efforts began in quarter 4 (Q4) 2016 and continued for two years. Thirty-one of Maryland’s 32 delivery hospitals (97%) participated in the two-year collaborative. Additionally, one specialty pediatric hospital with a NAS unit participated in the group learnings. Participating facilities implemented components of the MPSC NAS bundle and provided their staff caring for infants with NAS and their mothers access to the VON standardized educational curriculum. MPSC partnered with VON to conduct two audits of implementation of policies and procedures in Q1 2016 and Q3 2018. The Maryland Department of Health supplied quarterly aggregate hospital information on LOS, interhospital transfers, and 30-day readmissions of infants with a discharge diagnosis of ICD-10 P96.1.

Results: Among term infants with NAS with total hospital stay greater than 5 days, we observed a non-significant reduction in both mean and median LOS of 1.5 days. In this same group, the rate of interhospital transfers fell significantly from 20.1% in 2016 to 13.8% in 2017 and to 11.0% in 2018.

Conclusion: The best practice bundle created by the Maryland collaborative was associated with a reduction in the percentage of infants with NAS who required interhospital transfer, thereby reducing family disruption.

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Improving Outcomes through a Neonatal Abstinence Syndrome Collaborative in Maryland

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Abbreviations: LOS, length of stay; MDH, Maryland Department of Health; MPSC, Maryland Patient Safety Center; NAS, neonatal abstinence syndrome; VON, Vermont Oxford Network

Key points:

1. A state NAS Collaborative engaged 97% of delivery hospitals in education and standardization of care.
2. The Collaborative witnessed a 1.5-day decrease in length of stay, similar to that observed in other state Collaboratives.
3. The unique outcome of our Collaborative was a 50% decrease in the rate of interhospital transfer.
Tables: 2
Figures: 4
**Contributors’ Statement**

Bonnie DiPietro conceptualized the MPSC NAS initiative, ran the statewide collaborative, reviewed serial outcomes data, drafted the initial manuscript, and reviewed and revised the manuscript.

Kristin Silcox carried out data analysis and reviewed and revised the manuscript.

James Rost conceptualized the MPSC NAS initiative, assisted with the statewide collaborative and reviewed and revised the manuscript.

Lee Woods assisted with the statewide collaborative, supplied outcomes data, and reviewed and revised the manuscript.

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Madge Buus-Franks facilitated the collaboration between MPSC and VON and reviewed and revised the manuscript.

Jeffrey D. Horbar reviewed and revised the manuscript.

Mark L Hudak served as a consultant to the statewide collaborative, reviewed serial outcomes data, drafted the initial manuscript, and reviewed and revised all versions of the manuscript.

All authors approve the final version of the manuscript as submitted.
Abstract (300 words)

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**Conclusion:** The best practice bundle created by the Maryland collaborative was associated with a reduction in the percentage of infants with NAS who required interhospital transfer, thereby reducing family disruption.
INTRODUCTION

The incidence of neonatal abstinence syndrome (NAS) has increased dramatically in the United States over the past two decades, rising from 1.2 to 7.3 cases per 1,000 live births between 2000 and 2017. In 2017, West Virginia reported the highest state rate of 53.5 cases of NAS per 1,000 live births, followed by Maine (31.4), Vermont (29.4), Delaware (24.2), and Kentucky (23.9). Infants with NAS require intense supportive care and many receive pharmacologic treatment. NAS increases costs of newborn care by over $500 million annually and prolongs the average initial newborn hospital stay beyond two weeks of age. There is substantial variability in the incidence of NAS, models of NAS care, and NAS outcomes such as length of stay (LOS) and costs of care across hospitals.

Large national, state, and single-center collaborative quality improvement initiatives targeted at standardizing the approach to care of infants with NAS have reduced length of hospital stay, the rate and duration of pharmacologic treatment, and the total cost of care. Like many states, Maryland witnessed a substantial increase in the rate of NAS to 13.4 per 1,000 live births by 2014. We report the impact of a statewide Maryland Collaborative that harmonized approaches to diagnosis, assessment, and management across 31 of 32 birthing hospitals. This effort was well underway at the time of initial publication of the Eat-Sleep-Console (ESC) approach of resource-intensive non-pharmacologic care.

METHODS

The Maryland Patient Safety Center (MPSC) had directed the state’s obstetric and neonatal collaboratives since 2006. In 2015, the MPSC convened an interdisciplinary focus group to identify a priority health issue in the newborn domain that a statewide collaborative could
address. The group identified that the incidence of NAS in Maryland had increased by 90% between 2008 and 2015. A survey of treatment and management practices of all 32 birthing hospitals in Maryland revealed that only 63% of the hospitals had implemented a protocol for treatment of NAS, and only 45% reported providing specific training to staff about the care of infants with NAS. The survey also found that the initial hospital LOS varied across the state and that four hospitals did not use pharmacologic therapy but transferred infants to a higher level of care whenever such treatment was indicated.

By fall 2015, the MPSC had recruited a 22-member focus group of interdisciplinary obstetric and pediatric personnel from Maryland birthing hospitals to participate in the development of a two-year collaborative aimed at improving NAS outcomes. The group members were invited to participate in one of the following work groups to develop best practices and outcome metrics: (1) identification of infants at risk for NAS; (2) clinical assessment of the severity of NAS; and (3) management of NAS.

In the second quarter of 2016, MPSC partnered with the Vermont Oxford Network (VON) so that obstetric and neonatal personnel at the participating hospitals could access a robust educational curriculum created during the VON national NAS collaborative (2012-2015) and the VON NAS Toolkit. This allowed a rapid-cycle distribution of an up-to-date evidence-based curriculum to the interdisciplinary workforce engaged throughout Maryland in caring for substance-exposed infants and families. VON agreed to assist with two audits at all 31 participating birth hospitals. These audits were planned at the beginning and end of the two-year collaborative and were designed to collect information on hospital best practices.

By April 2016, the work groups had developed a bundle of best practices for care of infants with NAS and their mothers and families to improve statewide outcomes of babies with NAS. The
collaborative identified the following three specific, measurable, attainable, relevant, and time-limited (SMART) aims to be accomplished over two years: 1) decrease the mean statewide total hospital LOS of infants with NAS by 10%; 2) decrease the rate of transfer of infants with NAS to a higher level of care by 10% and 3) decrease the statewide 30 day hospital readmission rate by 10%. The group identified six key drivers of change: 1) improve the identification of women with substance use disorder; 2) improve the identification of infants at risk for NAS; 3) reduce inter-observer variability in Finnegan scoring (10); 4) develop a consistent management plan for infants with or at risk for NAS; 5) provide a rigorous educational program on the comprehensive management of infants with NAS including a focus on family-centered and trauma-informed care; and 6) improve the education of families about the natural history, treatment, and expected outcomes of NAS. The Key Driver Diagram included a set of best practices to accomplish the 3 SMART aims (Figure 1).

In October 2016, the MPSC launched the *Neonatal Abstinence Syndrome Collaborative: Improving Care to Improve Outcomes* with funding from the Maryland Department of Health (MDH). Thirty-one of Maryland’s 32 birthing hospitals (97%) as well as the only Maryland pediatric specialty hospital with a unit devoted to the extended care of infants with NAS had elected to participate in the collaborative. Participating birthing hospitals included both Level IV NICUs, 13 of 13 Level III centers (13), 10 of 10 Level II centers (10) and 5 of 6 Level I centers. Over the next two years, regular collaborative conference calls and webinars, frequent coordinating center phone calls and site visits to team leaders, and annual face-to-face meetings stimulated continued education and focus on the care bundles. MDH supplied data each quarter on LOS, interhospital transfers, and 30-day readmissions of babies with ICD-10 P96.1.
Additionally, VON monitored staff completion rates of the VON NAS online curriculum monthly.

The change in mean LOS over 12 quarters from 2016 to 2018 was assessed using a mixed effects linear model with a random effect for hospital. Statistical significance was set at P < 0.05. Analysis was performed using SAS 9.4 (SAS Institute Inc., Cary, NC). The change in the percentage of interhospital transfers was assessed using the Cochrane-Armitage trend test.

RESULTS

Center Participation

As part of the VON collaboration, staff at all participating hospitals were eligible to register for the online NAS educational curriculum that consisted of 18 individual modules. Over the course of the collaborative, the total number of module learning certificates awarded by VON increased linearly over time (Figure 2). Feedback was provided to each participating hospital team lead every month on their registrants’ completion of the 18 educational modules that provided 6.5 credit hours of education. Modules could be accessed at all hours, which allowed complete provider flexibility for learning.

Hospitals were empowered to register unlimited numbers of staff and providers and allow them access to the online modules. Support was provided to hospitals whose staff were not accessing the education through phone calls, site visits and collaboration with other facilities who demonstrated robust access. Further, VON provided a Center of Excellence in Education and Training Award to those hospitals at which 85% of registrants completed all 18 modules. Over the two years, 27 of 32 (85%) hospitals (26 birthing hospitals and the one pediatric specialty
hospital) achieved this milestone, earning Maryland the first State of Excellence in Education in Training award from VON.

VON Day Audits

MPSC did not track dates of implementation of best practices on a regular basis at the participating hospitals. However, in collaboration with VON, MPSC conducted 2 audits of the 31 participating Maryland birthing hospitals at the beginning and at the end of the collaborative. MPSC witnessed significant improvements in implementation of best practices for diagnosis and for both pharmacological and non-pharmacological treatment of infants with NAS as well as substantial (but not statistically significant increases) in education promoting standardization of the assessment of NAS severity and in the adoption of a breastfeeding guideline specific to mothers of infants with NAS (Table 1). MPSC did not ask hospitals to assess their rates of compliance with these best practices.

Maryland Administrative Data

From 2016 to 2018, MDH provided monthly and quarterly data on the number of newborns in the State with a diagnosis of NAS at the birth hospital, the average and median LOS, the number of newborns transferred for continuing NAS care, and the number of newborns readmitted after initial hospital discharge with a diagnosis of NAS. No significant change in LOS was identified by run chart analysis from the baseline period (January – September 2016) to the end of the collaborative (November 2017 – December 2018) (Figure 3) or beyond. However, the run chart for percentage of infants with NAS transferred for care to another facility decreased significantly from a baseline of 22.5% to 17.0% during the first year and further to 13.9% between July 2017 and January 2018 (Figure 4). To minimize the effect of potential inaccuracies in coding of NAS,
we limited our analysis of transfers to term infants (gestational age ≥ 37 weeks) with a diagnosis of NAS whose LOS was greater than 5 days. This restriction was meant to exclude from analysis a large number of infants coded with P96.1 who were observed for but did not develop signs of withdrawal by 3 to 5 days of age. This also preventing the confounding effect on length of stay of premature birth.

The percentage of term newborns with a diagnosis of NAS discharged home at less than 5 days of age increased slightly from 26.5% in 2016 to 30.6% in 2018 (Table 2). Among the term infants discharged home after 5 days of age, an 8.3% decline in mean LOS from 17.9 days in 2016 to 16.4 days in 2018 was not statistically significant. The median LOS declined from 16.0 days in 2016 to 14.5 days in 2018 and this also was not statistically significant. The percentage of term infants with a diagnosis of NAS transferred for continuing NAS care at any age decreased significantly from 20.1% in 2016 to 11.0% in 2018 (p < 0.005).

From 2016 through 2018, the number of newborns readmitted before 30 days of age with a primary diagnosis of NAS was less than the minimum threshold of 10 cases per year required by MDH to enable reporting and therefore could not be analyzed. Over the two-year period of the collaborative, those term infants who were transferred for continuing NAS care had average and median total LOS (birth hospital LOS plus transfer hospital LOS) of 35.5 and 31.0 days, respectively, compared to 17.4 and 15.0 days for term infants whose LOS exceeded 5 days who were discharged home directly from the birth hospital.

**DISCUSSION**

Our Maryland collaborative was the first statewide collaborative to take advantage of a robust web-based VON educational program on NAS that was based on AAP clinical guidance.⁴
Individual modules addressed a range of diverse topics that included topics such as providing family-centered and trauma-informed care to mothers, how best to identify infants at risk for or with clinical signs of NAS, standardized clinical assessment, and best practices for non-pharmacologic and pharmacologic treatment of NAS. Over the course of the Maryland collaborative, 3336 staff completed 39,101 individual modules at the 32 participating hospitals. In 85% of hospitals, at least 85% of eligible staff completed all 18 modules.

VON educational modules and other collaborative activities discussed above achieved substantial results. Over the two-year course of the collaborative, there was evidence of standardization of care, with a 15% or greater increase in the percentage of hospitals with policies or guidelines on topics that included the evaluation of infants at risk for NAS, standardization of NAS scoring, non-pharmacologic and pharmacologic treatment, and breastfeeding. The average number of policies developed per hospital from among the seven proposed for adoption increased from 4.8 to 5.9.

We focused our analysis of LOS to the subpopulation of term newborns (≥37 weeks gestational age) with an NAS diagnosis who were discharged home from the birth hospital at greater than 5 days of age. This strategy minimized both the confounding effects of prematurity on LOS and the inaccuracy that results from the extended newborn hospitalization of an infant at risk for but ultimately who did not develop clinical signs of NAS. No Maryland hospital had adopted the “Eat, Sleep and Console” protocol\textsuperscript{10} at any time during the two-year collaborative, which otherwise might have resulted in discharge before 5 days of age for some neonates with early clinical signs. Hence, we believe that most if not all the newborns discharged home by 5 days of age likely had relevant antenatal exposures but no clinical signs of NAS.
MDH data showed that the mean LOS in term neonates coded with NAS who were discharged home after 5 days of age was 17.9 days in 2016, 17.9 days in 2017, and 16.4 days in 2018. Our observed decrease of 1.5 days is similar to the unadjusted decrease in mean LOS from 21 to 19 days observed in the 199 center VON collaborative and from 18.3 to 17 days in the Ohio Perinatal Quality Collaborative in 52 Ohio hospitals. A collaborative of 11 Massachusetts hospitals that adopted the Eat-Sleep-Console protocol reported a slightly greater absolute reduction in mean length of stay of 3.3 days (from 14.2 to 10.9 days).

We found that the median percentage of term neonates coded with NAS who were transferred at any time for continuing NAS care decreased from a baseline of 22.5% to 17.0% in the first year and further to 13.9% in the second year and was afterwards sustained. Because our collaborative educational effort emphasized the parts of the VON curriculum that increased provider expertise and promoted a family-centered and trauma-informed approach to NAS care, we hypothesize that this decrease in transports resulted at least in part from these educational enhancements. Of note, no other multicenter collaborative has reported this specific salutary outcome.

Finally, we initially chose to assess the number of newborn infants coded with NAS readmitted within 30 days of initial hospital discharge with signs of NAS as a balancing measure to determine if our goal of reducing LOS increased subsequent readmissions. However, we cannot assess whether this outcome changed and can only state that readmission for NAS was a rare occurrence. For confidentiality reasons, MDH cannot report data for outcomes where the group size is 10 or less in each time interval. In each of the 3 years from 2016 to 2018, the number of readmissions was in fact 10 or less.

In summary, the strengths of our Maryland NAS collaborative included the consistently strong engagement by 31 of the 32 birth hospitals and the one pediatric specialty hospital in Maryland;
the outstanding standardized education that centers provided using the VON curriculum as a cornerstone; and the significant increase in center implementation of best practice guidelines for diagnosis and care of infants with NAS. The magnitude of reduction of LOS, while not statistically significant, resembled the absolute improvements reported in similar collaboratives. Importantly, we did observe a significant reduction in the percentage of term neonates with NAS who underwent interhospital transfer.

We acknowledge some possible limitations. First, centers created their own evidence-based protocols rather adopted a state-mandated guideline. Although we did not fully harmonize practices across the state, this flexibility allowed centers to more nimbly tailor protocols to their individual circumstances and we believe that this facilitated center recruitment. Second, inspection of state data suggested imprecision of NAS diagnosis because a large proportion of infants were coded as NAS yet had been discharged home by 5 days of age. These infants were almost certain to have had extended stays to observe for signs of withdrawal and discharge occurred in the absence of signs. For this reason, we limited our statewide trend analysis to term infants who remained in the hospital for more than a 5-day observation period, because these infants were more likely to have demonstrated signs of NAS. The types of non-pharmacologic management in this study predated the intensive regimen espoused in the Eat-Sleep-Console protocol. Hence, we believe it is highly unlikely that an infant with signs of NAS was discharged by 5 days of age due to non-pharmacologic management. Finally, the equivalency of the LOS for infants with NAS given this extraction to what other states have reported lends additional credence to our clinical reasoning.
**Funding:** This collaborative was supported by funds awarded by the Maryland Department of Health Maternal and Child Health Bureau Title V Program.

**Acknowledgements** We also wish to thank Robert Imhoff, former President and CEO of the MPSC for administrative support, Amy Gross, PhD at the MDH for statistical support, and John McGregor at VON who supported the learning collaborative at participating hospitals.

**Conflict of interest statement:** The authors have no competing interests nor conflicts of interest to disclose relevant to this project.

**Financial Disclosures**

Dr. Hudak was a paid consultant to the Maryland Patient Safety Collaborative. Dr. Horbar is Chief Executive Officer, President, Chief Scientific Officer, and an unpaid member of the Board of Directors of Vermont Oxford Network. Dr. Edwards receives salary support from Vermont Oxford Network. Dr. Buus-Frank was Executive Vice President and Director of Quality Improvement and Education at Vermont Oxford Network.

**REFERENCES**


Figure legends:

Figure 1: The Key Driver Diagram for the MPSC NAS project.

Figure 2: Cumulative total Maryland VON NAS certificates awarded from October 2016-December 2018.

Figure 3: Run chart showing the median LOS of all newborns with an ICD-10 diagnosis of NAS. The baseline period ran from January through September 2016 and the measure period ran from October 2016 through December 2018.

Figure 4: Run chart showing the percentage of term newborns (gestational age ≥ 37 weeks) with an ICD-10 diagnosis of NAS and a total hospital LOS greater than 5 days who were transferred to a higher-level neonatal unit or to a specialty hospital. The baseline period ran from January through September 2016 and the measure period ran from October 2016 through December 2018. Based on the 24-month measure period of October 2016 – September 2018, the median percentage of NAS transfers decreased significantly from 22.5% to 13.9% based on a 95% confidence level.
Figure 2. Total Maryland NAS Certificates Earned, October 2016 – December 2018
Figure 3 Median Length of Stay (LOS) of Newborns with NAS, Maryland, January 2016-December 2018
Figure 4 Percent of Term (≥ 37 weeks’ gestation) NAS Newborns Transferred to a Higher-Level Nursery or Specialty Hospital by Month, Maryland, January 2016-December 2018

Table 1. Percent of Centers with a NAS Policy or Guideline

<table>
<thead>
<tr>
<th></th>
<th>Audit 1 (N=31 hospitals) Jan-Mar 2016 (%)</th>
<th>Audit 2 (N=31 hospitals) Jul-Sep 2018 (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening for maternal substance use</td>
<td>96.8</td>
<td>96.8</td>
<td>NS</td>
</tr>
<tr>
<td>Evaluation and comprehensive treatment at infants at risk for or showing signs of withdrawal</td>
<td>68.8</td>
<td>93.5</td>
<td>0.012</td>
</tr>
<tr>
<td>Use of a scoring system</td>
<td>100.0</td>
<td>100.0</td>
<td>NS</td>
</tr>
<tr>
<td>Formal education program that promotes standardization of NAS scoring</td>
<td>50.0</td>
<td>64.5</td>
<td>0.244</td>
</tr>
</tbody>
</table>
Non-pharmacological treatment of NAS | 50.0 | 77.4 | 0.024
Pharmacological treatment of NAS | 53.1 | 87.1 | 0.003
Breastfeeding or the provision of expressed human milk in substance exposed infants | 56.3 | 71.0 | 0.225

Table 2. Discharge Characteristics and Length of Stay for Term Infants with NAS, 2016-2018

<table>
<thead>
<tr>
<th>Year</th>
<th>NAS Newborns (No.)</th>
<th>NAS Newborns Discharged Home 0-5 Days (%)</th>
<th>NAS Newborns Discharged Home &gt; 5 Days (%)</th>
<th>% NAS Newborns Transferred* (%)</th>
<th>LOS (days) for NAS Newborns Discharged Home &gt; 5 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>2016</td>
<td>786</td>
<td>26.5</td>
<td>53.4</td>
<td>20.1</td>
<td>17.9</td>
</tr>
<tr>
<td>2017</td>
<td>763</td>
<td>27.7</td>
<td>58.1</td>
<td>13.8</td>
<td>17.9</td>
</tr>
<tr>
<td>2018</td>
<td>729</td>
<td>30.6</td>
<td>58.4</td>
<td>11.0</td>
<td>16.4</td>
</tr>
</tbody>
</table>

Total live births in Maryland numbered 73,073 in 2016; 71,589 in 2017; and 71,037 in 2018.

*Trend statistically significant at p< 0.005