MATERNAL AND INFANT-FOCUSED NEONATAL ABSTINENCE SYNDROME INVESTMENT PROGRAM

EVALUATION REPORT

MASSACHUSETTS
HEALTH POLICY COMMISSION

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KEY TERMS

DCF	Department of Children and Families
EI	Early Intervention
LOS	Length of stay
MOUD	Medications for Opioid Use Disorder[i]
NAS	Neonatal Abstinence Syndrome
NICU	Neonatal Intensive Care Unit, a level III hospital nursery (the highest level of care for newborns).
NON-PHARMACOLOGIC INTERVENTIONS	Non-pharmacologic interventions include rooming-in, skin-to-skin contact, and use of mother's milk (breastfeeding and pumping of breastmilk) to reduce symptoms of NAS and the need for pharmacologic treatment and encourage maternal involvement in the care of the newborn.
NON-PRESCRIBED OPIOID USE	Use of opioids not according to prescription by medical professional
OEN	Opioid Exposed Newborn
OUD	Opioid Use Disorder
PEER MOMS/RECOVERY COACHES	Peer moms/recovery coaches —also known as peer mentors—are staff members in recovery who have lived experience of OUD and pregnancy. They are trained to support families from the prenatal to postpartum periods, encouraging women to feel safe and confident during their pregnancy journeys.
PERINATAL	The period occurring before, during, and after birth
SCN	Special Care Nursery, a level II hospital nursery.
SUD	Substance Use Disorder

i For the purposes of this report MOUD is used in place of Medication-Assisted Treatment (MAT) to reduce stigma and support evidence that medication is a primary treatment for addiction.

EXECUTIVE SUMMARY

BACKGROUND

The opioid epidemic has impacted millions of lives in the United States, including reproductive-aged and pregnant women[ii] who have experienced significant increases in rates of opioid use disorder (OUD).[1] From 1999 to 2014, the country saw maternal OUD rates at delivery more than quadruple.[2] Opioid use during pregnancy and after delivery can affect the health of both mother and infant. Infants exposed to opioids in utero may experience a period of withdrawal called neonatal abstinence syndrome (NAS[iii]), with symptoms including feeding intolerance, tremors, irritability, and in some instances, respiratory distress and seizures.[3] In Massachusetts, there was a six-fold increase in the incidence of NAS between 2004 and 2013.[4] In response to these trends, providers, policy makers, and communities have recognized opportunities to improve care and supports for infants and families impacted by OUD.

Caring for infants with NAS can be costly and complex, often requiring infants to be transferred to a higher level of care (e.g., the neonatal intensive care unit (NICU) or special care nursery (SCN)) to monitor infants' symptoms and administer pharmacologic treatment as appropriate.[5] In 2012, the national average inpatient stay after birth for infants diagnosed with NAS was 16.9 days, with a mean hospital charge per stay of $66,700. In comparison, the mean hospital charge for an uncomplicated term (37+ weeks gestation) infant birth was $3,500.[6] Transfer to a higher acuity setting can require separating the mother from their infant, often for extended periods, which inhibits mother-infant bonding.

Emerging evidence suggests that an integrated, family-centered approach that involves substance use treatment for mothers and symptom prevention and management in a lower acuity setting for infants may be preferable and more cost-effective than previous approaches.[3,7] Recent studies have demonstrated that non-pharmacologic interventions, including use of mother's milk (breastfeeding and pumping of breastmilk), rooming-in (care of the infant in the same room as the mother), and skin-to-skin contact (placement of the infant directly on the chest of the mother or family member), have been associated with reduced hospital length of stay (LOS) for infants, reduced NICU admissions, and decreased need for pharmacologic treatment among opioid exposed newborns (OENs).[8,9,10,11] Furthermore, the Association of State and Territorial Health Officials (ASTHO) suggests that – in addition to attending to the needs of infants – care models should provide comprehensive care for the mother, including treatment for medical needs, substance use disorder(s), and any underlying social and mental health needs.[12] To accelerate adoption of evidence-based interventions and emerging best practices to care for mothers with OUD and OENs, the Massachusetts Health Policy Commission (HPC) developed the Mother and Infant-Focused Neonatal Abstinence Syndrome Investment Program (NAS Investment Program) in 2016.

OVERVIEW OF THE HPC'S MOTHER AND INFANT-FOCUSED NEONATAL ABSTINENCE SYNDROME INVESTMENT PROGRAM

The primary goal of the NAS Investment Program was to test promising interventions to improve quality of care for OENs and their mothers. Following a competitive selection process, the HPC Board approved close to $3 million in funding for the NAS

ii For the purposes of this report the terms "woman/en" and "mother" were independently defined by each citation and hospital based on their data collection practices. The HPC recognizes that birthing people can include transgender and nonbinary people, and that the term "mother" does not always identify the birthing parent.

iii NAS refers to clinical symptoms in newborns following in-utero exposures; it has been mostly used to describe opioid withdrawal. Most recently, Neonatal Opioid Withdrawal Syndrome (NOWS) is increasingly being used as an alternative term to refer to symptoms in newborns following in-utero opioid exposure specifically, rather than other substances. For this report, NAS is used to refer to newborn opioid withdrawal in alignment with the Request for Proposals.

Investment Program across six hospital awardees: Baystate Medical Center, Beverly Hospital, Boston Medical Center, Lawrence General Hospital, Lowell General Hospital, and UMass Memorial Medical Center. Awardees of the NAS Investment Program implemented inpatient quality improvement interventions that focused on family-centered approaches to improving care and reducing hospital LOS, NICU admissions, and need for pharmacologic treatment. Key components of the care model included:

INCREASING NON-PHARMACOLOGIC INTERVENTIONS	OPTIMIZING NAS PHARMACOLOGIC TREATMENT	INCREASING ACCESS TO WRAPAROUND SERVICES
Increasing non-pharmacologic interventions such as rooming-in, skin-to-skin contact, use of mother's milk, and sustained maternal presence at the infant's bedside to reduce NAS symptoms and encourage parental involvement in the care of the infant.	Optimizing NAS pharmacologic treatment by standardizing clinical scoring methods for NAS symptoms and modifying medication protocols to ensure infants receive appropriate dosing when medication is necessary.	Increasing access to services for mother and infant after hospital discharge to support their recovery and enable mothers to care for their infant and families in a safe and healthy environment.

In addition, staff from the six awardees participated in trainings, such as trauma informed care trainings, to improve their knowledge about working with this population and to address implicit biases and stigma. The awardees also received technical assistance offered by the HPC via its clinical advisor, the Neonatal Quality Improvement Collaborative of Massachusetts (NeoQIC).

FINDINGS AND LESSONS LEARNED

The six awardees greatly improved care and outcomes for mothers with OUD and infants at risk for NAS. Between January 2017 and April 2019, a total of 1,107 mother-infant dyads received care through the NAS Investment Program. Specific results include:

- **Hospital Utilization:** The adoption of evidence-based interventions and expansion of services for mothers with OUD led to significant improvements in care and outcomes for infants at risk for NAS, including a nearly 50% reduction in need for pharmacologic treatment, a 30% reduction in use of intensive care settings, and a 33% reduction in hospital LOS.
- **Non-Pharmacologic Interventions:** The reductions in hospital utilization were driven by increased adoption of non-pharmacologic interventions such as rooming-in (18% increase), use of mother's milk (23% increase), and skin-to-skin contact. According to staff, these interventions empowered parents to care for their infants, increased maternal-infant bonding, and improved patient experience due to increased parental involvement in the infant's care.
- **Continuum of Care:** Awardees of the NAS Investment Program expanded wraparound services, including access to substance use treatment, social resource connections, and/or government services. Many teams integrated new staff roles, such as peer moms/recovery coaches and social workers, to provide continuous education and support to parents. These connections to services in combination with an understanding care team helped women feel prepared and supported in their parenting journey.

SUSTAINABILITY

The NAS Investment Program was designed to catalyze organizational changes that advanced best practices in care for OENs and their families during and after the grant period. To create durable change, awardees focused on both culture and practice. Awardees described that one of the greatest achievements of the NAS Investment Program was changing attitudes and culture in the care for families, mothers, and infants impacted by OUD. These culture changes are particularly significant because they are both a prerequisite for successful practice change and a means of sustaining those changes over time within their institutions. The six awardees were leaders in state-wide quality improvement efforts, openly sharing data, practices, and ideas with birthing hospitals across the state. This strong collaboration, built through the NAS Investment Program, allowed for sustained improvements in care for families affected by OUD across the Commonwealth and continues to encourage innovative approaches to caring for patients impacted by OUD.

ABOUT THE HPC

The HPC is an independent state agency that advances a more transparent, accountable, and equitable health care system through its policy leadership and innovative investment programs. The HPC's goal is better health and better care – at a lower cost – for all residents across the Commonwealth.

INTRODUCTION

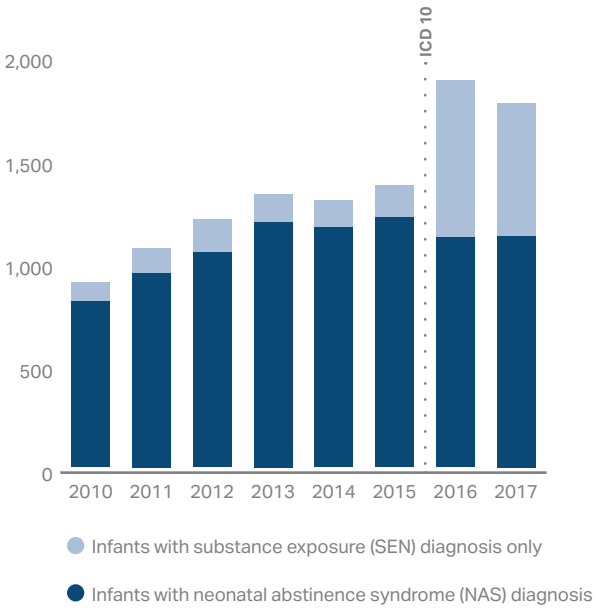
BACKGROUND: PERINATAL OPIOID USE DISORDER AND NEONATAL ABSTINENCE SYNDROME

Over the last two decades, there has been a dramatic increase in the use of opioids in the United States, with New England having among the highest rates of opioid use disorder (OUD) in the country.[13] This rise in opioid use has also led to increases in the incidence of OUD in pregnancy and the incidence of neonatal abstinence syndrome (NAS), nationally and locally. Massachusetts has been particularly impacted by these trends, with the incidence of infants diagnosed with NAS or born substance-exposed in the state increasing six-fold from 2004 to 2013 and two-fold from 2010 to 2017 (see **Exhibit 1**).[6,14] NAS is a condition that can affect infants with prenatal exposure to opioids as a result of the mother's use of opioids and/or prescribed medications for opioid use disorder (MOUD). Infants with NAS exhibit symptoms of opioid withdrawal including irritability, tremors, feeding intolerance, and, in some instances, respiratory distress and seizures.[3] Caring for infants with NAS can be complex and costly. In the past, the dominant model of treatment for infants with NAS has been centered on pharmacologic treatment with opioids — most commonly neonatal morphine — often requiring transfer of the infant to a higher level of care.[5]

The increase in the number of opioid exposed newborns (OENs) and infants with NAS has substantial implications for the health care system and for families. Increasing numbers of infants with NAS has led to increased admissions to the neonatal intensive care unit (NICU), longer hospital lengths of stay (LOS), and rising health care costs that particularly burden public payers.[6,5,15] In 2012, the national average for an inpatient stay after birth for infants diagnosed with NAS was 16.9 days, with a mean hospital charge per stay of $66,700. In comparison, the mean hospital charge for an uncomplicated term (37+ weeks gestation) infant birth was $3,500.[6] Long hospital stays, often in the NICU, have important implications for families: separating infants from families inhibits opportunities for parents to bond with their children and to be involved in their infants' care in the hospital.

Over the last decade, however, evidence has emerged suggesting that non-pharmacologic interventions may be preferable to treating infants with NAS.[3,7] Studies have shown that these non-pharmacologic interventions, centered on family engagement and parental presence, have been associated with reduced hospital LOS, reduced NICU admissions, and decreased need for pharmacologic treatment.[8,9,10,11]

Exhibit 1: Trends of NAS/SEN births in MA, 2010–2017



Addressing the rise in perinatal opioid use also requires prioritizing care and recovery for the mother. A critical component of caring for women with OUD is identifying OUD in pregnancy and ensuring appropriate treatment, including the use of MOUD when appropriate, and providing counseling and wraparound social services.[12] While initiating maternal MOUD may increase the

risk of NAS for infants, it also improves outcomes for mother and infant overall. Mothers on MOUD are at less risk for relapse, are more likely to adhere to prenatal care and addiction treatment programs, and are at lower risk for obstetric complicatons.[16] After delivery, mothers who are in treatment for OUD with MOUD and avoid non-prescribed opioid use are more likely to engage in non-pharmacologic interventions, particularly breastfeeding; currently, guidelines encourage breastfeeding for mothers with OUD that are stable on medication treatment and discourage breastfeeding for mothers using non-prescribed opioids.[16,17] Data also suggests that mothers on MOUD without non-prescribed opioid use may be able to spend more time at their infant's bedside.[9] In light of these and other findings, the benefits of maternal MOUD to both mother and infant should outweigh the potential association of increased NAS severity, and MOUD should continue to be used to treat perinatal OUD when appropriate.

Comprehensive care for pregnant and parenting women with substance use disorders (SUD) often requires treatment for co-occurring mental health conditions and polysubstance use, as well as social needs, such as housing and employment support.[18,19] Adverse childhood and adult experiences play a critical role in many women's development of non-medical drug use. For example, psychological and emotional distress as well as physical or sexual abuse are considered risk factors for non-prescribed opioid use among women.[20] In addition, barriers to access, lack of trust, stigma, and fear can deter pregnant women with OUD from engaging in care.[17] Many pregnant women with SUD report negative experiences with health care institutions due in part to the history of criminalizing substance use during pregnancy.[21] While the American College of Obstetrics and Gynecology has consistently stated that drug use in pregnancy does not necessarily indicate an individual's parental fitness,[22] misinformation and implicit and/or explicit biases among staff can negatively affect attitudes toward women with OUD and their ability to parent effectively. Engaging with pregnant and parenting women with OUD requires health care organizations to reorient their approach to care by offering a family-centered care model that extends beyond traditional obstetric care to build trust and address mental health, substance use, and socioeconomic barriers.[23, 24, 25]

In the context of the increasing incidence of perinatal opioid use in Massachusetts and the need for effective care models to treat mothers and infants affected by OUD, the HPC developed the Mother and Infant-Focused Neonatal Abstinence Syndrome Investment Program (NAS Investment Program). Through this investment, the HPC sought to accelerate adoption of evidence-based interventions and emerging best practices to care for OENs, promote strategies that increase retention in addiction treatment for pregnant and postpartum women, and promote integration of health and social services to meet the complex, multifaceted needs of these families.

OVERVIEW OF THE HEALTH POLICY COMMISSION'S MOTHER AND INFANT-FOCUSED NEONATAL ABSTINENCE SYNDROME INVESTMENT PROGRAM

Chapter 224, "An Act Improving the Quality of Health Care and Reducing Costs through Increased Transparency, Efficiency and Innovation," authorized the HPC to invest in new and promising care delivery and payment models through initiatives such as the Health Care Innovation Investment (HCII) Program, a competitive investment program. In the FY 2015 state budget, the legislature directed the HPC to implement an investment program to enhance and/or improve care for OENs and for women with OUD during and after pregnancy.

In March 2016, the HPC launched its $3 million NAS Investment Program to test promising interventions to improve quality of care for OENs and their mothers. The NAS Investment Program supported six eligible birthing hospitals in Massachusetts to develop and/or enhance programs with goals to: 1) increase treatment supports for women with OUD during pregnancy; 2) test a fully integrated model of postnatal supports for families with substance exposed newborns; and 3) demonstrate that cost-savings and quality improvement are both achievable through an integrated delivery model to care for OENs and their full family units.

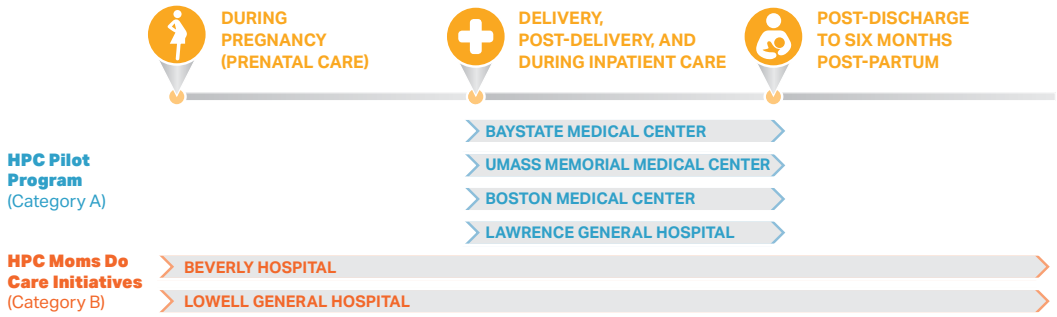
Within the NAS Investment Program, two tracks of funding were made available. In Category A, eligible birthing hospitals[iv] were invited to request up to $250,000 to support development and/or refinement of hospital inpatient quality improvement initiatives related to NAS (e.g. non-pharmacologic interventions, NAS severity scoring protocol development, and training on these and other relevant topics). In Category B, eligible birthing hospitals[v] were invited to request up to $1,000,000 to: 1) implement Category A hospital inpatient quality improvement initiatives, 2) increase the use of evidence-based MOUD for pregnant and postpartum women with OUD, and 3) increase the number of buprenorphine-waivered obstetrician/gynecologists and primary

iv Category A funding was made available to birthing hospitals that were not eligible for the Community Hospital Acceleration, Revitalization, and Transformation (CHART) Investment Program.

v Category B funding was made available to birthing hospitals that were eligible for the Community Hospital Acceleration, Revitalization, and Transformation (CHART) Investment Program.

care providers affiliated with the applicant birthing hospital. As outlined in **Exhibit 2**, four hospitals, Baystate Medical Center, Boston Medical Center, Lawrence General Hospital, and UMass Memorial Medical Center, received Category A funding. Two hospitals, Beverly Hospital and Lowell General Hospital, received Category B funding (see **Sidebar: The Moms Do Care Program (Category B)**). The findings and lessons learned within this report focus primarily on the Category A hospital inpatient quality improvement initiatives implemented at all six hospitals.

Exhibit 2: Funding outline of the NAS Investment Program



HOSPITAL	CATEGORY	AWARD	PREPARATION START	IMPLEMENTATION START	GRANT COMPLETION
Baystate Medical Center	A	$249,778	January 2017	March 2017	August 2018
Beverly Hospital	B	$1,000,000	February 2017	June 2017	April 2019
Boston Medical Center	A	$248,976	January 2017	March 2017	August 2018
Lawrence General Hospital	A	$250,000	February 2017	May 2017	April 2019
Lowell General Hospital	B	$999,032	February 2017	June 2017	May 2019
UMass Memorial Medical Center	A	$249,992	January 2017	April 2017	September 2018

SIDEBAR: THE MOMS DO CARE PROGRAM (CATEGORY B)

In addition to implementing hospital inpatient quality improvement initiatives (Category A), the two awardees that received Category B funding (Beverly Hospital and Lowell General Hospital) implemented the Moms Do Care (MDC) program. The MDC model was initially piloted in Cape Cod and Worcester in 2015 through the Massachusetts Department of Public Health's (DPH) federal Targeted Capacity Expansion grant, administered by the Substance Abuse and Mental Health Services Administration (SAMHSA), which aimed to expand Medication Assisted Treatment for Prescription Drug and Opioid Addiction (MAT-PDOA). The MDC program aims to expand medical and behavioral health service system capacity to engage and retain pregnant and postpartum women with OUD in trauma-informed and integrated MOUD which includes health care, addiction, and recovery support services. Participants in the MDC program are supported in recovery throughout the prenatal and postpartum periods by a peer mom/recovery coach and a multidisciplinary care team. In addition, providers go through several training sessions (e.g., trauma-informed care, compassion fatigue, paths to recovery) to provide better care to participants. The two MDC initiatives that were implemented at Category B Hospitals were administered separately by DPH, and evaluated by an organization sub-contracted by DPH, Advocates for Human Potential (AHP). Key findings from the MDC initiatives can be found in the Sidebar: Findings from the Moms Do Care initiatives. In parallel to the MDC program, the HPC, pursuant to an agreement with DPH, supported the Boston Medical Center Office-Based Addiction Treatment Training and Technical Assistance Center (OBAT TTA) to provide waiver training throughout Massachusetts, with an emphasis on regions with MDC sites.

All six awardees implemented inpatient quality improvement interventions to improve care and reduce hospital LOS, NICU admissions, and need for pharmacologic treatment. Key components of the care model included increasing non-pharmacologic interventions, optimizing NAS pharmacologic treatment, and increasing access to services for mother and infant after discharge.

Exhibit 3: Key components of the NAS Invesment Program

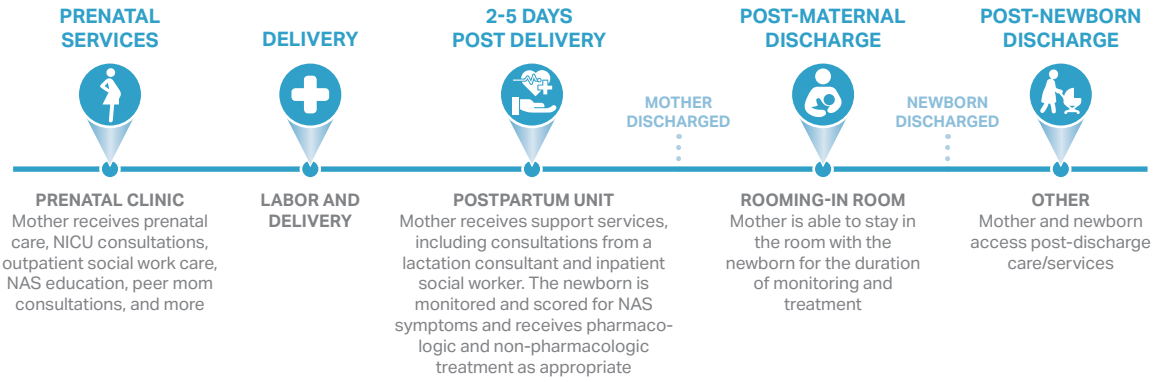
Increasing non-pharmacologic interventions. Awardees focused on promoting non-pharmacologic interventions such as rooming-in, skin-to-skin contact, use of mother's milk (breastfeeding and pumping of breastmilk), and sustained maternal presence at the infant's bedside, particularly after maternal discharge. Research shows that these approaches have been seen to reduce symptoms of NAS and the need for pharmacologic treatment and encourage maternal involvement in the care of the infant.[8,9,10,11]

Optimizing NAS pharmacologic treatment. Awardees standardized assessment and scoring of NAS symptoms and optimized protocols for pharmacologic treatment to ensure infants received appropriate dosing when medication was necessary. Some programs standardized their use of the Finnegan Neonatal Abstinence Scoring System (FNASS)[vi], while others implemented the Eat, Sleep, Console (ESC) approach.[vii]

Increasing access to services for mother and infant after discharge. Awardees implemented NAS discharge care plans (Plan of Safe Care[viii]) and facilitated transitions to family support, peer counseling, Early Intervention (EI) services, pediatric primary care, and engagement with the Department of Children and Families (DCF). In addition, awardees hired new staff such as social workers and peer moms/recovery coaches to better support patients.

The pathway below (see **Exhibit 4**) provides an example of services typically offered during the prenatal to postpartum periods. While the awardees implemented similar initiatives, each site modified their care model based on patient needs and existing hospital resources and processes (for more details about each site, see **Appendix: Highlights of Individual Initiatives**).

Exhibit 4: Example care pathway from mother-infant dyad impacted by OUD



Adopting new care components required capacity building efforts to improve provider knowledge, skills, and attitudes. These activities included: training staff on addiction and trauma-informed care, improving data collection, implementing principles of quality improvement (QI), and participating in technical assistance provided by the Neonatal Quality Improvement Collaborative of Massachusetts (NeoQIC) (see **Sidebar: sidebar: NeoQIC**).

vi FNASS is a tool that provides a severity score based on 21 clinical signs of opioid withdrawal.

vii ESC NAS assessment tool determines a need for intervention for NAS based on the infant's ability to maintain essential functions of eating, sleeping, and consoling.[11]

viii The Plan of Safe Care is a document created jointly by a pregnant or parenting woman, and her provider. This document helps women to think about what services or supports they might find useful, to record their preparations to parent and organize the care and services they are receiving.

SIDEBAR: NEOQIC

NeoQIC is a voluntary collaborative of newborn health care providers in Massachusetts that seeks to improve care through joint quality improvement initiatives. NeoQIC first launched improvement efforts around NAS in 2012, focusing on in-hospital care of infants with NAS including standardization of symptom assessment and pharmacologic treatment. In 2015, the Massachusetts Perinatal Quality Collaborative (MPQC), a statewide quality collaborative of obstetric providers, created a task force on the care of mothers with OUD and developed a comprehensive toolkit of best practices and resources. To better align these efforts, NeoQIC and MPQC formed the Perinatal Neonatal Quality Improvement Network of Massachusetts (PNQIN) in 2016 and launched a joint collaborative aimed at improving the care of mothers, infants, and families affected by perinatal opioid use. The concurrent partnership with HPC allowed NeoQIC and PNQIN to develop new structures and tools to drive improvement efforts. The collaborative is anchored on biannual statewide summits that bring together hospitals, community providers, public health agencies, community organizations, and families, and is supported by numerous other activities including webinars, trainings, and toolkits. Throughout the HPC's NAS Investment Program, NeoQIC provided technical assistance to the six awardees, facilitated cross-team learnings, conducted trainings, and supported data collection and analysis.

EVALUATION APPROACH OVERVIEW

The HPC used a mixed methods evaluation approach to understand the implementation and impact of the NAS Investment Program (see **Appendix: NAS Investment Program Evaluation Methods**). Qualitative assessments of written deliverables and interviews with staff across the six awardees were conducted by the HPC over the course of the NAS Investment Program. Quantitative assessments were based on key performance indicators (KPIs) and secondary measures jointly developed by the HPC and NeoQIC based on a review of the literature and input from key stakeholders. NeoQIC worked directly with awardees to collect quantitative data for these metrics throughout the NAS Invesment Program.

Given the focus on quality improvement as a foundation for this work, quantitative data analysis focused on performance over time. Metrics were assessed across all six awardees in aggregate with quarterly data. Statistical process control[ix] methods were used for data analysis, including control charts and run charts. Data from 2016 was considered baseline and compared to performance data from January 2017 through June 2019. During the baseline period from January 2016 to December 2016, 406 mother-infant dyads received care across the six awardees. During the intervention period, from January 2017 to June 2019, a total of 1107 mother-infant dyads received care. In addition to time-series analyses of the main performance indicators, sub-group analyses and multivariate regression models were used to better understand the drivers of improvement (see **Appendix: Multivariate Modeling**).

Measures addressed maternal care, neonatal care, and post-discharge care, with most measures focused on hospital-based care of the mother and infant. The findings and lessons learned from this program were organized into three categories:

CATEGORY	KEY METRICS
HOSPITAL UTILIZATION	• Rates of pharmacologic treatment for NAS • Location of care for infant • Hospital length of stay for infant
NON-PHARMACOLOGIC INTERVENTIONS	• Rooming-in of mother and infant (at least one night) • Use of mother's milk • Skin-to-skin contact • Cuddling programs
CONTINUUM OF CARE	• Wraparound prenatal and postpartum services • Department of Children and Families mandated referrals • Early Intervention referrals

ix Statistical process control is a statistical approach to data analysis widely used in quality improvement. It examines time-series data to understand whether variations in data represent normal fluctuations in a stable process or special signal reflecting a change in performance.[26]

FINDINGS AND LESSONS LEARNED

The six awardees achieved substantial improvements in care for mothers with OUD and OENs. They successfully implemented best practices by increasing non-pharmacologic interventions, optimizing NAS pharmacologic treatment, and increasing access to wraparound services. Throughout the intervention period, awardees observed reductions in the need for pharmacologic treatment, use of intensive care settings such as NICUs, and hospital LOS for infants. These outcomes were driven in part by the adoption of non-pharmacologic interventions as the primary approach to caring for OENs. At the same time, awardees worked to increase supports for mothers and families by providing wraparound services, including referrals to social services, connections to treatment, and coordination with the Department of Children and Families.

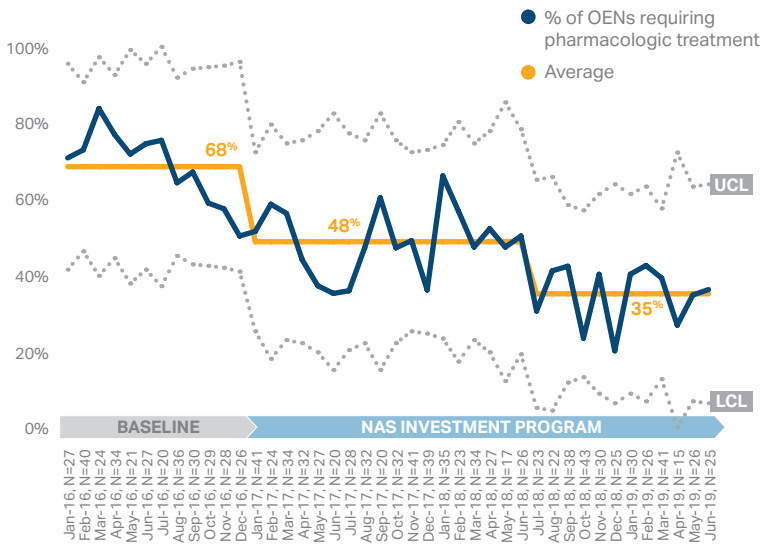
HOSPITAL UTILIZATION/IMPACT

By adopting evidence-based interventions and expanding services focused on OUD throughout the perinatal period, awardees saw reductions in need for pharmacologic treatment, use of intensive care settings, and hospital LOS.

REDUCTIONS IN NEED FOR PHARMACOLOGIC TREATMENT

Pharmacologic[x] treatment can be used to treat infants' symptoms of withdrawal; however, administering pharmacologic treatment often requires infants to be transferred to higher levels of care (NICU or Special Care Nursery (SCN)) for extended periods. NICUs and SCNs are expensive and can have physical environmental features, such as bright lights, constant sounds, and limited spacing, which are less conducive to parental engagement and may be stressful for infants. These features can prevent infants from being able to settle and can potentially exacerbate NAS symptoms. During the NAS Investment Program, all awardees focused on administering non-pharmacologic interventions as primary treatment for OEN, and, in cases where pharmacologic agents were still needed, optimizing dosing for pharmacologic treatment. When comparing data from the baseline year to the intervention period, the percentage of term OENs requiring pharmacologic treatment for NAS decreased from 68% to 48% to 35%, an overall reduction of nearly 50% (see **Exhibit 5**). A similar pattern was seen for all OENs (including both term and pre-term infants.) **Exhibit 5** shows that improvement began as the NAS Investment Program launched in early 2017. Further improvement was seen as the awardees continued to implement new strategies in 2018 to 2019.

Exhibit 5: Term OENs requiring pharmacologic treatment



x Pharmacologic treatment for NAS, when needed, is typically provided as morphine or methadone. For some patients, a second pharmacologic agent may be necessary; this is typically phenobarbital or clonidine.

The need for pharmacologic treatment for OENs is determined by a symptom scoring tool, making standardization of assessment and scoring of NAS symptoms an important intervention point. Hospital policy determines which scoring tool is used. Historically, hospitals have used the FNASS, a tool that provides a severity score based on 21 clinical signs of opioid withdrawal.[27] Two awardees focused on standardizing their use of the FNASS tool and optimizing protocols for pharmacologic treatment to ensure that infants received the most appropriate dosing. More recently, a new approach to scoring and treating NAS has emerged. In contrast to FNASS, the ESC approach determines the need for pharmacologic treatment for NAS based on the infant's ability to maintain essential functions of eating, sleeping, and being consoled.[10,11,27,28] ESC encourages families to participate in the scoring and treatment of their infants. During the intervention period, four awardees implemented and utilized the ESC approach.

Changes in scoring and medication protocols were initially met with hesitation from some hospital staff who anticipated that these changes might lead to under treatment and/or discomfort for the newborn. However, as awardees adopted innovative medication protocols, such as initiating Pro re nata (PRN) or "as needed" dosing of pharmacologic treatment and decreasing use of continuous cardiac monitoring, staff began to see the benefits for both infant and mother. Since pharmacologic treatment and the use of cardiac monitors usually require infants be in a NICU or SCN, these changes allowed infants to either stay with their mothers during their entire treatment process or experience only brief separations for treatment. In addition, many awardees stated that using the ESC approach encouraged providers to involve families in scoring and provision of non-pharmacologic interventions for the infant, leading to better outcomes.

REDUCTIONS IN ADMISSIONS TO NICU OR SCN

For some infants, a NICU or SCN is the most suitable care setting. When appropriate, however, care outside of a NICU or SCN offers several potential benefits, including a more soothing environment and increased opportunity for mother-infant bonding and non-pharmacologic interventions. Over the course of the NAS Investment Program, the percent of term OENs requiring care in a NICU/SCN decreased from 56% to 39%, a 30% decrease (see **Exhibit 6**). Much of this difference is likely due to the reduction in need for pharmacologic treatment (see **Exhibit 7**) and changes in some hospital policies such that infants receiving pharmacologic treatment no longer required transfer to a NICU or SCN (see **Non-pharmacologic Interventions: Rooming-In**).

REDUCTIONS IN INFANT HOSPITAL LENGTH OF STAY

The average hospital LOS[xi] for term OENs decreased from 18.0 days to 13.9 days to 12.1 days,

Exhibit 6: Term OENs receiving care in the NICU/SCN

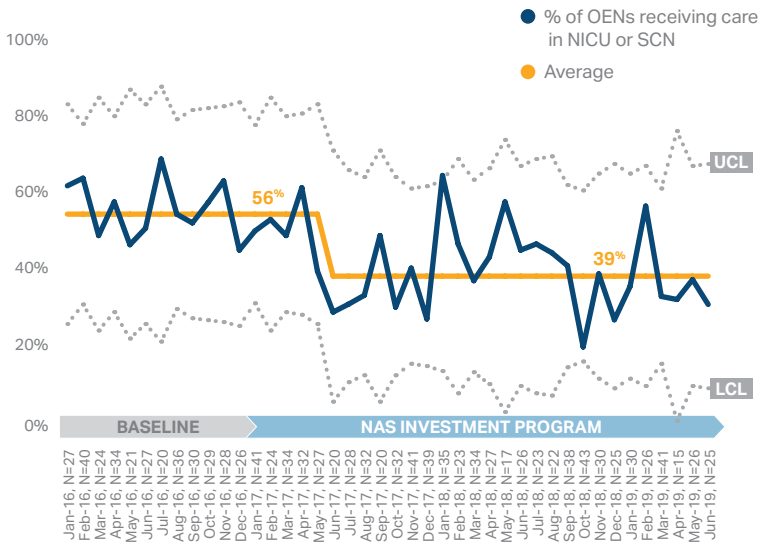
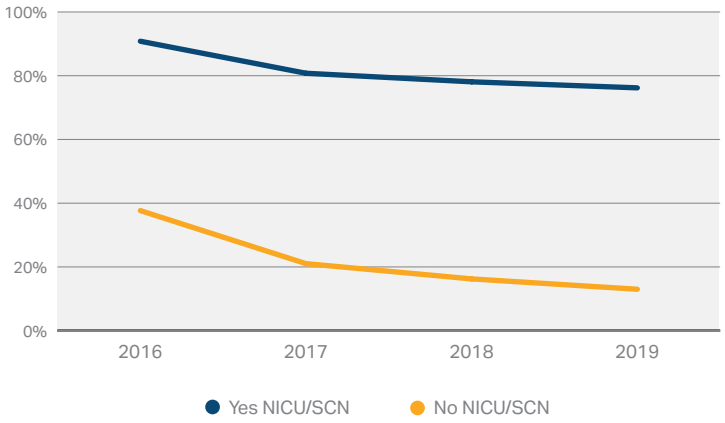


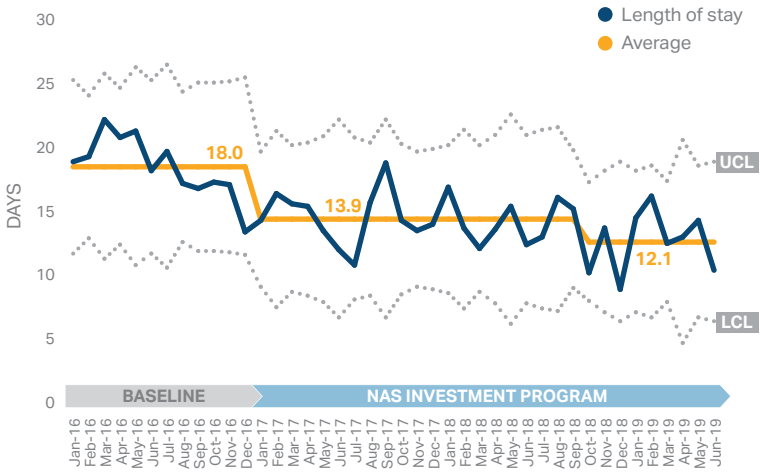
Exhibit 7: Term OENs receiving pharmacologic treatment by location of care



xi Median hospital LOS for term OENs decreased from 17 days to 8 days. Average and median hospital LOS differ due to skewed data, with a small number of infants having a relatively long length of stay.

a nearly 33% decrease over the course of the NAS Investment Program (see **Exhibit 8**). When the NAS Investment Program launched in 2017, awardees observed an immediate reduction in LOS, which continued to decline over the course of the program. Notably, for infants who required care in a NICU/SCN, the LOS within a NICU/SCN did not change, with a median NICU/SCN LOS of 12 days throughout the NAS Investment Program. This suggests the decrease in overall hospital LOS was driven through reductions in non-NICU/SCN LOS and/or reductions in need for NICU/SCN care.

Exhibit 8: Average length of stay (days) for term OENs



NON-PHARMACOLOGIC INTERVENTIONS

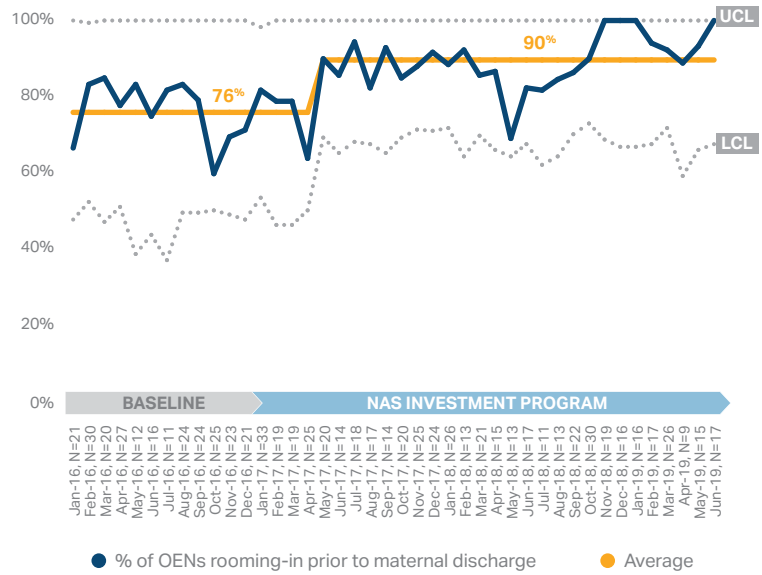
Increasing non-pharmacologic interventions centered on family engagement was a critical component of the NAS Investment Program. All awardees noted that the emphasis on non-pharmacologic interventions had a positive impact on infants, parents, and staff. According to staff, these interventions empowered parents to care for their infants, increased maternal-infant bonding, and improved patient experience due to increased parental involvement in the infant's care. Staff saw firsthand the benefits of non-pharmacologic interventions for both mother and infant, which, in combination with trainings, helped fight stigma and positively influence staff's knowledge, skills, and attitudes (see **Sustainability**). Additionally, non-pharmacologic interventions were strongly associated with better hospital utilization outcomes in subgroup and multivariate analyses.

ROOMING-IN

Rooming-in between infants and mothers is an effective non-pharmacologic intervention for infants at risk for NAS.[8,29] Rooming-in allowed for eligible mother-infant dyads to stay together while the infant was monitored and/or treated for NAS symptoms, and provided a private, quieter setting for rest and treatment than a NICU or SCN. Many awardees noted that rooming-in allowed for greater opportunity to engage in other non-pharmacologic interventions such as use of mother's milk and skin-to-skin contact. In addition, they stated that rooming-in allowed for greater parental engagement and increased the mother's confidence in her parenting skills.

For the purposes of the NAS Investment Program, rooming-in was defined as the infant staying in the mother's room for at least one night prior to maternal discharge. Rooming-in was measured for all term OENs as well as for term OENs deemed to be eligible for rooming-in according to individual hospital policy.[xii] Overall, 74% of term OENs across the six awardees were eligible for rooming-in. Among all term OENs eligible for rooming-in, 76% roomed-in at the start of the NAS Investment Program. That number increased to 90% in mid-2017 and was sustained throughout the duration of the NAS Investment Program (see **Exhibit 9**[xiii]).

Exhibit 9: Eligible term OENs rooming-in prior to maternal discharge (five awardees)



xii Hospital rooming-in eligibility criteria were similar across awardees, with some minor differences. All awardees considered dyads eligible for rooming-in unless safety for infant was a concern. Awardees varied in approach to rooming-in in situations when DCF had taken custody of the infant.

xiii One awardee was excluded because they did not have data for the baseline period.

Subgroup and multivariate analyses were completed to better understand the impact of rooming-in on NICU/SCN use, pharmacologic treatment, and hospital LOS. Lower rates of NICU/SCN care and pharmacologic treatment were seen among OENs that roomed-in (see **Exhibit 10 and 11**). Similar patterns were seen for LOS, with median hospital LOS for term OENs being lower for infants who received rooming-in compared to those who did not (see **Exhibit 12**).

While this analysis measured only one night of rooming in, many awardees also offered rooms for mothers to stay with their infants beyond maternal discharge from the hospital, sometimes for several weeks.[xiv] This allowed mothers to stay with their infants for the duration of the infant's treatment and promoted maternal engagement in the infant's care and mother-infant bonding. Providing space for extended rooming-in, however, requires an investment in space and resources. Rooming-in after maternal discharge can also be challenging for parents when life circumstances and competing priorities (e.g., transportation, coordinating care for an older child) make long-term rooming-in difficult.

Exhibit 10: Term OENs requiring care in NICU/SCN by receipt rooming-in

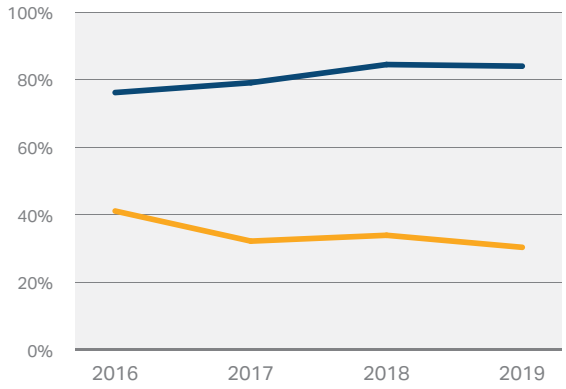


Exhibit 11: Term OENs requiring pharmacologic treatment for NAS by receipt of rooming-in

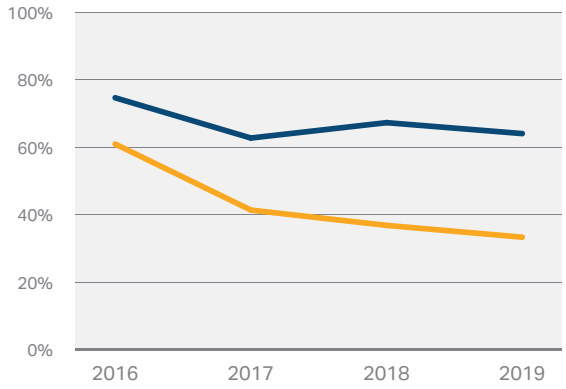
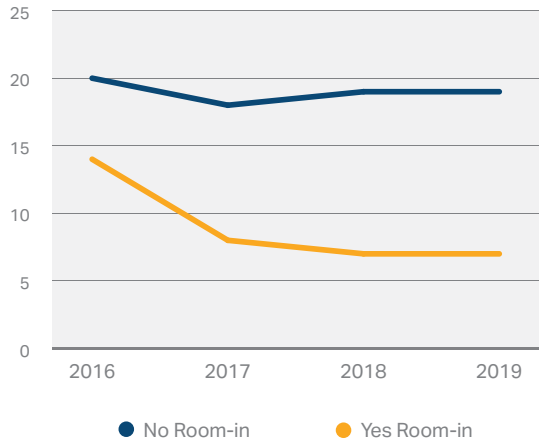


Exhibit 12: Median hospital LOS (days) for term OENs by receipt of rooming-in



xiv In 2019, NeoQIC began to collect an additional measure of rooming-in for at least one night after maternal discharge; this may prove to be a more useful measure of this non-pharmacologic intervention as it would more accurately reflect a hospital's ability to facilitate rooming-in throughout the newborn's hospitalization even beyond maternal discharge.

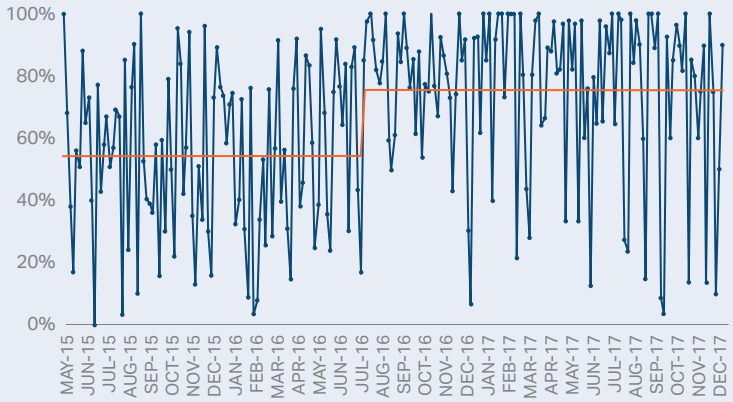
★ AWARDEE SPOTLIGHT: ROOMING-IN ★

Boston Medical Center aimed to increase parental time spent at infant's bedside by designating private rooms for rooming-in for mother and infant after maternal discharge. This allowed mothers to stay with the infant during monitoring and treatment. One of the many innovations in BMC's improvement efforts was establishing parental presence at bedside as a performance indicator, which allowed them to target improvements over time for this important measure. Their results around parental presence were shared in a 2018 publication which concluded that, "comprehensive QI programs focused on non-pharmacologic interventions, function-based assessments, and methadone resulted in significant sustained improvements in NAS outcomes." The publication noted parental presence increased from 55.6% to 75.8%. (see **Exhibit 13**).[10]

"The most important change has been the engagement of families into the care plan, with an increase in parental presence at the bedside throughout the hospitalization."

– BOSTON MEDICAL CENTER STAFF MEMBER

Exhibit 13: Parental presence at bedside by month of admission to Boston Medical Center



MOTHER'S MILK

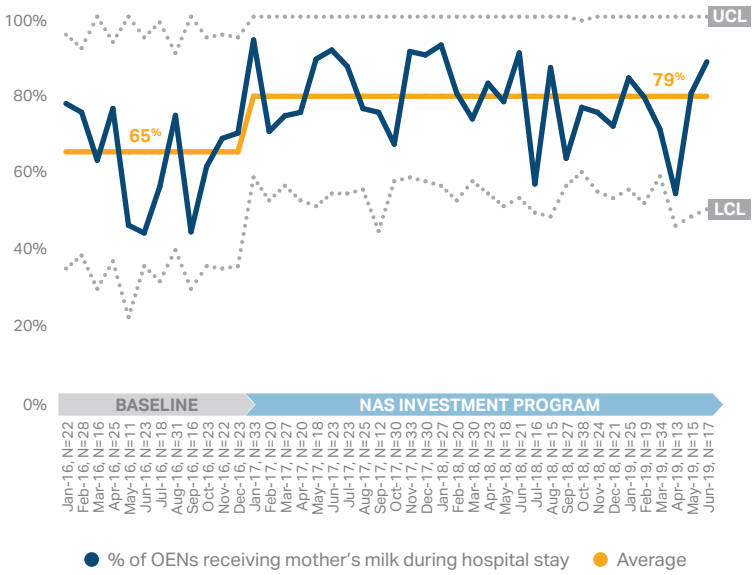
Use of mother's milk is associated with health benefits for both infant and mother.[30] Supporting appropriate use of mother's milk is an important component of non-pharmacologic interventions, and the American College of Obstetrics and Gynecology promotes that women on stable doses of MOUD should be encouraged to breastfeed.[31] Each hospital determines policies for use of mother's milk. These guidelines were generally similar across the six awardees, with mother's milk encouraged for mothers that were using only prescribed opioids, such as MOUD, but not permitted for mothers that were using non-prescribed opioids.

To better support breastfeeding, many awardees hired staff to provide education on the benefits of mother's milk and encourage the use of mother's milk throughout the hospitalization and postpartum periods. Awardees noted lactation teams, peer moms, nurses, and additional staff played an integral role in implementing breastfeeding initiatives and improving the culture of supporting mothers with breastfeeding. Despite these efforts, many awardees still encountered challenges when mothers were ineligible to breastfeed, infants did not gain adequate weight through breastfeeding alone, or mothers were unaware if breast-feeding their infant was safe. In response, they expanded hours of lactation education and support, placed pumps in convenient locations, and/or incorporated fortifying and bottle-feeding breastmilk into their protocols.

Awardees measured the use of mother's milk at any time during hospitalization and at hospital discharge for all OENs and for OENs eligible to receive mother's milk by hospital policy. Overall, 63% of OENs were eligible to receive mother's milk per hospital

policy over the course of the NAS Investment Program. Among eligible OENs, 65% were receiving mother's milk at the start of the NAS Investment Program, and this increased to nearly 80% in 2017 with the launch of awardees' initiatives, a 23% increase (see **Exhibit 14**). The 80% rate is comparable to national breastfeeding rates among all newborns; the latest data from the Centers for Disease Control and Prevention showed that 83% of infants born in 2015 in the United States received some amount of breastfeeding.[10,32] While both mother's milk during hospitalization and mother's milk at discharge are valuable metrics, mother's milk at the time of discharge more likely reflects potential sustainment of breastfeeding. Use of mother's milk among eligible OENs at discharge remained relatively consistent throughout the duration of the NAS Investment Program, at approximately 67%.

Exhibit 14: Eligible OENs receiving mother's milk during hospital stay



Similar to rooming-in, subgroup and multivariate analyses showed that infants who received mother's milk had lower rates of NICU/SCN use and pharmacologic treatment compared to OENs that did not receive mother's milk (see **Exhibit 15 and 16**). Similar patterns were seen for hospital LOS, with median hospital LOS for term OENs being lower for infants who received mother's milk compared to those who did not (see **Exhibit 17**).

Exhibit 15: Term OENs requiring care in NICU/SCN by receipt of mother's milk

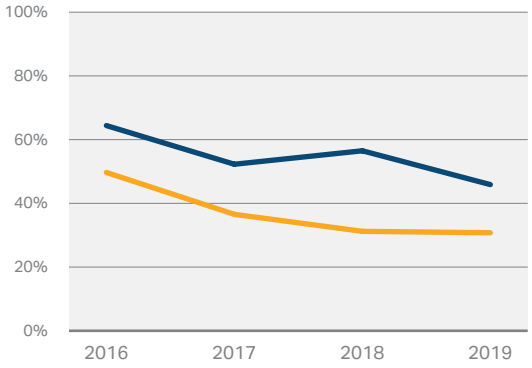


Exhibit 16: Term OENS requiring pharmacologic treatment for NAS by receipt of mother's milk

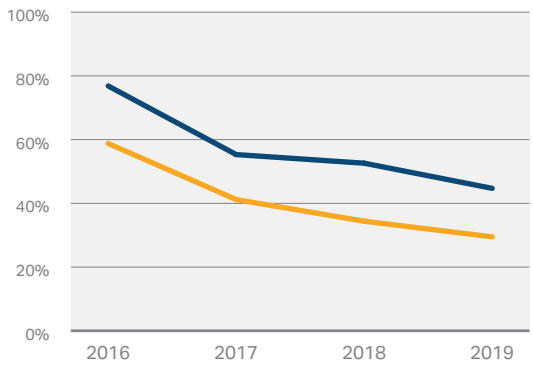
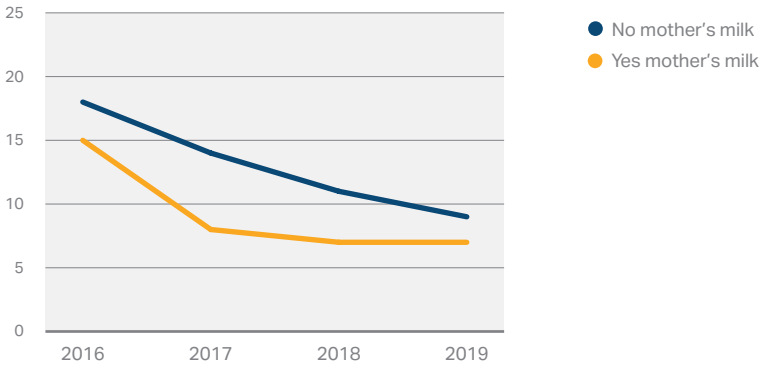


Exhibit 17: Median hospital LOS (days) for term OENs by receipt of mother's milk



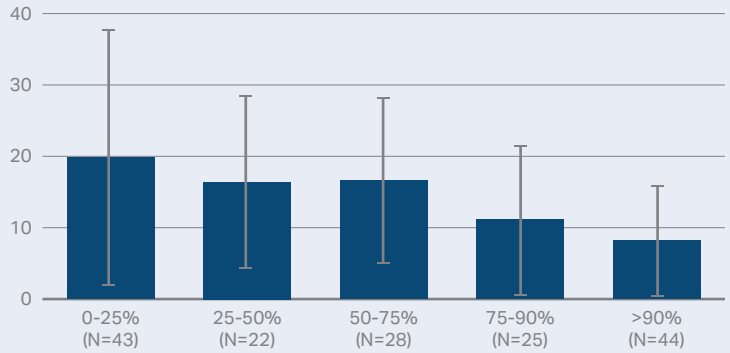
★ AWARDEE SPOTLIGHT: MOTHER'S MILK ★

UMass Memorial Medical Center noted breastfeeding promotion as one of the most successful non-pharmacologic intervention strategies in their initiative. The impact of the lactation team and peer mom, who was trained as a lactation consultant, were driving forces towards their breastfeeding goal. UMass also used additional analyses to examine specific innovations in NAS care, including a dose-response analysis showing shorter hospital LOS associated with increased use of mother's milk (see **Exhibit 18**).

"NICU length of stay didn't change that much, but we were able to shift so that [fewer infants] needed it. And the reason that [fewer] of them needed it is because we believe [our peer mom] was able to engage more of them in proactive breastfeeding, and our lactation consultants were able to capture them earlier and they would get more people to try."

–UMASS MEMORIAL MEDICAL CENTER STAFF MEMBER

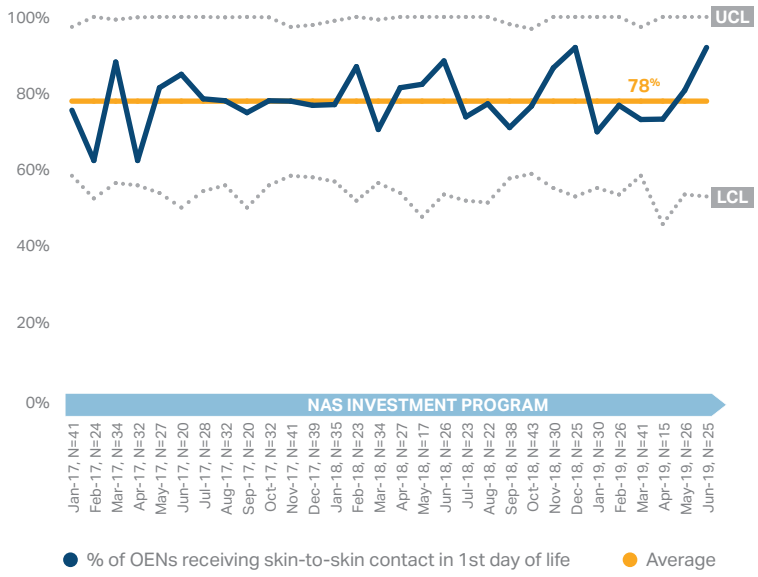
Exhibit 18: Percentage of mother's milk use by LOS (days) among eligible OENs (Q4 2016–Q3 2018)



SKIN-TO-SKIN CONTACT AND CUDDLING

Parental engagement through skin-to-skin contact strengthens the bond between parent and infant and helps soothe infants' irritability.[33] It is also important in monitoring infants' symptoms when using the ESC scoring approach. Awardees measured whether infants received skin-to-skin contact from a family member in the first day of life. Of note, this measure was less reliable than others, as skin-to-skin contact is not always documented in the patient chart as a specific intervention; thus, reported performance may be an underestimate. From 2017 to 2019, 76-78% of term OENs received skin-to-skin contact in the first day (see **Exhibit 19**), and no sustained change was seen over the course of the NAS Investment Program.

Exhibit 19: Term OENs receiving skin-to-skin contact in 1st day of life



Following similar patterns of the other non-pharmacologic interventions, OENs who received skin-to-skin contact were less likely to require pharmacologic treatment and care in a NICU/SCN, and more likely to have reduced hospital LOS.

Exhibit 20: Term OENS requiring pharmacologic treatment for NAS by receipt of skin-to-skin contact

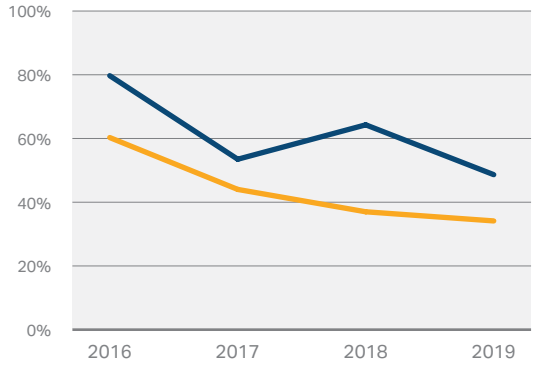


Exhibit 21: Term OENS requiring care in NICU/SCN by receipt of skin-to-skin contact

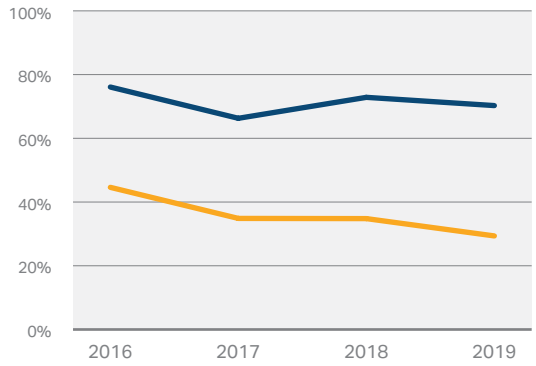
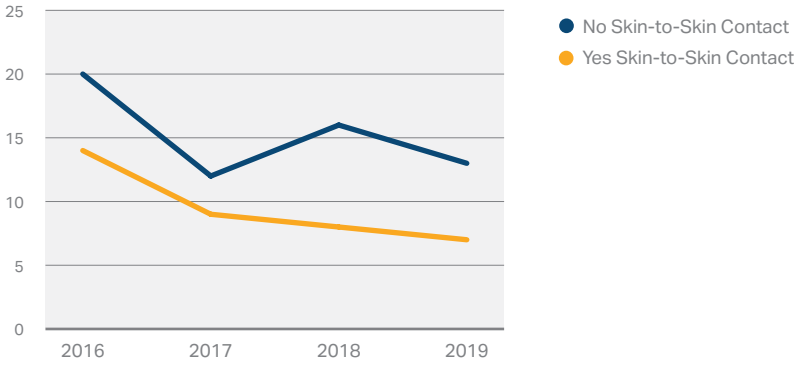


Exhibit 22: Median hospital LOS (days) for term OENs by receipt of skin-to-skin contact



★ AWARDEE SPOTLIGHT: CUDDLER PROGRAM ★

To increase non-clinical human contact when parents were not able to be present, many awardees created or expanded "cuddler programs" that placed volunteer cuddlers in the NICU, SCN, and occasionally in private rooms to ensure that OENs experienced regular soothing, regardless of if a parent or family member was able to be present at the bedside.

Lawrence General Hospital developed a comprehensive cuddler program for their hospital and set a goal of having cuddlers available at any time from 7am to 10pm, with some taking overnight shifts. After parents completed cuddler consent forms, hospital staff placed identifying tags on infants' bassinets stating, "I can be cuddled" so that volunteers were aware of the infants that were participating. Over the course of their initiative, Lawrence General Hospital increased their number of cuddlers and total hours of cuddling. In 2017, they used cuddlers for a total of 241 hours. In the first 7-months of 2019, they had already reached 685 hours. By fall 2019, they had recruited 80 active cuddlers with 12 new cuddlers scheduled to be trained in the coming months.

*"Our staff are now very open to the idea of cuddlers and have been successful with completing the cuddler consent forms with **all** new patients in the special care nursery."*

– LAWRENCE GENERAL HOSPITAL STAFF MEMBER

CONTINUUM OF CARE

Providing comprehensive services to women with OUD throughout their pregnancy, during labor and delivery, and in the post-partum period was an important component of the NAS Investment Program. It has been well documented that providing a targeted array of health services from pre-pregnancy to motherhood has a positive effect on improving maternal and newborn health.[34] However, women with OUD may be hesitant to engage in care given the historical context of the United States' drug policies.[35,36] The political and social response of drug use during pregnancy has led to a lack of trust in the health care system.[35,37]

During the NAS Investment Program, many awardees focused on combating the issue of distrust and addressing other barriers to engagement, such as lack of transportation, childcare, and support from family and friends. Awardees aimed to create a safe space for families to receive care, with some even providing parking vouchers and subsidized transportation services to decrease the burden of travel to and from the hospital for parents, or connecting families to various social services and groups to help provide additional support. These changes were made possible by expanding wraparound services, integrating new staff roles, and providing continuous education and support to parents and staff.

WRAPAROUND SERVICES AND ENGAGEMENT IN CARE

A key goal of awardees was to engage women in services as early as possible prenatally and provide additional support post-discharge by expanding wraparound services such as patient education, recovery support, and resource connections and referrals. They hired new staff in outreach and support roles, like social workers and peer moms/recovery coaches. These staff worked with women to understand the DCF reporting requirements and processes. They performed regular check-ups with families from six months to one year postpartum, with some awardees implementing home visiting models. This holistic approach to caring for families with the introduction of new staff roles and expertise helped shift hospital staff's attitudes, leading to a reduction in stigma and a more welcoming environment for patients in care settings (see **Sustainability**). These changes streamlined communication between inpatient and outpatient staff and increased maternal engagement and support for women with OUD throughout the continuum of care.

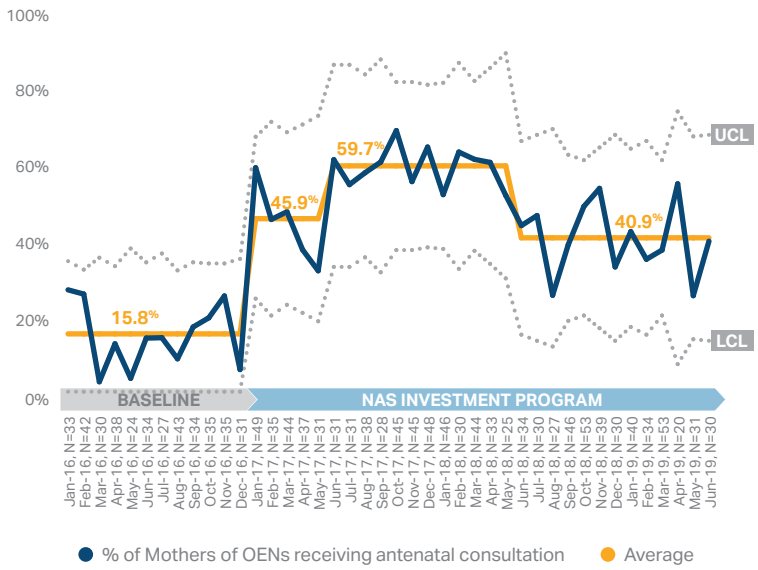
Providing additional support services and social resource connections was particularly important for this population, as women faced numerous barriers to engaging in both their own medical care, and care for their infant. These barriers included lack of transportation, housing instability, lack of support from friends and family, shame and fear associated with OUD, and the fear of possible family separation by DCF. To address these barriers, awardees implemented the following strategies:

PREGNANCY AND PARENTING EDUCATION	NAS SPECIFIC CARE	MATERNAL CARE AND SUPPORT SERVICES
• Childbirth education • Breastfeeding education and support • Mindfulness education • **Labor and delivery and pediatric staff consultations**	• Understanding NAS and NAS care • **DCF referral and screening process** • Plan of Safe Care	• Prenatal care engagement • Substance use treatment referrals and MOUD compliancy • Mental health services • **EI referrals**

In addition to implementing these strategies, care teams helped mothers feel prepared and supported during their inpatient care and after discharge. Many of the teams reported that the women who enrolled in their programs felt fearful or apprehensive about engaging with the health care system. Women had questions about NAS, the hospital's approach to caring for OENs, and the DCF process. Teams took time to create a welcoming and supportive environment for women and their families. As one staff member at Beverly Hospital noted, **"Providing a safe place to advocate for these moms as individuals, in whatever stage they're at in their recovery, whether they're still using or in long-term recovery, just making a safe place for them to build a community among themselves as women in recovery who are also mothers, is really important."** A Lawrence General Hospital staff member noted that, **"Women have expressed feeling more at ease coming into the hospital to deliver as they are aware of what to expect. In general, women suffering from addiction are hesitant to access health care based on judgement and stigma, amongst other things.** [...] **It's important for the women to feel as if they have an ally and support that is genuinely interested in their wellbeing."** To better understand how awardees connected families to other services, measurements were collected regarding antenatal consultations, DCF mandated referrals, and EI referrals.

ANTENATAL CONSULTATIONS: To improve communication with families, hospital teams encouraged mothers of OENs to meet with pediatrics or neonatology prior to delivery to review expected neonatal management plans. The percent of mothers of OENs that received an antenatal consultation with pediatrics or neonatology increased from 16% to 46% with the launch of the NAS Investment Program in 2017, and then increased further to 60%. However, this second increase was not sustained, and the rate of antenatal consultation was 40% for the last year of the NAS Investment Program (see **Exhibit 23**). This may reflect a limitation of the traditional structure of antenatal consultation, in which families are asked to arrange a separate appointment for the pediatrics or neonatology service. More recently, centers have begun to explore opportunities to make this consultation a part of already established care visits, recognizing that transportation to and from the hospital can pose a barrier to uptake on this service.

Exhibit 23: Mothers of OENs receiving antenatal consultation with Pediatrics or Neonatology



DEPARTMENT OF CHILDREN AND FAMILIES INTERACTIONS: Custody of newborns is often determined by Massachusetts' DCF through the mandated reporting and referral process. Though the specific language of state and federal mandated reporting requirements can vary somewhat, in general, medical professionals, including physicians, nurses, and clinical social workers, are required to inform DCF and file a 51A reporting document in the case of a mother and/or newborn with a positive test result of drug or alcohol exposure and/or if there is "reasonable cause" to suspect that the newborn is suffering physically or emotionally from physical drug dependence.[38,39,40,41,42] Once filed, DCF conducts a preliminary screening that involves information gathering from the mandated reporter, local law enforcement, criminal records, and other sources to determine custody and next steps.[38,41] From 2017 to 2019, approximately 97% of families served by the NAS Investment Program experienced mandated referrals to DCF and approximately 71% of mothers retained custody. Mandated reporting of drug use during pregnancy, and in some states, the prosecution of drug use during pregnancy can deter patients from seeking prenatal care and jeopardize the doctor-patient relationship.[43,44]

Recognizing the central role of DCF, several awardees developed relationships with their local DCF field offices, with the intention of improving communication. Staff reported significant fear from patients about the outcomes of the DCF process and DCF visits, in the hospital and at home. To respond to those concerns, awardees created opportunities for women to engage with DCF staff during their pregnancies to learn more about the reporting and screening processes. Certain staff, like social workers, played a supporting role for families by preparing mothers for the DCF process during prenatal sessions, in the hospital post-delivery, and during meetings with DCF in the postpartum period. Awardees also worked with DCF to explain the hospital's care model (including the focus of non-pharmacologic interventions and parental engagement), and, where appropriate, provided details about the mother's engagement in treatment and supports available to her. Hospital teams advocated to keep infants with their mothers during the rooming-in period when available, except for extreme circumstances. A Lowell General Hospital staff member noted, **"I think our relationship [with DCF] is very collaborative and supportive of one another. You know, we don't always agree on every decision, but I think we have a very good relationship with them, and we talk to them regularly. They're engaged in our process, and in trying to help moms."**

EARLY INTERVENTION REFERRALS: OENs are eligible for the EI program which provides support to families and caregivers to enhance the development and learning of infants and toddlers. Awardees aimed to refer all families with OENs to this program as one way to connect families with needed support after discharge. The rate of referrals to EI prior to discharge was around 80%. While this percentage did not increase over the course of the NAS Investment Program, it already reflected a fairly high rate of referral. One challenge area noted by awardees was the inability to track families post-referral to understand if they actually received EI services, and if so, for what period of time they received them. Increasing referral rates to services like EI remains a focus area for PNQIN.

SIDEBAR: FINDINGS FROM THE MOMS DO CARE INITIATIVES

The Moms Do Care (MDC) intiatives at Beverly Hospital and Lowell General Hospital operated over 28 months, from March 2017 to July 2019. During that time, the two hospitals enrolled 113 women in the initiatives. Participants included women ages 18 or older who were pregnant, screened positive for OUD, and were either already on MOUD or willing to consider initiation. MDC core components included: a service model that featured peer support, care management and referral, and access to MOUD; a service timeframe that responded to the critical need for intervention both prenatally and postpartum; and training and technical assistance activities to create a context for the program that was non-stigmatizing and trauma-informed. Key highlights from the evaluation of the MDC initiatives include:

Participant Exposure

- At entry into MDC, three-quarters of participants reported using drugs weekly or more often in the past year. Only about a third, however, were using opioids during the 30 days prior to enrollment.
- After tobacco, women reported using heroin, marijuana, and fentanyl most frequently during the 30 days prior to enrollment in MDC.
- Nearly half the MDC participants experienced at least one opioid overdose in their lifetime. Of these, about a third had overdosed during the past year.
- The women enrolled in MDC came to the program with high rates of exposure to trauma over their lifetimes.
- Nearly three-quarters of women reported experiencing one or more traumatic events as a minor and about one-third met criteria for post-traumatic stress disorder.
- Most women reported serious anxiety, and three-quarters reported having serious depression across their lifespan. More than a quarter reported attempting suicide.
- Nearly three-quarters of MDC participants were already being prescribed MOUD at enrollment into the program.

Provider Training

- All MDC staff received training in addiction and recovery; substance use disorders and co-occurring disorders; stages of change; Motivational Interviewing; recovery coaching and supervision; ethics and boundaries; gender-specific practice; and trauma-informed care, compassion fatigue, and self-care.
- Trainings on trauma-informed care were reported as the most beneficial type of training by the majority of respondents.
- 156 area providers attended 28 buprenorphine waiver trainings between December 2017 and June 2019.

Participant Outcomes

- MDC delivered over 9,000 services, with the early postpartum period being the most intense phase of services. Peer services and case management made up most of the services delivered through MDC.
- MDC achieved a high level of engagement and retention in services. Women stayed in MDC, on average, for 8.1 months; the average length of engagement prenatally was 3.1 months and in the postpartum period was 5.3 months.
- There was improved access to substance use and mental health treatment; treatment tailored to pregnant or parenting women; and counseling for trauma, domestic violence, post-traumatic stress disorder or related issues at six-month follow-up.
- MDC participants were extremely satisfied with the program. Qualitative data highlights satisfaction with MDC's resource/referral and advocacy services, the availability of ongoing emotional support, help working with DCF, and the peer group meetings.
- MDC participants showed a sharp decline in their use of drugs "weekly or more often" in the six months post-baseline and postpartum. Between baseline and six-month follow-up there was approximately a 73% decrease in the use of drugs, and this remained consistent at six months postpartum.

*The evaluation of the two MDC initiatives was conducted by Advocates for Human Potential (AHP). The AHP evaluation team included Amy Salomon, Ph.D., David Centerbar, Ph.D., Denise Lang, Alison Neto, M.S.W., Christine LaBelle, and Lisa Lundquist, M.A. The project was funded in part by the Massachusetts Health Policy Commission (HPC) and is administered through the Massachusetts Department of Public Health's Bureau of Substance Addiction Services (BSAS)

MEDICATIONS FOR OPIOID USE DISORDER

MOUD is an evidence-based, clinically effective treatment that combines maintenance medication (methadone and buprenorphine) with counseling and behavioral therapies to treat OUD. MOUD is also a recommended best practice to treat OUD during pregnancy and postpartum as the medications prevent withdrawal symptoms, allowing women to focus on other aspects of recovery and better engage in prenatal and postnatal care.[18,45] During the NAS Investment Program, approximately 75-80% of mothers of OENs were receiving MOUD during pregnancy. While this rate did not increase over the course of the program, it may be a higher rate of MOUD than in populations of women with OUD in other settings, and the high performance during baseline most likely reflects work done in these communities to engage with patients over many years.[46]

Multivariate models (see **Appendix: Multivariate Modeling**) were used to better understand the relationship between type of maternal opioid use and need for pharmacologic treatment. A particularly notable finding was the association of maternal use of MOUD with pharmacologic treatment for NAS; infants born to mothers receiving MOUD or MOUD in combination with non-prescribed opioids had higher odds of needing pharmacologic treatment for NAS as compared to infants born to mothers taking only non-prescribed opioids. Given the many known benefits of MOUD treatment on both maternal and neonatal outcomes, this potential association with increased NAS severity should be acknowledged as an allowable secondary effect of the more important goal of increasing MOUD engagement in pregnant women with OUD. Furthermore, the value of MOUD engagement was seen in subgroup analyses which showed that by the end of the NAS Invesment Program, non-pharmacologic interventions were highest among OENs exposed to MOUD alone, and lowest among OENs exposed only to non-prescribed opioids. This difference suggests that women engaged in MOUD and comprehensive treatment have a greater ability and likelihood to engage in non-pharmacologic interventions for the care of their newborn. Importantly, hospital policies are also a factor (i.e., many hospitals prohibit breastfeeding if there is continued non-prescribed drug use).

SIDEBAR: ANALYSES BY RACE AND ETHNICITY

Policies related to non-prescribed drug use have led to differential criminalization by race, thereby disproportionately affecting communities of color, particularly Black communities. This is specifically highlighted by the 1980s crack epidemic which was concentrated in Black neighborhoods.[xv] The expansion of the "war on drugs" and inaccurate portrayals of "crack babies" began an era of intrusive health care measures. These measures included state investigations of women's reproductive decisions and punitive reporting that regarded pregnant or parenting women with SUD as unfit to parent.[21] This shift from providing medical treatment for SUD to criminalizing addiction during pregnancy led to laws that furthered the stigmatization of SUD during pregnancy and increased incarceration rates of Black women.[48] The historical inequities that come from criminalization of perinatal SUD have lasting consequences on family structures and community health that can be seen in current disparities in health outcomes and access to proper treatment programs within Black communities.[49] Unlike some states that still criminalize substance use during pregnancy, Massachusetts does not mandate screening or testing for substance use during pregnancy but does require mandated reports and referrals to DCF.[50]

Subgroup analyses by race and ethnicity allowed for initial exploration of potential disparities and inequities in outcomes for women and infants impacted by prenatal opioid use. Analyses were based on maternal self-reported race and ethnicity. From January 2017 to July 2019, there were 1,107 mothers served by the six awardees; of those, 83% were non-Hispanic White, 3% were non-Hispanic Black, 11% were Hispanic, and 3% were other or unknown. The subsequent analyses should be interpreted in the context of a relatively small number of non-Hispanic Black mothers.

With regards to maternal care, MOUD use was most prevalent among non-Hispanic White mothers as compared to non-Hispanic Black and Hispanic mothers. As displayed in **Exhibit 24**, 56% of non-Hispanic White mothers were using MOUD alone during pregnancy, as compared to 22% of non-Hispanic Black mothers and 33% of Hispanic mothers. Any MOUD use was seen in 82% of non-Hispanic White mothers, 58% of non-Hispanic Black mothers, and 62% of Hispanic mothers. These findings are consistent with a state-wide study that found Black non-Hispanic women (75.4%) and Hispanic women (77%) were significantly less likely to receive any MOUD during pregnancy compared to White non-Hispanic women (88.9%.)[51]

These initial analyses suggest that non-Hispanic Black women and Hispanic women with OUD may experience barriers to MOUD treatment during pregnancy.

Subgroup analyses were also conducted to understand if there were differences in care delivery by race and ethnicity. Many practices were similar across the groups, including rates of rooming-in, skin-to-skin contact, and EI referral, providing reassurance that these families are equally engaged in care in the hospital. However, use of mother's milk appeared lower in non-Hispanic Black women. To further explore this disparity, use of mother's milk by race and ethnicity was examined by mother's eligibility to breastfeed. Across the six awardees, non-Hispanic Black women and Hispanic women had lower rates of eligibility for breastfeeding than White women (see **Exhibit 25**), but use of mother's milk was comparable among White, Black, and Hispanic women who were eligible for breastfeeding (see **Exhibit 26**). While further research is needed to understand the reasons for differences in eligibility, early analysis suggests that the disparity in eligibility to breastfeed may be linked to lower rates of MOUD access for non-Hispanic Black women. These findings reveal systemic gaps and areas for continued improvement in care for pregnant women with OUD.

Exhibit 24: Women using MOUD during pregnancy by race/ethnicity

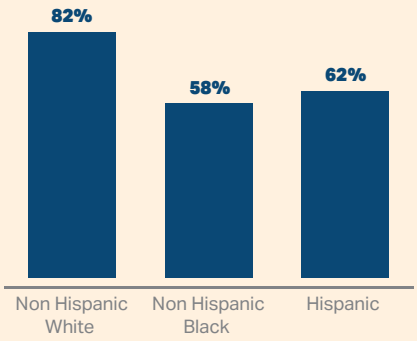


Exhibit 25: Mothers eligible to use mother's milk by race and ethnicity

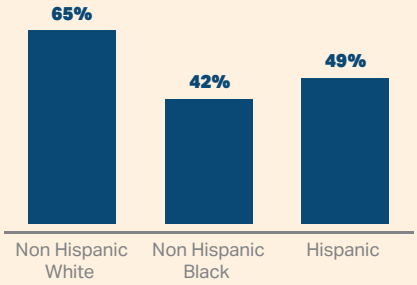
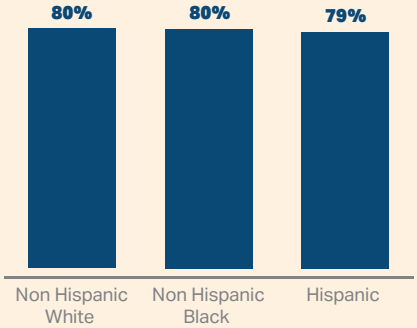


Exhibit 26: Mother's milk use among eligible newborns by race and ethnicity



xv Drug Abuse Act of 1986 created 100 times harsher federal penalties and longer prison sentences for those using crack-cocaine over powder cocaine, thus further stigmatizing and marginalizing Black communities.[47]

SUSTAINABILITY

The NAS Investment Program aimed to promote respectful, patient-centered care through the recovery and birthing process by creating changes in staff attitudes as well as adoption of best care practices and protocols. While the NAS Investment Program was time-limited, it created changes that extended beyond the grant period.[xvi] These changes span from organizational culture and adoption of hospital policies to decisions about resource allocation and sustaining care models.

CULTURE CHANGE AND POLICY ADOPTION

Awardees noted that one of the greatest achievements of the NAS Investment Program was the shift in attitudes and organizational culture towards the care for families, mothers, and infants impacted by OUD. As the hospitals launched their initiatives, several teams identified opportunities for improvement:

- **Knowledge and Skills:** Awardees noted that some staff lacked a current and comprehensive understanding of OUD during pregnancy and most up-to-date care practices. As a result, there were inconsistencies in both communication and adoption of some important care practices, specifically, the need for universal, standardized screening of mothers for unhealthy substance use, the importance of accurate and objective scoring of OENs, and the process for referring eligible infants to EI.
- **Attitude and Bias:** All awardees noted that some of their staff members had implicit and explicit biases that stigmatized mothers with OUD. Moreover, some staff were hesitant about adopting new practices and reluctant to fully integrate new staff (e.g., peer moms/recovery coaches) into the care team.

To address the operational and attitudinal changes needed to overcome staff's initial resistance, awardees employed some of the following strategies:

TRAINING: Providing trainings and educational opportunities focused on trauma-informed care, addiction medicine, and caring for infants and families impacted by OUD improved staff's overall knowledge, skills, and attitude when working with the target population.

STAFFING: Hiring peer moms/recovery coaches and social workers to support and advocate for families allowed women to feel safe and confident during their pregnancy and post-partum, and contributed to an overall culture change in the hospital.

COMMUNICATION: Open communication through staff meetings, huddles, and other feedback mechanisms increased staff engagement and allowed for early buy-in and continuous improvement of care protocols.

PATIENT-CENTERED APPROACH: Centering patients and families in care by reestablishing trust and emphasizing non-pharmacologic interventions allowed hospital staff to witness the health benefits of involving families in infants' care and better understand the patients they serve.

Across the awardees, staff members noted significant changes at both the personal and organizational level that influenced how they approached and delivered care to families affected by OUD. While the trainings strengthened skills and knowledge, many teams observed that staff fully bought into the program when they were able to see the improvements in outcomes for both infant and mother. One Boston Medical Center staff member said, **"There was a lot of resistance to change early on and misunderstanding about the goals of the initiative. Now, these changes have been incorporated into our culture due to continued education and support of our staff, and staff witnessing the improvements."**

xvi All of the NAS initiatives addressed in this report were implemented prior to the COVID-19 pandemic. Some activities that Awardees planned to continue after the award period may have been suspended or altered as a result of the pandemic.

In addition, many staff observed that once staff began working closely with the families, it changed their outlook. One Lowell General Hospital staff member noted, "[We are] trying to help to take away from that judgmental stance that maybe people don't even realize that they have sometimes [when] working with women on [MOUD]. So, it was really huge in [...] getting our compassion up, to help really understand where women are coming from, and really trying to approach in a supportive and collaborative way, rather than in any kind of judgmental way." Another staff member from Boston Medical Center said, **"If you're able to [witness] the benefit and seeing the mother being a mother then I think it's going to change your whole way of caring for the parent."**

As staff and leadership came to understand the benefits of this trauma-informed, family-centered care approach, the initiatives gained increasing support, which laid a foundation for long-term programmatic sustainability. A Baystate Medical Center staff member said, "I'm really proud that we have developed something that women can feel safe and even excited, right, about having their baby because they can feel supported – we don't have to feel shame around this piece – and that we're building the programming that will support these families and that will last. And it's time because before it was not this way."

RESOURCE ALLOCATION AND PROTOCOL ADOPTION

As the NAS Investment Program ended, awardees also had to make decisions about what practices, processes, and resources would continue following the end of the grant period. At the close of their initiatives, all awardees were asked to comment on their plans for sustaining their initiatives. Notably, all the awardees planned to integrate the key features of their initiatives into standard workflows and operations. Common elements that continued include rooming-in models, prioritizing non-pharmacologic interventions, breastfeeding guidelines, ESC assessments, cuddler programs, PRN or "as-needed" dosing, and wraparound services. Following the initial investment and training, many of these practices were integrated into existing practices and workflows.

Other practices — such as allocating designated space for rooming-in post-maternal discharge and compensation for non-clinical staff — remained a challenge as they required more significant financial and/or organizational resource commitments. In several cases, the teams were able to secure hospital commitment to continue their care models or pursue additional grant funding. Many of the awardees worked closely with leadership teams to gain buy-in and long-term support for the initiatives, citing improved outcomes for mother and infant and the potential for lower costs due to shorter hospital LOS in lower-level acute care settings.

PROMOTING BEST PRACTICES ACROSS THE COMMONWEALTH

The substantial improvements achieved by the NAS Investment Program took place within a broader statewide movement to improve quality and refine best practices in birthing hospitals across Massachusetts. After contracting with NeoQIC to provide technical assistance for the six awardees, the HPC has continued to contract with NeoQIC and PNQIN to further statewide quality improvement initiatives. These activities have continued following the conclusion of operations of the NAS Investment Program and include:

- **Data collection and monitoring:** In addition to supporting data collection at the six hospitals during the grant period, NeoQIC collected and continues to collect data about care practices and outcomes for OENs from birthing hospitals across the state to track adoption and implementation of best care practices and monitor trends in outcomes.
- **Expanded support of non-pharmacologic interventions for infants at risk of NAS:** NeoQIC continues to support birthing hospitals across the Commonwealth in improving non-pharmacologic interventions for infants at risk of NAS, including the expansion of the ESC method. This includes providing technical assistance through training sessions, summits, and webinars; assessing technical assistance needs through surveys (see **Sidebar: sidebar: PNQIN 2020 Practice Survey**) and outreach; and maintaining an online repository of resources and toolkits.
- **Convenings:** NeoQIC, in collaboration with PNQIN, organizes biannual state-wide convenings that focus on improving care for families affected by perinatal opioid use by bringing together hospital teams, public health and state agencies, and other stakeholders.
- **Stigma, Bias, and Trauma-Informed Care Trainings:** NeoQIC, in collaboration with PNQIN, offers stigma, bias, and trauma-informed care trainings to hospitals participating in the Alliance for Innovation on Maternal Health (AIM) across the Commonwealth.

SIDEBAR: PNQIN 2020 PRACTICE SURVEY

In February 2020, the PNQIN leadership team distributed a survey about clinical practices related to the care of mothers and newborns affected by perinatal opioid use. This survey primarily focused on inpatient care and discharge planning for OENs. The survey went to team leaders at approximately 44 birthing hospitals in Massachusetts and was completed by 27, including all six of the awardees in the NAS Investment Program. Key findings include:

- NAS Diagnosis and Treatment: The majority of birthing hospitals reported that they use the Eat, Sleep, Console method to score NAS symptoms.
- Inpatient Care Team: Lactation specialists are included in the care of NAS infants in a majority of birthing hospitals. Every NAS Investment Program awardee reported having a volunteer cuddler program, as compared to a little over half of the other hospitals. Also, a greater percentage of NAS Investment Program awardees include physical and occupational therapists in the care of infants with NAS.
- Referral Process: A majority of birthing hospitals report all OENs to DCF. A greater percentage of NAS Investment Program awardees reported using a standard tool to determine the need for a 51A report to DCF. Across all birthing hospitals, the majority allow infants to room-in with their mothers after filing a 51A report and allow unsupervised visits between mother and infant after DCF assumes custody.

CONCLUSION

Implementing and expanding care models focused on families, mothers, and infants impacted by the opioid epidemic has been a focus for many birthing hospitals throughout Massachusetts. The six awardees participating in the NAS Investment Program produced real and important improvements in care and outcomes for mothers with OUD and infants at risk for NAS by increasing non-pharmacologic interventions, optimizing pharmacologic treatment, and increasing access to services for mother and infant post-discharge. These improvements were seen across a diverse group of hospitals throughout the state and reflect the "Triple Aim" promoted by the Institute for Healthcare Improvement: improving the patient experience, improving the health of populations, and reducing the cost of health care.[12]

Throughout the NAS Investment Program, awardees emphasized the importance of decreasing the need for pharmacologic treatment to address NAS symptoms by increasing opportunities for maternal-infant bonding. They expanded both their staff and infrastructure to support non-pharmacologic interventions that enable bonding. As a result, there was an 18% increase in rooming-in, a 23% increase in use of mother's milk, and a 30% reduction in care of newborns in an intensive care setting. Awardees also adopted and modified care and medical protocols to better engage families in caring for their infants and expanded services to connect families to behavioral health and social services.

Culture change was another important contributor to success. Awardees took a multi-faceted approach to fighting stigma and building support for the initiatives among staff through implementing trainings, expanding staff to include peer moms/recovery coaches and social workers, and engaging the workforce through weekly meetings at which staff could learn more about positive outcomes of the program and provide real-time feedback.

Adoption of these processes helped awardees achieve significant improvements in outcomes, including a 50% reduction in need for pharmacologic treatment for NAS and a 33% reduction in hospital LOS. Non-pharmacologic interventions were strongly associated with better outcomes in subgroup and multivariate analyses, supporting the promotion of these interventions as strategies to reduce pharmacologic treatment, reduce hospital LOS, and improve care.

While the emphasis of the NAS Investment Program was on infants experiencing NAS, the design of awardees' initiatives highlights the interdependence between treating infants and treating mothers particularly as it relates to MOUD.

In subgroup and multivariate analyses, MOUD for mothers was considered a strong determinant of engagement during hospitalization, including in non-pharmacologic interventions. The fact that such engagement was critical to achieving NAS Investment Program outcomes lends further support to recommendations by professional organizations and public health agencies that MOUD remain the cornerstone of treatment for OUD, particularly during pregnancy.

This connection is important as it relates to the ability to access treatment for OUD, which, as findings from the NAS Investment Program suggest, may be more difficult for non-Hispanic Black and Hispanic women. Although the numbers of non-Hispanic Black and Hispanic women in this analysis were small, multivariate models showed consistent trends of higher MOUD use for White women than for non-Hispanic Black and Hispanic women. To better understand these trends, a multidisciplinary team from PNQIN, supported by the HPC through the DPH's SAMHSA State Opioid Response grant, is currently working to further identify and understand racial and ethnic inequities across the perinatal continuum for people and families affected by substance use disorder. Findings from this work may help guide ongoing improvement effort to promote evidence-based practices for caring for this population.

Throughout this effort, the six awardees have engaged with peer hospitals across Massachusetts to share their experiences in treating NAS. Lessons learned by awardees have already spread to many other institutions and have helped inform the HPC's ongoing work to improve maternal and child health, including the Cost-Effective, Coordinated Care for Caregivers and Substance-Exposed Newborns (C4SEN) Investment Program in 2021.

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APPENDIX

HIGHLIGHTS OF INDIVIDUAL INITIATIVES

Although all the awardees shared core components of the care model, each hospital adapted their initiative to meet their specific needs, level of experience, and available resources. These individual spotlights highlight key elements of each awardee's initiative.

BAYSTATE MEDICAL CENTER

✓ **Rooming-in post maternal discharge** ✓ **Social worker** ✓ **Eat, Sleep, Console scoring**

Key Features: Baystate Medical Center's initiative focused on various strategies to improve outcomes for mothers with OUD and infants with NAS by improving rooming-in services, staffing a social worker to support mothers, and increasing patient education.

- Dedicated four rooms on the postpartum floor to provide ongoing co-located care to eligible mothers and their infant after maternal discharge.
- Provided prenatal care to pregnant women with OUD and support from a social worker in the co-located EMPOWER program.
- Developed a parent teaching checklist to facilitate parent education and simplify documentation.

BEVERLY HOSPITAL

✓ **Rooming-in post maternal discharge** ✓ **Cuddler program** ✓ **Eat, Sleep, Console scoring** ✓ **Moms Do Care Program**

Key Features: Beverly Hospital focused on reinforcing trauma informed care approaches, coordinating care among inpatient staff and between inpatient/outpatient staff, engaging mothers in education activities, and increasing partnership with local DCF offices.

- Held monthly meetings to review and receive feedback on patient care and initiated team huddles to share information between inpatient and outpatient care teams.
- Worked with volunteers and hospital staff to offer therapeutic arts and education programming, mindfulness education, and the cuddler program.
- Increased communication with Salem DCF office to create a survey, "32-week summary," to prepare mothers on what to expect during the referral process.

BOSTON MEDICAL CENTER

✓ **Rooming-in post maternal discharge** ✓ **Cuddler program** ✓ **Eat, Sleep, Console scoring** ✓ **Peer recovery coach**

Key Features: Boston Medical Center focused primarily on implementing new protocols to increase use of non-pharmacologic interventions, including Eat, Sleep, Console scoring, PRN or "as needed" dosing, and private rooming-in.

- Provided trainings to other hospitals on implementation of the Eat, Sleep, Console (ESC) approach and trauma informed care.
- Implemented PRN dosing which allowed infants to receive as-needed dosing in the nursery for four hours and return to their mother's room, if able.
- Designated private rooms on the pediatric floor for mothers post-discharge to stay while their infants continued to be monitored and treated.

LAWRENCE GENERAL HOSPITAL		
✓ Rooming-in post maternal discharge	✓ Cuddler program	✓ Social worker

Key Features: Lawrence General Hospital focused on expanding buy-in and awareness of their NAS initiative, increasing maternal engagement through culturally competent care, and increasing maternal-infant bonding.

- Developed a comprehensive cuddler program to assist in holding and comforting infants when parents were not able to be present or in need of respite.
- Mandated stigma and sensitivity awareness training and optional trauma-informed care training to reduce bias and promote culturally competent care.
- Hired a social worker to increase maternal engagement by providing support and education to the mother during the prenatal and postpartum period.

LOWELL GENERAL HOSPITAL			
✓ Rooming-in post maternal discharge	✓ Cuddler program	✓ Eat, Sleep, Console scoring	✓ Moms Do Care Program

Key Features: Lowell General Hospital focused on staff education, creating a multidisciplinary NAS quality improvement team, and implementing protocols that optimized pharmacologic treatment and increased opportunity for non-pharmacologic interventions.

- Conducted a needs assessment to determine educational gaps among staff.
- Developed curriculum for an education pathway that was required for staff (mostly nurses), including trauma informed care trainings.
- Created patient education materials such as handouts, posters, crib cards, and cuddler program materials.

UMASS MEMORIAL MEDICAL CENTER			
✓ Rooming-in post maternal discharge	✓ Cuddler program	✓ Eat, Sleep, Console scoring	✓ Peer Recovery Coach

Key Features: UMass Memorial Medical Center focused funding on standardizing care protocols and increasing parental presence with infants.

- Held weekly meetings to review various NAS protocols, such as their morphine weaning protocol, and reflect on data measurement.
- Implemented a cuddler program where volunteers were available 24/7 to cuddle infants in the NICU.
- Hired a peer mom as a lactation consultant to support mothers in the prenatal and postpartum periods, and specifically with breastfeeding support during inpatient care and post-discharge.

MULTIVARIATE MODELING

Multivariate models were used to better understand drivers of need for pharmacologic treatment and hospital LOS. A logistic regression model of factors associated with need for pharmacologic treatment is shown in **Exhibit 27**. As compared to maternal use of MOUD alone, maternal use of non-prescribed opioids in combination with MOUD was associated with increased need for pharmacologic treatment while maternal use of non-prescribed opioids alone or other prescribed opioids alone was associated with decreased need for pharmacologic treatment. Other factors associated with increased need for pharmacologic treatment included maternal use of benzodiazepines or selective serotonin reuptake inhibitors (SSRIs) and male newborn gender. Other factors associated with decreased need for pharmacologic treatment included more recent year of birth, skin-to-skin contact, and rooming-in, with any mother's milk use trending towards association with decreased pharmacologic treatment.

Exhibit 27: Factors associated with pharmacologic treatment for NAS

FACTORS	aOR*	95% CL*
Maternal Opioid Exposure		
MOUD alone	1.00	Referent
Non-prescribed opioids without MOUD	**0.65**	**0.43-1.00**
MOUD and non-prescribed opioids	**1.52**	**1.09-2.13**
Other prescribed opioids	**0.17**	**0.08-0.34**
Other Maternal Exposures		
Benzodiazepine or SSRI	**1.40**	**1.04-1.90**
Year of Birth		
2016	1.00	Referent
2017	**0.55**	**0.38-0.79**
2018	**0.41**	**0.28-0.60**
2019	**0.32**	**0.20-0.50**
Male Sex	**1.33**	**1.03-1.72**
Inborn at hospital	0.68	0.44-1.05
Skin-to-skin contact in first day of life	**0.71**	**0.51-0.99**
Rooming-in before maternal discharge	**0.36**	**0.25-0.51**
Any mother's milk during hospitalization		
Yes	0.77	0.4-1.01
No	1.00	Referent
Ineligible	1.24	0.83-1.85

*Adjustable for all variables in table, and random effects of site.

A linear regression model of factors associated with hospital LOS is shown in **Exhibit 28**. Again, there is evidence that other types of maternal opioid use are associated with lower hospital LOS as compared to maternal MOUD use. Rooming-in is associated with shorter hospital LOS, but significant associations were not seen for skin-to-skin care or receipt of mother's milk. However, this is likely due to the very strong association of need for pharmacologic treatment with hospital LOS; in the adjusted model, infants who required pharmacologic treatment had an average hospital LOS of 22 days as compared with 7 days for infants who did not require pharmacologic therapy. The extent to which pharmacologic treatment drives hospital LOS makes it more difficult to identify other factors that are also significantly associated with hospital LOS.

Exhibit 28: Factors associated with increased length of stay in days

	ADJUSTED ANALYSIS*				
FACTOR	aRATE RATIO	95% CL	RISK DIFFERENCE (DAYS)	aMEAN DAYS	95% CL
Maternal Opioid Exposure					
MOUD alone	Ref		Ref	13.6	12.8-14.4
Non-prescribed opioids without MOUD	**0.86**	**0.79-0.93**	1.5	15.1	13.5-16.8
MOUD and non-prescribed opioids	**1.07**	**1.00-1.14**	1.9	15.5	14.3-16.7
Other prescribed opioids	**0.79**	**0.71-0.87**	-3.4	10.2	7.9-12.5
Other Maternal Exposures					
Benzodiazepine or SSRI					
Yes	**1.08**	**1.02-1.14**	1.9	16.3	14.1-18.5
No	Ref		Ref	14.3	13.4-15.3
Year of Birth					
2016	Ref		Ref	15.1	13.9-16.2
2017	1.05	0.98-1.12	0.0	15.1	13.9-16.3
2018	1.00	0.93-1.07	-0.9	14.2	11.8-16.5
2019	1.03	0.94-1.12	0.3	15.3	13.3-17.4
Gender					
Male	1.02	0.98-1.07	0.6	15.2	13.9-16.5
Female	Ref		Ref	14.6	13.3-15.8
Inborn at hospital					
Yes	0.94	0.87-1.01	-0.6	14.8	13.6-15.9
No	Ref		Ref	15.4	13.2-17.5
Received Pharmaceutical Therapy					
Yes	**3.21**	**3.06-3.38**	15.1	21.7	18.9-24.6
No	Ref		Ref	6.6	6-7.2
Received skin-to-skin contact					
Yes	0.96	0.9-1.02	-0.8	14.6	13.2-16
No	Ref		Ref	15.4	14.2-16.6
Roomed-in for at least one night					
Yes	**0.92**	**0.86-0.98**	-1.2	14.4	12.9-15.9
No	Ref		Ref	15.6	14.5-16.8
Received any mother's milk during hospitalization (full cohort)					
Yes	0.98	0.92-1.05	2.2	16.2	14.9-17.4
No	Ref		Ref	14.0	12.6-15.4
Ineligible	**1.15**	**1.06-1.23**	0.0	14.0	12.7-15.3

*Multivariable mixed effects linear regression with hospital site as random effects (gamma distribution)

NAS INVESTMENT PROGRAM EVALUATION METHODS

The primary goal of the NAS Investment Program was to test promising interventions to improve quality of care for OENs and their mothers. Awardees of the NAS Investment Program implemented inpatient quality improvement interventions to improve care and reduce hospital LOS, NICU admissions, and need for pharmacologic treatment. Key components of the care model included increasing non-pharmacologic interventions, optimizing NAS pharmacologic treatment, and increasing access to services for mother and infant after discharge. To evaluate performance against these goals, the HPC adapted an evaluation framework described by Berry et al., 2013 which is often used by the Centers for Medicare and Medicaid Services to evaluate tests of innovative health care service delivery models.[52] Three broad categories—implementation, impact, and sustainability—assess the program across its lifespan:

- **Implementation:** Was the intervention fully deployed? What were the key lessons learned or challenges faced during implementation?
- **Impact:** Did the intervention achieve the program goals?
- **Sustainability:** Did the intervention produce lasting changes?

The HPC used a mixed methods approach to assess performance across these three domains. HPC evaluation staff conducted 18 semi-structured interviews with awardee staff (3-5 interviews per awardee) including Program Managers, clinical staff, and non-clinical roles. The HPC also collected written reflections from the awardees each quarter of both preparation and implementation, as well as initial, interim (two-year programs only), and final self-assessment reports. Interview transcripts and written reflections were qualitatively coded using NVIVO software to identify key themes, successes, and challenges.

The HPC contracted with NeoQIC to support the collection and synthesis of quantitative data. To support data collection of the data elements comprising the performance indicators (see **Exhibit 29**), standardized data forms were created by NeoQIC. The data forms were piloted by several awardees and revised for clarity and format. A shared database was created on REDCap at Beth Israel Deaconess Medical Center (BIDMC); participating hospitals completed a Data Use Agreement (DUA) with BIDMC to allow data sharing into the database. The majority of performance indicators were adopted for use across the state collaborative, with a few measures used only by the awardees; a core data form included the data elements for the statewide collaborative, and a supplemental data form was created for the few additional data elements specific to HPC. The data form was completed through medical record review, and data was entered into REDCap by trained team members at each hospital through an online interface.

Hospitals were asked to complete the data form for all OENs at risk for NAS due to intrauterine opioid exposure, and their mothers. Each hospital developed a local system to identify and track eligible patients.

The database was launched in 2017 with the start of the NAS Investment Program. Awardees were also asked to enter retroactive data from 2016 when possible, to form a baseline. The data form was revised in 2019.

NeoQIC used two statistical process control methods in the NAS Investment Program: run charts and control charts. Run charts and control charts allow for identification of non-random patterns in time-series data that suggest statistically significant changes in performance. Performance on the various metrics was assessed across all six awardees in aggregate with run charts with quarterly data. Selected measures were examined with control charts with monthly data. In addition to time-series analyses of the main performance indicators, two additional methods were used to better understand drivers of improvement: sub-group analyses and multivariate regression models.

For the purpose of this analysis, 2016 is labeled as a baseline period, and January 2017 to June 2019 is labeled as the NAS Investment Program period. For most measures, complete data was available from all six awardees for the entire time period; for a few measures, 2016 data was only available for five awardees, and complete data was available for all six awardees from 2017 onwards. Across the awardees, improvements in practice were made iteratively; informal changes in practice were started as early as 2016, while other more formal structural changes were launched in 2017 and later; modifications to practices were made frequently. Thus, performance on key measures is more appropriately assessed in the context of ongoing improvements over time, rather than before and after a specific point in time. In addition, data is presented through June 2019 for all hospitals regardless of whether the awardees' initiatives ended in 2018 or 2019 to better assess the lasting impact of the NAS Investment Program.

Using a mixed methods approach for the NAS Investment Program was particularly important because these initiatives were not designed as controlled trials, so measured changes could have multiple causes. Furthermore, qualitative observation and input

from the teams carrying out each initiative were essential for interpreting measured changes and for accurately representing the effectiveness of the initiative.

Qualitative and quantitative data were analyzed separately for each awardee. Analysis of staff interviews and written deliverables were used to answer questions about implementation, impact, and sustainability, while KPI data were primarily used to measure initiative impact. The HPC compared findings across the six awardees to identify important themes that emerged from the cohort, including key lessons that may be valuable for organizations interested in expanding care for mothers with OUD and OENs. These findings are highlighted in the **Findings and Lessons Learned** section of the report.

It is important to note the limitations of these evaluation findings. First, as mentioned above, the NAS Investment Program was not designed as a controlled trial, with some initiatives lacking complete baseline data or comparison group data. Second, many elements of care and improvement were not captured by the quantitative measures. These include other measures of non-pharmacologic interventions, such as rooming-in after maternal discharge, use of cuddlers, and use of other adjunctive treatments such as occupational therapy and physical therapy. These unmeasured care elements may have contributed substantially to the improvements seen. Perhaps more important, the initiatives did not formally capture patient experience; this is an important area for future research. Third, while these analyses attempted to identify the independent impact of non-pharmacologic interventions on outcomes, the use of these interventions cannot be fully separated from maternal characteristics and hospital policies. In many cases, factors such as ongoing non-prescribed drug use or DCF custody may have been the primary determinants of non-pharmacologic interventions rather than hospital practices or family engagement or education. Fourth, although the six awardees represented diverse geography and diverse populations, the limited racial diversity in the final dataset limits the ability to fully understand potential racial disparities. Finally, awardees have been engaged in optimizing care for women with OUD and infants with NAS for years and have long been recognized as centers of excellence in this area. They brought strong foundations to the NAS Investment Program; similar results may not have been seen at other centers.

Exhibit 29: Performance Indicators for NAS Investment Program

MATERNAL CARE MEASURES	
• MOUD among Mothers of OENs	• Antenatal Consults with Pediatrics among Mothers of OENs
• Exclusive MOUD among Mothers of OENs	
NEONATAL CARE MEASURES	
• Length of Stay (all infants)	• Average Duration of Pharmacologic Treatment
• Length of Stay (term infants)	• Requiring a Secondary Pharmacologic Treatment for NAS
• Length of Stay (preterm infants)	• Breastmilk Eligibility
• Care in NICU or SCN	• Use of Mother's Milk at Initiation (eligible infants)
• NICU/SCN Length of Stay (all infants)	• Use of Mother's Milk at Initiation (all infants)
• NICU/SCN Length of Stay (infants requiring NICU or SCN care)	• Use of Mother's Milk at Discharge (eligible infants)
• Pharmacologic Treatment for NAS (all infants)	• Use of Mother's Milk at Discharge (all infants)
• Pharmacologic Treatment for NAS (term infants)	• Use of Mother's Milk at Discharge (infants that initiated breastmilk)
• Pharmacologic Treatment for NAS (pre-term infants)	• Skin-to Skin Contact
• Morphine as Primary Treatment for NAS	• Rooming-in Eligibility
• Methadone as Primary Treatment for NAS	• Rooming-in (eligible infants)
• Buprenorphine as Primary Treatment for NAS	• Rooming-in (all infants)
POST-DISCHARGE CARE MEASURES	
• Early Intervention Referral	• Discharge Home with Biologic Parent
• Department of Children and Families Mandated Referral	• 30 Day Readmission

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