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Length of Stay Among Infants with Neonatal Abstinence Syndrome and Risk of Hospital Readmission

Hafsatou Diop[1] · Xiaohui Cui[1] · Timothy Nielsen[1] · Elizabeth Peacock-Chambers[2] · Munish Gupta[3]

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Abstract

Objectives To assess whether a shorter length of stay (LOS) is associated with a higher risk of readmission among newborns with neonatal abstinence syndrome (NAS) and examine the risk, causes, and characteristics associated with readmissions among newborns with NAS, using a longitudinally linked population-based database.

Methods Our study sample included full-term singletons with NAS (n = 4,547) and without NAS (n = 327,836), born in Massachusetts during 2011–2017. We used log-binomial regression models to estimate the crude risk ratios (cRRs) and adjusted RRs with 95% confidence intervals (CI) of the association between LOS and readmissions, controlling for maternal age, race/ethnicity, education, marital status, insurance, method of delivery, birthweight, adequacy of prenatal care, smoking, and abnormal conditions of newborn.

Results Compared with infants without NAS, infants with NAS had a non-significantly higher risk of readmission within 2–42 days (2.8% vs. 2.5%; p = 0.17) and a significantly higher risk of readmission within 43–182 days (2.7% vs. 1.8%; p < 0.001). The risk of readmission within 2–42 days was significantly higher among infants with NAS with a LOS of 0–6 days compared to a LOS of 14–20 days (reference group) (aRR: 2.1; 95% CI: 1.2–3.5). No significant differences in readmission rates between 43 and 182 days were observed across LOS categories.

Conclusions Among infants with NAS, a LOS of 0–6 days was associated with a significantly higher risk of readmission within 2–42 days of discharge compared to a longer LOS.

Keywords Neonatal abstinence syndrome (NAS) · Length of stay · Readmissions · PELL

Significance

What's known on this subject? Prior research has emphasized the need to reduce length of stay among infants with NAS. New research has shown significant reductions in LOS for infants with NAS using innovative care approaches, particularly approaches focused on non-pharmacologic interventions.

What this study adds? While decreasing LOS among infants with NAS can be beneficial to the family and reduce cost, the risk of readmission within 2–42 days was significantly higher among infants with a LOS of 0–6 days compared to infants with a LOS of 14–20 days.

Introduction

The incidence of neonatal abstinence syndrome (NAS), a growing public health problem, has increased over the last several years (Milliren et al., 2018; Patrick et al., 2012, 2015a, 2015b; Wachman et al., 2018a, 2018b). Nationally, the incidence of NAS increased more than fivefold from 1.5 to 8.0 per 1000 births between 2004 and 2014 (Winkelman et al., 2018), with more recent data indicating an incidence as high as 30.8 per 1000 births in 2015 (Lind et al., 2019). This increase mirrors the increasing number of deliveries to mothers with evidence of opioid use disorder (Haight et al., 2018; Schiff et al., 2018). NAS is characterized by a host of withdrawal symptoms experienced by newborns as

✉ Hafsatou Diop
Hafsatou.Diop@Mass.Gov

[1] Massachusetts Department of Public Health, 250 Washington Street, 6th Floor, Boston, MA 02108, USA

[2] University of Massachusetts School of Medicine Baystate, Springfield, MA, USA

[3] Beth Israel Deaconess Medical Center, Boston, MA, USA

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a result of intrauterine exposure to opioids (Hudak & Tan, 2012). In addition to NAS, intrauterine opioid exposure can result in greater prevalence of preterm birth, low birthweight and small for gestational age, all of which can contribute to prolonged length of stay (LOS) and substantial increase in costs (Norgaard et al., 2015; Patrick et al., 2012; Strahan et al., 2020).

Without a standardized treatment strategy, LOS among infants with NAS varies widely based on the pharmacologic or non-pharmacologic treatments used (Bogen et al., 2017; Patrick et al., 2014; Walsh et al., 2018). In a systematic review including one randomized clinical trial, two cohort studies, and two chart reviews, LOS ranged from 12.08 to 36 days with morphine and 21–44.23 days with methadone (Slowiczek et al., 2018). However, another study found that after adjusting for maternal opioid type and treatment site, compared with morphine, methadone was associated with a 2.7-day reduction in LOS attributable to NAS (Davis et al., 2018).

Reducing LOS has been a primary or secondary aim of many recent improvement initiatives targeting families affected by NAS, and numerous single center and multicenter initiatives have shown significant reductions in LOS for infants with NAS through the use of innovative care approaches, particularly initiatives focused on non-pharmacologic interventions (MacMillan et al., 2018; Patrick et al., 2016; Sanlorenzo et al., 2018; Wachman et al., 2018a, 2018b; Wachman et al., 2018a, 2018b; Walsh et al., 2018; Whalen et al., 2019). While decreasing LOS among infants with NAS can be beneficial to the family and reduce hospital charges related to NAS, limited data are available on whether a shorter LOS may be associated with adverse effects such as readmissions and only a few studies examined readmissions of infants with NAS beyond 30 days. Hence, it is important to balance the goal of reducing LOS with the risk of readmission within 2–42 days and 43–182 days after discharge to minimize illness and cost. Our objectives are as follows: (1) to examine the risk of readmission, causes, and characteristics associated with readmission among infants with NAS; and (2) to assess whether a shorter LOS is associated with a higher risk of readmission among infants with NAS using a longitudinally linked population-based database.

Methods

Data Sources

This study used the Massachusetts Pregnancy to Early Life Longitudinal (PELL), a population-based data system of birthing people and children, which links delivery records to their corresponding hospital discharge records for delivery and non–delivery related inpatient admissions, observational stays, and emergency department visits over time. More than 99% of all deliveries in Massachusetts have been linked in PELL. The PELL linkage allows infants born to the same person to be identified as siblings and multiple hospitalization records belonging to the same person or child to be uniquely identified longitudinally (Diop et al., 2016).

Data Linkage and Study Sample

The PELL core linkage was constructed by matching delivery records with hospital discharge records using a 6-step linkage algorithm, including medical record number, facility code, zip code, birthing parent's date of birth (MM, DD, YY), infant's date of birth (MM, DD, YY) and sex, and was used to create unique parent and infant IDs. Then, the PELL core linkage was matched to post birth inpatient hospital discharge records to track all infants and birthing parents over time. All linkages were performed using SAS version 9.3 (SAS Institute, Cary, NC) and Link Pro (InfoSoft, Inc, Winnipeg, Manitoba, Canada).

Our study included 493,850 resident live births during 2011–2017 from PELL. In order to minimize confounding, we excluded multiple births (n = 20,056) and infant deaths within 365 days (n = 1,572) from this study. We also excluded preterm birth, defined as births at < 37 weeks gestation (n = 31,869) from this analysis, because preterm birth is an intermediate variable (mediator) and lies on the causal pathway from exposure (LOS) to outcome (readmission). Adjusting for a variable that is on the causal pathway is unnecessary and can also be detrimental for estimation of total effects (Ananth & Schisterman, 2017). After excluding births with missing covariates (n = 70,996), our final study sample was 369,357 full-term singleton live births, including 4,547 infants with NAS (Fig. 1). NAS diagnosis was identified using the International Classification of Diseases, 9th Revisions, Clinical Modification (ICD-9-CM) diagnosis code 779.5 (drug withdrawal syndrome in a newborn) and ICD-10-CM diagnosis code P96.1 (neonatal withdrawal symptoms from maternal use of drugs of addiction).

Dependent Variable

Our main dependent variable was readmission among infants with NAS defined as any inpatient admissions following discharge home from the delivery hospitalization. The primary cause of readmission was identified using the ICD-9-CM or ICD-10-CM code listed as the primary diagnosis for the readmission encounter.

Independent Variables

Our independent variable was infant LOS for the birth hospitalization, which was calculated as the number of days

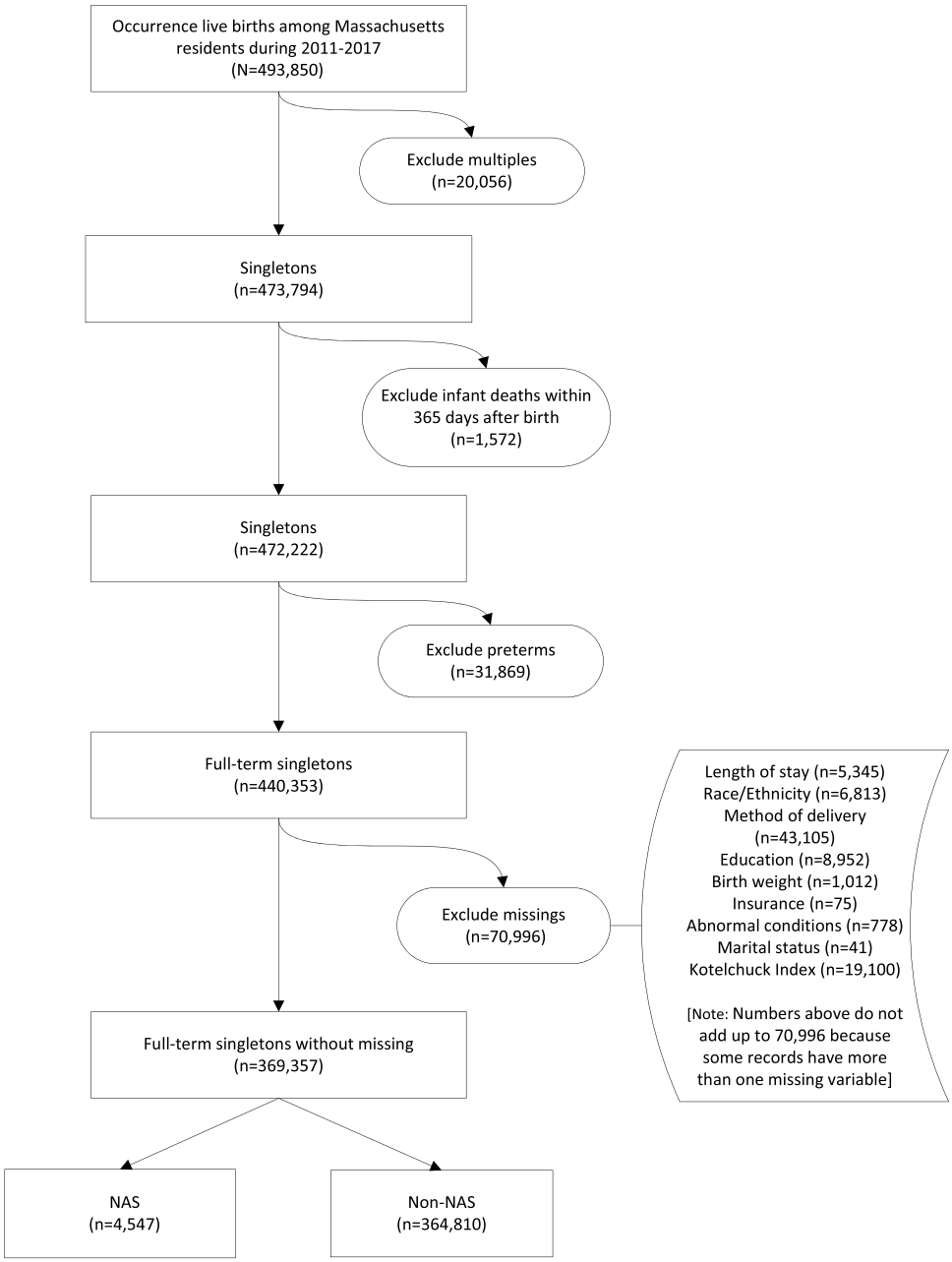

Fig. 1 Flow Diagram of Study Sample with Inclusion and Exclusion Criteria

between the date of birth and the date of discharge home from the birth hospitalization, including transfers after birth. Transfers were defined as any readmissions to the same or different hospital on day 0 or 1 following discharge from the transfer or readmission hospitalization (Weiss et al., 2009). LOS was categorized as 0–6, 7–13, 14–20, 21–27, and 28 + days.

Covariates

Several neonatal and maternal factors affect the expression of NAS symptoms, including gestational age, sex, genetics, and maternal polysubstance abuse or smoking (Anbalagan & Mendez, 2021). We selected covariates that were known to be associated with LOS or readmission, not just for infants with NAS but also for infants in general. The most commonly reported predictors of readmission and LOS among infants with and without opioid withdrawal include jaundice, respiratory complications, sepsis or other infections, low birthweight, insurance, and race/ethnicity (Bhatt et al., 2021; Milliren et al., 2021; Pohjanpää et al., 2022). While our covariates are based on the literature, we assessed confounding with the exposure (LOS) and outcome (readmission) using bivariate analysis. Covariates included maternal race/ethnicity (Hispanic, white non-Hispanic, Black non-Hispanic, and other non-Hispanic), maternal age (< 25, 25–29, 30–39, or 40 + years), maternal

education (< high school, high school diploma/GED, or some college/higher), insurance (public, including government programs such as CommonHealth, Healthy Start, Medicaid/MassHealth, and Medicare or free care, or private, including commercial indemnity plan, commercial managed care or other private insurance, or self-pay), method of delivery (vaginal or cesarean), birthweight (low birthweight defined as birthweight less than 2500 g or normal birthweight), prenatal care (inadequate/intermediate or adequate/adequate plus) as defined by the Kotelchuck Index, marital status (Yes/No), smoking during or within three months prior pregnancy (Yes/No), and abnormal conditions of newborn (Yes/No). Abnormal conditions of newborn included acidosis, anemia, congenital infection, cyanosis, fetal alcohol syndrome, hyaline membrane disease/respiratory distress syndrome, hypotonia, hypoxia, intracranial hemorrhage, jaundice, and seizure or serious neurologic dysfunction. All covariates were derived from the linked birth certificate data and were included in our models for more accurate estimate of the risk of readmission.

Statistical Analysis

We calculated the mean and median LOS and readmissions within 2–42 days and between 43 and 182 days for infants with and without NAS. To assess for confounding, we examined the relationship between LOS and maternal and infant characteristics, and readmissions within 2–42 days and between 43 and 182 days after discharge home among infants with NAS using χ^2 statistics ($\alpha = 0.05$). Among the selected covariates, only insurance was associated with readmissions between 42 and 182 days, while education, insurance, Kotelchuck Index, smoking, and abnormal conditions of newborns were significantly associated with LOS. We used log-binomial regression models to estimate the crude and adjusted risk ratios (aRRs) and 95% confidence intervals (CIs) of the association between LOS and readmissions, adjusting for maternal age, race/ethnicity, education, marital status, insurance, method of delivery, birthweight, adequacy of prenatal care, smoking, and abnormal conditions of newborn. All analyses were preformed were performed using SAS version 9.3 (SAS Institute, Cary, NC). We received approval from the Massachusetts Department of Public Health (MDPH) to conduct this study in accordance with M.G.L. c. 111, Section 24A, which included a Waiver of Consent. This study was also approved by the MDPH Institutional Review Board.

Results

Among 369,357 full term singletons born during 2011–2017 included in this analysis, 4547 (1.2%) infants were identified with NAS. Infants with NAS experienced a longer LOS compared to infants without NAS (mean: 18.7 vs. 2.7 days and median: 17 vs. 2 days). Table 1 shows the risk of readmissions by LOS among infants with and without NAS. The overall proportion of readmission within 2–42 days among full-term singletons with NAS was 2.8% compared with 2.5% among infants without NAS, which was not significant ($p = 0.17$). However, between 43 and 182 days the percentage of readmission was 2.7% for infant with NAS compared to 1.8% for infants without NAS, which was statistically significant ($p < 0.001$).

While among infants with NAS, the risk of readmission within 2–42 days did not vary significantly ($p = 0.06$) across LOS categories, higher percentages of readmission were observed in the 0–6 days group (4.4%) and 7–13 days group (2.7%) and the lowest percentage was observed in the 14–20 days group (2.3%). Similarly, for readmissions between 43 and 182 days, no significant differences were observed ($p = 0.63$) across LOS categories. Among infants without NAS, we observed a dose response with readmissions in both time periods significantly increasing with increasing LOS ($p < 0.001$). Table 2 presents the distribution of maternal and infant characteristics by LOS among infants with NAS. While differences in LOS by maternal education, insurance, adequacy of prenatal care, marital status, smoking and abnormal condition of newborn were statistically significant, we found no significant differences by maternal race/ethnicity, age, method of delivery and birthweight.

Table 1 Readmission by length of stay among singleton infants with NAS and infants without NAS: Massachusetts, 2011–2017

Length of stay	Total (N)	Readmission after discharged home			
		2–42 Days		43–182 Days	
		N	%	N	%
Infant with NAS					
0–6 Days	824	36	4.4	22	2.7
7–13 Days	807	22	2.7	23	2.9
14–20 Days	1269	29	2.3	36	2.8
21–27 Days	755	19	2.5	15	2.0
28 + Days	892	22	2.5	29	3.3
Total	4547	128	2.8	125	2.7
			p = 0.06		p = 0.63
Infant without NAS					
0–6 Days	358,928	8704	2.4	6258	1.7
7–13 Days	4285	171	4.0	161	3.8
14–20 Days	855	74	8.7	65	7.6
21–27 Days	273	44	16.1	31	11.4
28 + Days	469	100	21.3	85	18.1
Total	364,810	9093	2.5	6600	1.8
			p < *0.001*		**p < *0.001***

The bold indicates a statistically significant *p* value less than 0.05

Table 2 Length of stay by maternal and infant characteristics among infants with NAS: Massachusetts, 2011–2017

	N	%				
		0–6 Days	7–13 Days	14–20 Days	21–27 Days	28 + Days
Race/ethnicity						
Hispanic	342	20.5	18.7	25.1	14.9	20.8
White non-Hispanic	3991	17.7	17.6	28.2	17.1	19.4
Black non-Hispanic	158	19.6	22.2	27.2	9.5	21.5
Other non-Hispanic	56	26.8	10.7	26.8	10.7	25.0
Mother's age						
Less than 25	975	17.3	19.3	29.2	17.0	17.1
25–29	1761	17.8	16.7	27.8	18.0	19.6
30–34	1282	18.3	18.0	26.8	14.7	22.2
35 +	529	20.0	17.8	28.4	15.9	18.0
Mother's education[c]						
Less than high school	830	15.3	16.1	26.0	18.2	24.3
High school/GED	1692	16.6	17.3	28.9	16.7	20.6
Some college/higher	2025	20.5	18.8	27.9	15.9	16.9
Insurance[c]						
Private[a]	382	33.2	21.5	19.9	12.3	13.1
Public[b]	4165	16.7	17.4	28.6	17.0	20.2
Method of delivery						
Vaginal	3323	18.5	18.4	27.8	16.5	18.8
C-Section	1224	17.2	15.8	28.3	16.9	21.8
Birth weight						
Low birth weight	298	11.7	20.1	30.5	16.8	20.8
Normal weight	4249	18.6	17.6	27.7	16.6	19.5
Kotelchuck index[c]						
Inadequate/intermediate	1874	13.3	17.4	29.2	18.4	21.7
Adequate/adequate plus	2673	21.5	18.0	27.0	15.4	18.1
Married[c]						
Yes	758	26.3	19.1	24.9	14.0	15.7
No	3789	16.5	17.5	28.5	17.1	20.4
Smoking[c]						
Yes	3094	15.6	16.9	28.6	17.9	20.9
No	1453	23.4	19.5	26.4	13.8	16.9
Abnormal conditions of newborn[c]						
Yes	2748	13.9	17.1	28.4	18.2	22.4
No	1799	24.5	18.7	27.2	14.2	15.4

[a]Private insurance includes commercial indemnity plan, commercial managed care or other private insurance and self-pay

[b]Public insurance includes government programs including CommonHealth, Healthy Start, Medicaid, and Medicare (may also be HMO or managed care), or free care

[c]$p < 0.001$

Readmission after discharge home by maternal and infant characteristics among infants with NAS is presented in Table 3. No maternal and infant characteristics were significantly different between readmitted and non-readmitted infants except for insurance. In the multivariate models of readmission among infants with NAS, the readmission rate within 2–42 days was significantly higher among infants with a LOS 0–6 days compared to infants with a LOS 14–20 days (reference group) (aRR: 2.1; 95% CI: 1.2–3.4) (Fig. 2a). No significant differences in readmission rates between 43 and 182 days were observed across LOS categories (Fig. 2b).

Table 4 shows the leading causes of readmissions within 2–42 days among infants with NAS, which include diseases of the respiratory system (30.1%), NAS (14.0%), certain conditions originating in the perinatal period (18.4%) and

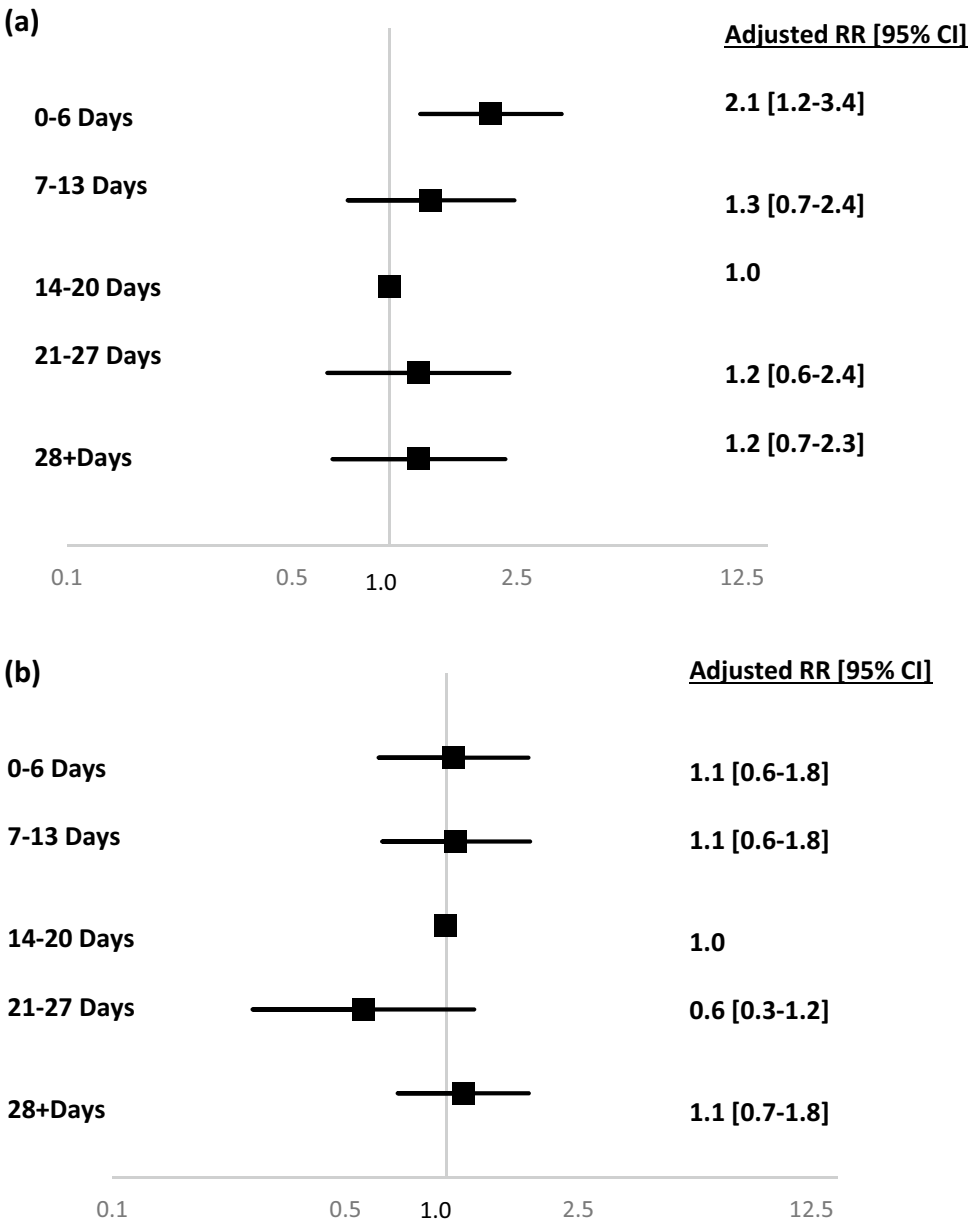

Fig. 2 **a** Association of length of stay and readmission within 2–42 days after discharge home, among infants with NAS: Massachusetts, 2011–2017. **b** Association of length of stay and readmissions within 43–182 days after discharge home among infants with NAS: Massachusetts, 2011–2017

other causes (37.5%). The majority (63.2%) of the readmissions due to NAS within 2–42 days occurred among infants with a shorter LOS (0–6 days), while only 9.8% of readmissions due to diseases of the respiratory system occurred among infants with a LOS of 0–6 days (data not shown in Table 4). Between 43 and 182 days, the causes of readmission included diseases of the respiratory system (47.6%), certain conditions originating in the perinatal period (0.6%) and others causes (51.8%).

Discussion

This study provided an opportunity to examine readmission patterns by LOS among infants with NAS beyond the neonatal period. Compared to infants without NAS, infants with NAS had non-significantly higher readmission rates within 2–42 days of discharge, and between 43 and 182 days of discharge. These findings are similar to population level studies from New York and Washington states, which showed higher readmission rates for infants with NAS within 30 days of discharge in New York and in the first five years of life in Washington (Patrick et al., 2015a, 2015b; Witt et al., 2017).

Perhaps more strikingly, among infants with NAS, a LOS of 0–6 days was associated with a significantly higher risk

Table 3 Readmissions by maternal and infant characteristics among infants with NAS: Massachusetts, 2011–2017

	Total (N)	Readmission after discharged home			
		2–42 Days		43–182 Days	
		N	%	N	%
Race/ethnicity					
Hispanic	342	7	2.0	9	2.6
White non-Hispanic	3991	115	2.9	110	2.8
Black non-Hispanic	158	5	3.2	4	2.5
Other non-Hispanic	56	1	1.8	2	3.6
Mother's age					
Less than 25	975	29	3.0	25	2.6
25–29	1761	44	2.5	56	3.2
30–34	1282	39	3.0	33	2.6
35 +	529	16	3.0	11	2.1
Mother's education					
Less than high school	830	20	2.4	24	2.9
High school/GED	1692	47	2.8	53	3.1
Some college/higher	2025	61	3.0	48	2.4
Insurance type*					
Private[a]	382	9	2.4	3	0.8
Public[b]	4165	119	2.9	122	2.9
Method of delivery					
Vaginal	3323	95	2.9	91	2.7
C-section	1224	33	2.7	34	2.8
Birth weight					
Low birth weight	298	8	2.7	10	3.4
Normal weight	4249	120	2.8	115	2.7
Kotelchuck index					
Inadequate/intermediate	1874	44	2.3	58	3.1
Adequate/adequate plus	2673	84	3.1	67	2.5
Married					
Yes	758	26	3.4	18	2.4
No	3789	102	2.7	107	2.8
Smoking					
Yes	3094	84	2.7	88	2.8
No	1453	44	3.0	37	2.5
Abnormal conditions of newborn					
Yes	2748	70	2.5	78	2.8
No	1799	58	3.2	47	2.6

[a]Private insurance includes commercial indemnity plan, commercial managed care or other private insurance and self-pay

[b]Public insurance includes government programs including CommonHealth, Healthy Start, Medicaid, and Medicare (may also be HMO or managed care), or free care

*p = 0.01 for readmission in 43–183 days

Table 4 Causes of readmission after discharge home among Infants with NAS: Massachusetts, 2011–2017

Causes of readmission	2–42 Days		43–182 Days	
	N	%	N	%
Diseases of respiratory system	41	30.1	78	47.6
NAS	19	14.0	0	0
Certain conditions originating in the perinatal period	25	18.4	1	0.6
Other	51	37.5	85	51.8

63.2% of the readmissions due to NAS within 2–42 days had a LOS of 0–6 days; while for readmissions due to diseases of the respiratory system, only 9.8% had a LOS of 0–6 days

of readmission within 2–42 days of discharge as compared to a longer LOS. In contrast, among infants without NAS, longer a LOS was associated with increasing rates of readmission, both within 2–42 days of hospital discharge and between 43 and 182 days of discharge. For infants without NAS, this pattern likely reflects increased severity of illness among infants with longer LOS leading to a higher risk for readmission. For infants with NAS, a LOS of 0–6 days likely reflects lower severity of NAS symptoms, perhaps secondary to improvement in non-pharmacologic care and less need for pharmacologic treatment. While these findings would generally be considered positive outcomes for the infant and family, they suggest that shorter LOS may be associated with particular risks for readmission, and interventions to improve the discharge process should be considered.

This potential association of shorter LOS with increased readmission risk was also seen in New York, where, LOS less than 7 days was associated with the highest odds of readmission (Patrick et al., 2015a, 2015b). Importantly, the New York study examined infants born between 2006 and 2009; our study examined infants born between 2011 and 2017, a period when many improvements in inpatient care of infants with NAS were being implemented and decreased LOS was being seen, both in Massachusetts hospitals and nationwide (Patrick et al., 2016). As we continued to see a higher risk of readmission among infants with NAS with the shortest LOS, our findings suggest these improvements in inpatient care may not have led to safer discharge practices and reduced risks of readmission after discharge among infants with NAS within 2–42 days and between 43 and 182 days. Future studies are needed to explore why infants with NAS appear to be at higher risk of readmission between 43 and 182 days.

The association between LOS 0–6 days and higher readmission rates within 2–42 days of discharge for infants with NAS suggests that some infants may be discharged too early or without proper outpatient supports in place. Prior research has emphasized the need to reduce LOS to minimize

patient's harm, reduce cost, and improve maternal bonding (Asti et al., 2015). Several studies have used hospital-based quality improvement strategies, non-pharmacologic care, standardized approaches, types of drug, and staff education to successfully reduce LOS (Asti et al., 2015; Davis et al., 2018; Holmes et al., 2016; Wachman et al., 2018a, 2018b; Walsh et al., 2018). However, most studies did not examine readmission rates, and the few that did, report zero or rare readmission events (Grossman et al., 2017a, 2017b; Wachman et al., 2018a, 2018b).

Very little literature examined short-term outcomes of infants following hospital discharge, and quality improvement efforts have largely focused on inpatient care. While efforts to improve family-centered and non-pharmacologic care of infants with NAS during the birth hospitalization should be applauded, these efforts should also focus on discharge planning and readiness to monitor for post-discharge complications. Importantly, infants with NAS had higher rates of readmission between 43 and 182 days after discharge as compared to infants without NAS; in these infants with NAS, readmission rates 43–182 days after discharge were not related to the hospital LOS. These findings highlight the need for ongoing support for these families beyond the initial hospitalization and immediate post-hospitalization period.

This study has a few limitations. First, this study used administrative data and relied on ICD-9-CM and ICD-10-CM diagnosis codes to identify NAS and does not exclude the possibility that some infants were incorrectly coded as having NAS when they did not or vice versa. Second, the primary cause of readmission was identified using the ICD-9-CM or ICD-10-CM code listed as the primary diagnosis for the readmission encounter and did not provide additional information to understand why infants are readmitted. Third, we defined transfers as readmissions the same day or the day after discharge from the delivery hospitalization, which could potentially have slightly undercounted the number of readmissions. However, since the number of infants who were readmitted without being transferred is much larger, this small number is probably not sufficient to affect our findings. Forth, this study was limited to infants who were born in MA hospitals and were readmitted in MA hospitals and may have missed infants who were readmitted in hospitals across state borders. Fifth, we did not have information on specific treatment regimens used for infants with NAS, and thus could not examine the relationship between in-hospital care and risk of readmission.

Finally, we excluded a high number of records due missing covariates from this study. However, we did not find any significant difference in the percent of NAS among excluded (1.31%) and included (1.23%) records. Among infants with NAS, when we compared LOS among included and excluded records, we found no difference in LOS (18.6 and 18.7 days, respectively). However, among non-NAS infants, excluded records due to missingness have longer LOS (3.4 days) compared to 2.4 days among included records, and given the large number, the difference is significant. Since our focus was infants with NAS, this difference did not affect our results.

Despite these limitations, this study has several strengths. This study used a large, longitudinally linked population-based database, which includes all in-state resident births and hospital discharge records, and contained detailed post-birth hospital utilization, which allows tracking of infants across all hospitals in the state. The PELL database also allowed following infants with NAS beyond the neonatal period, which is not always possible with hospital-based studies. This study was restricted to singleton and full-term infants to reduce the confounding effects of preterm birth on LOS.

These findings have implications for clinical providers. While decreasing LOS for infants with NAS can be beneficial to the family and health care system, further research is needed to identify and address necessary outpatient supports that could potentially reduce readmissions. Furthermore, readmission is marker of severe illness. Infants with NAS and shorter LOS may experience greater illness or neonatal challenges that did not rise to the level of hospital admission. Hospital teams and health care providers should therefore ensure that families of infants with NAS are prepared for discharge, with coordinated hand-offs to outpatient providers when possible, and public health systems and quality collaboratives should place a particular focus on identifying improvement opportunities in the care of infants with NAS and their families after hospital discharge.

Conclusions

Among infants with NAS, a LOS of 0–6 days was associated with a significantly higher risk of readmission within 2–42 days of discharge as compared to a longer LOS. This is a notable finding that further supports the concern that higher readmission rates may be due to some infants being discharged too early. Future research should examine in depth infants with a LOS of 0–6 days and and readmissions to see if any common features emerge and potential interactions between treatment regimen and LOS on the risk of readmission at the hospital and the population levels.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10995-022-03481-8.

Author contributions All authors contributed to the development of the manuscript and have provided input and reviewed the final manuscript.

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