

Incidence and Costs of Neonatal Abstinence Syndrome Among Infants With Medicaid: 2004–2014

Tyler N.A. Winkelman, MD, MSc,^{a,b} Nicole Villapiano, MD, MSc,^c Katy B. Kozhimannil, PhD, MPA,^d Matthew M. Davis, MD, MAPP,^{e,f} Stephen W. Patrick, MD, MPH, MSc^{g,h}

abstract

OBJECTIVES: To describe incidence, health care use, and cost trends for infants with neonatal abstinence syndrome (NAS) who are covered by Medicaid compared with other infants.

METHODS: We used 2004–2014 hospital birth data from the National Inpatient Sample, a nationally representative sample of hospital discharges in the United States ($N = 13\,102\,793$). Characteristics and trends among births impacted by NAS were examined by using univariate statistics and logistic regression.

RESULTS: Medicaid covered 73.7% of NAS-related births in 2004 (95% confidence interval [CI], 68.9%–77.9%) and 82.0% of NAS-related births in 2014 (95% CI, 80.5%–83.5%). Among infants covered by Medicaid, NAS incidence increased more than fivefold during our study period, from 2.8 per 1000 births (95% CI, 2.1–3.6) in 2004 to 14.4 per 1000 births (95% CI, 12.9–15.8) in 2014. Infants with NAS who were covered by Medicaid were significantly more likely to be transferred to another hospital and have a longer length of stay than infants without NAS who were enrolled in Medicaid or infants with NAS who were covered by private insurance. Adjusting for inflation, total hospital costs for NAS births that were covered by Medicaid increased from \$65.4 million in 2004 to \$462 million in 2014. The proportion of neonatal hospital costs due to NAS increased from 1.6% in 2004 to 6.7% in 2014 among births that were covered by Medicaid.

CONCLUSIONS: The number of Medicaid-financed births that are impacted by NAS has risen substantially and totaled \$462 million in hospital costs in 2014. Improving affordable health insurance coverage for low-income women before pregnancy would expand access to substance use disorder treatment and could reduce NAS-related morbidity and costs.



^aDivision of General Internal Medicine, Department of Medicine, Hennepin County Medical Center, Minneapolis, Minnesota; ^bCenter for Patient and Provider Experience, Minneapolis Medical Research Foundation, Minneapolis, Minnesota; ^cFamily Health Network, Cortland Regional Medical Center, Cortland, New York; ^dDivision of Health Policy and Management, School of Public Health, University of Minnesota, Minneapolis, Minnesota; ^eMary Ann & J. Milburn Smith Child Health Research Program, Ann and Robert H. Lurie Children's Hospital, Chicago, Illinois; ^fDepartment of Pediatrics, Feinberg School of Medicine, Northwestern University, Chicago, Illinois; and Departments of ^gPediatrics and ^hHealth Policy, School of Medicine, Vanderbilt University, Nashville, Tennessee

Dr Winkelman conceived and designed the study, acquired data, conducted data analysis and interpretation, and drafted the manuscript; Dr Villapiano conceived and designed the study, interpreted data, and provided critical revisions to the manuscript; Drs Kozhimannil and Davis interpreted data and provided critical revisions to the manuscript; Dr Patrick conceived and designed the study, interpreted data, provided critical revisions to the manuscript, and supervised the study; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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WHAT'S KNOWN ON THIS SUBJECT: Neonatal abstinence syndrome (NAS) disproportionately impacts Medicaid beneficiaries. However, NAS incidence and associated costs among infants with Medicaid are poorly defined and overall national estimates of NAS in the United States are out-of-date.

WHAT THIS STUDY ADDS: Between 2004 and 2014, NAS incidence rose over fivefold among a nationally representative sample of infants with Medicaid. By 2014, NAS impacted 14.4 infants per 1000 births and totaled \$462 million in hospital costs among births financed by Medicaid.

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The incidence of neonatal abstinence syndrome (NAS) rose sharply between 2000 and 2012 as the opioid epidemic expanded across the United States.¹⁻³ NAS is a withdrawal syndrome that occurs in infants who are exposed to opioids in utero. The syndrome is characterized by tremors, irritability, poor feeding, respiratory distress, and seizures, all of which develop shortly after birth.⁴ Infants with NAS have longer hospital stays, higher rates of readmission, and are more likely than nonopioid-exposed newborns to require care in the NICU for management of their symptoms.⁵⁻⁷

Maternal opioid use and NAS disproportionately impact low-income women and infants who receive medical care covered by Medicaid.^{3,5} Although Medicaid pays for the majority of NAS-related births, the incidence of NAS among births financed by Medicaid remains poorly defined.^{3,5} Furthermore, although reports of hospital costs for NAS-related care exist, there are no data describing aggregate NAS-related hospital costs among infants enrolled in Medicaid, nationally.^{8,9} Hospital costs are important to consider because Medicaid does not reimburse on the basis of charges but on a schedule often closer to costs. Information regarding NAS incidence and costs could help state and federal health officials target efforts to improve care delivery for infants with the syndrome, expand treatment for pregnant women, and prevent NAS. For these reasons, Congress called on the Government Accountability Office to report “the proportion of children born in the United States with NAS who are eligible for medical assistance under State Medicaid programs...and the costs associated with coverage under such programs.”¹⁰ However, the subsequent Government Accountability Office report was largely based on qualitative data,

because little quantitative data are available to guide such an overview.¹¹

We sought to characterize the impact of NAS among Medicaid beneficiaries by addressing the following 3 important and unanswered questions: (1) What is the incidence of NAS among Medicaid-financed births, nationally, and how has it changed over time?; (2) What are the characteristics and health care use patterns of infants with NAS who were enrolled in Medicaid compared with infants without NAS who were enrolled in Medicaid and infants with NAS who were enrolled in private insurance?; and (3) How did mean and aggregate hospital costs change between 2004 and 2014 for infants with NAS covered by Medicaid? We also contribute to the literature on NAS by providing the most recent NAS incidence estimates based on available national data.

METHODS

Study Design and Setting

We conducted a serial cross-sectional analysis by using data from the 2004 through 2014 National Inpatient Sample (NIS) compiled by the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality.¹² The NIS is the largest annual all-payer database of hospital discharges in the United States. It includes patient and hospital-level data from more than 1000 nonfederal hospitals in 46 states and encompasses 97% of the US population. Before 2012, the NIS sample included all discharges from 20% of US hospitals. Beginning in 2012, the NIS sampling frame changed to 20% of discharges from all US hospitals. To account for this sampling redesign, we applied trend weights provided by the Healthcare Cost and Utilization Project to allow for comparison across years.

Identification of Sample

Our sample consisted of infant discharge records of all hospital births from 2004 through 2014 in the NIS. Births were identified by using *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes V30.0× to V39.0×. Infants with NAS were identified if ICD-9-CM code 779.5 was listed in any diagnosis field. We excluded cases of iatrogenic NAS that occur when an infant is exposed to opioids after birth, using previously described methods.^{1,3,5}

The NIS provides a primary payer for each hospital discharge. For purposes of this study, the primary payer was categorized as either private, Medicaid, or uninsured. Discharges with any public primary payer were categorized as Medicaid because Medicaid paid for >99% of birth-related discharges covered by a public payer in all our sampled years.⁵

Characteristics of Infants With NAS Compared With Other Infants

We examined characteristics of infants with NAS who were enrolled in Medicaid and compared them to (1) infants enrolled in Medicaid without NAS, and (2) infants enrolled in private insurance with NAS. We compared differences in sex, income quartile of patient’s zip code, and rural status. We also estimated incidence of preterm deliveries (ICD-9-CM codes 765.21–765.28) and presence of comorbidities known to be common among infants with NAS by using previously described methods (ie, respiratory diagnoses, low birth weight, seizures, or feeding difficulty).⁵

Outcome Measures

NAS Incidence

We first calculated the annual national incidence of NAS among all infants per 1000 hospital births. We then determined the annual incidence of NAS within Medicaid

and private payer subgroups. The purpose of this subgroup analysis was to ultimately determine costs among infants whose care was financed by a health insurance entity, and thus, we did not examine NAS incidence among uninsured infants.

Health Care Use and Costs

We compared the rate of hospital transfer to another facility, mean length of stay, and mean cost of birth hospitalization among infants with NAS who were enrolled in Medicaid to infants without NAS who were enrolled in Medicaid and to infants with NAS who were enrolled in private insurance.

To obtain hospital costs, we used Agency for Healthcare Research and Quality's cost-to-charge ratio files to convert charges.^{8,12} We applied the cost-to-charge ratio to each charge in our analytic sample and inflation-adjusted resultant costs to 2014 dollars by using the Consumer Price Index for All Urban Consumers.¹³

We aggregated hospital costs for all NAS births covered by Medicaid in each year of our study. Less than 4% of NAS discharges were missing cost information. Next, we aggregated hospital costs for all births covered by Medicaid in each year of our study. We then determined the proportion of birth-related hospital costs due to NAS in each year of our study among infants covered by Medicaid. Similar analyses were conducted for total birth-related costs due to NAS among all-payers.

Finally, we estimated excess costs among infants covered by Medicaid due to NAS over the course of our study period by multiplying the number of weighted NAS births in each time period by the average cost for a non-NAS birth who were covered by Medicaid and subtracting these values from aggregated hospital costs for infants with NAS who were covered by Medicaid.

Data Analysis

We used weighted frequencies to describe characteristics of infants with NAS who were enrolled in Medicaid, infants without NAS who were enrolled in Medicaid, and infants with NAS who were enrolled in private insurance. Differences were compared by using Pearson's χ^2 tests. We similarly estimated health care use and mean hospital costs among these groups by using univariate frequencies and compared differences with χ^2 tests and *t* tests. To characterize broad time trends, we determined length of stay and mean hospital costs during 3 time periods (2004–2006 vs 2007–2010 vs 2011–2014). Because transfer to another facility was only available for years 2010–2014, we did not examine changes in transfer rates over time.

We used multivariable negative binomial and logistic regression to compare length of stay and transfer rates, respectively, between infants with NAS enrolled in either Medicaid or private insurance. Our models accounted for year, sex, income quartile of patient's zip code, urban versus rural residence, hospital type (rural versus urban nonteaching versus urban teaching), and prematurity.

To obtain annual hospital costs for infants with and without NAS covered by Medicaid we used Stata's total commands with survey weights. We determined excess costs among infants with NAS covered by Medicaid using methods described in the previous section.

We used logistic regression and predictive margins to obtain unadjusted NAS incidence nationally and among infants who were enrolled in Medicaid or private insurance. NAS incidence is reported as NAS cases per 1000 hospital births.

All analyses were conducted by using Stata 15.0 (StataCorp, College Station, TX). Estimates are weighted,

unless otherwise noted, to allow for nationally representative inferences and to account for changes to the NIS sampling strategy in 2012. We considered 2-sided $P < .05$ to be statistically significant. Our study was exempt from human subjects review per the Minneapolis Medical Research Foundation's policy on de-identified data sets.

RESULTS

Sample Characteristics

Our sample consisted of 9 115 457 birth discharge records from 2004 through 2014, representative of 43.6 million weighted births. In this sample, 3 991 336 infants were covered by Medicaid, representative of 19.1 million weighted births. Medicaid was the primary payer for 43.9% of hospital births (95% confidence interval [CI], 42.8%–44.9%) in our pooled national sample. There were 35 629 infants with a diagnosis of NAS during our study period, representative of 173 384 weighted births. Medicaid was the primary payer for 73.7% (95% CI, 68.9%–77.9%) of NAS-related births in 2004 and 82.0% (95% CI, 80.5%–83.5%) of NAS-related births in 2014.

Infants with NAS who were enrolled in Medicaid were significantly more likely to be male, reside in a rural county, and have comorbidities reflective of the syndrome than infants without NAS who were enrolled in Medicaid. Similarly, infants with NAS who were enrolled in Medicaid were more likely to live in poor and rural counties but were less likely to be diagnosed with a NAS-related comorbidity compared with infants with NAS enrolled in private insurance (Table 1).

NAS Incidence

Between 2004 and 2014, the incidence of NAS in the United States increased from 1.5 per 1000 hospital births (95% CI, 1.2–1.9) to

TABLE 1 Characteristics of Infants Enrolled in Medicaid With NAS, Medicaid Without NAS, and Private Insurance With NAS, United States, 2004–2014

Characteristic	Medicaid With NAS, Weighted % (95% CI)	Medicaid Without NAS, Weighted % (95% CI)	<i>P</i> ^a	Private With NAS, Weighted % (95% CI)	<i>P</i> ^a
Unweighted, <i>n</i>	28 251	3 963 085	na	4906	na
Weighted population estimate	137 575	18 961 469	na	23 834	na
Female	46.0 (45.3–46.6)	49.0 (48.9–49.0)	<.001	44.1 (42.7–45.6)	.02
Income quartile			.15		<.001
1, lowest income	39.4 (37.7–41.1)	40.0 (38.5–41.4)		21.0 (19.1–23.1)	
2	27.6 (26.6–28.7)	28.7 (27.8–29.5)		22.4 (20.9–23.9)	
3	21.6 (20.5–22.7)	20.8 (20.0–21.5)		27.5 (26.0–29.1)	
4, highest income	11.4 (10.6–12.2)	10.7 (9.7–11.6)		29.0 (27.0–31.1)	
Rural residence	21.1 (19.2–23.1)	16.8 (15.9–17.8)	<.001	14.5 (13.0–16.1)	<.001
Preterm delivery, <37 wk	17.7 (17.0–18.3)	8.4 (8.1–8.6)	<.001	17.5 (16.3–18.7)	.78
Any comorbidity ^b	43.9 (42.9–44.9)	12.8 (12.6–13.1)	<.001	47.2 (45.5–49.0)	<.001

Medicaid with NAS is the reference group. na, not applicable.

^a Medicaid With NAS is the reference group.

^b Any respiratory diagnosis, low birth wt, seizure, and feeding difficulty.⁵

8.0 per 1000 hospital births (95% CI, 7.2–8.7), a more than fivefold increase (Fig 1). The rising incidence of NAS was driven in large part by a substantial increase in NAS among Medicaid covered births. In 2004, the incidence of NAS among Medicaid-financed births was 2.8 per 1000 hospital births (95% CI, 2.1–3.6). By 2014, 14.4 per 1000 hospital births (95% CI, 12.9–15.8), or 1.4% of all Medicaid-financed births, were affected by NAS. The incidence of NAS births financed by private insurance also increased between 2004 and 2014, but to a lesser degree (2004: 0.5 per 1000 births [95% CI, 0.4–0.6] vs 2014: 2.0 per 1000 births [95% CI, 1.8–2.2]).

Health Care Use and Costs

In unadjusted analyses, infants with NAS who were covered by Medicaid were significantly more likely to be transferred to another hospital for care than were infants without NAS who were covered by Medicaid or infants with NAS who were covered by private insurance between 2010 and 2014 (Table 2). In each time period we examined, infants with NAS who were covered by Medicaid had hospital stays that were significantly longer than infants without NAS who were covered by Medicaid or infants with NAS who were covered by private insurance (Table 2).

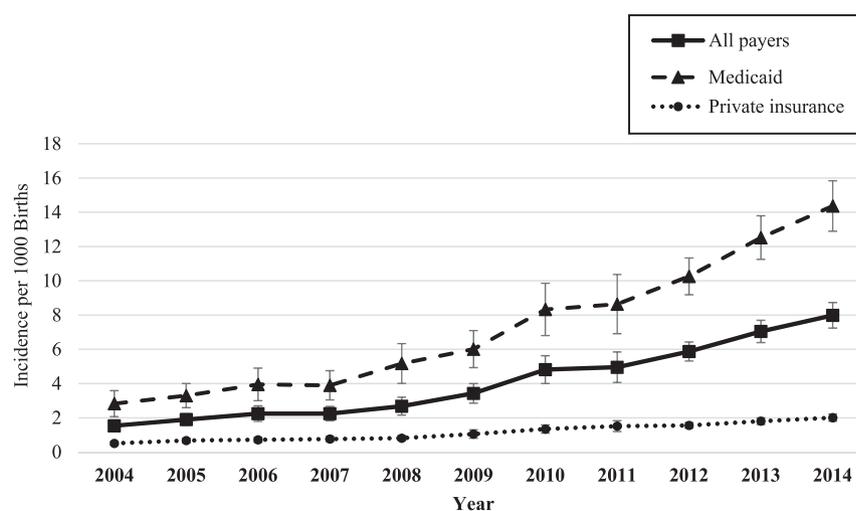


FIGURE 1 Incidence of NAS by primary payer.

Differences in transfer rates and length of stay between infants with NAS who were covered by Medicaid and private insurance persisted after controlling for patient and hospital-level factors. In adjusted analyses, infants with NAS who were covered by Medicaid were more likely to be transferred to another hospital for care (8.6% vs 7.1%; *P* = .02) and to have longer lengths of stay (16.5 days vs 14.6 days; *P* < .001) compared with infants with NAS who were covered by private insurance.

The mean cost for an infant with NAS was significantly higher than for an infant without NAS. Between 2011 and 2014, mean hospital costs for an infant with NAS covered by Medicaid

were over fivefold higher than for an infant without NAS (\$19 340 per birth vs \$3700 per birth; *P* < .001). Mean inflation-adjusted hospital costs for infants with NAS covered by Medicaid increased 26% between 2004 and 2006 and 2011 and 2014 (\$15 350 vs \$19 340; *P* < .001; Table 2).

Annual hospital costs (adjusted for inflation to 2014 US dollars) for infants with NAS who were covered by Medicaid increased significantly during our study period. Costs totaled \$65.4 million (95% CI, 46.4–84.4) for all infants with NAS who were covered by Medicaid in 2004 and increased to \$462 million (95% CI, 383–541) in 2014 (Fig 2).

TABLE 2 Unadjusted Health Care Use and Cost Among Infants Enrolled in Medicaid With NAS, Medicaid Without NAS, and Private Insurance With NAS, United States, 2004–2014

Characteristic	Medicaid With NAS, Weighted Estimate (95% CI)	Medicaid Without NAS, Weighted Estimate (95% CI)	<i>P</i> ^a	Private With NAS, Weighted Estimate (95% CI)	<i>P</i> ^a
Transfer to another hospital, %	8.6 (7.8–9.4)	1.8 (1.7–1.9)	<.001	7.0 (6.0–8.1)	.01
Mean length of stay, d					
2004–2006	14.7 (13.5–15.8)	3.3 (3.2–3.4)	<.001	13.2 (12.0–14.3)	.02
2007–2010	16.9 (16.0–17.8)	3.5 (3.4–3.6)	<.001	15.2 (13.7–16.7)	.04
2011–2014	16.6 (16.1–17.1)	3.5 (3.5–3.6)	<.001	14.9 (14.1–15.8)	<.001
Mean cost ^b of birth hospitalization per infant, \$					
2004–2006	15 350 (13 660–17 050)	3060 (2830–3290)	<.001	16 610 (14 190–19 020)	.28
2007–2010	18 510 (16 860–20 160)	3360 (3110–3600)	<.001	19 670 (17 400–21 930)	.30
2011–2014	19 340 (18 290–20 390)	3700 (3670–3840)	<.001	21 050 (19 340–22 760)	.04

^a Medicaid With NAS is the reference group.

^b Costs are inflation-adjusted to 2014 US dollars and do not include costs after hospital transfer.

Between 2004 and 2014, hospital costs totaled \$2.5 billion (95% CI, 2.3–2.7) for infants with NAS who were covered by Medicaid. If none of these infants had developed NAS, hospital costs would have totaled roughly \$487 million. Therefore, NAS resulted in ~\$2 billion in excess costs among Medicaid-financed deliveries during our study period. Total costs by other payers (ie, Medicaid, private, and all-payers) can be found in the Supplemental Information. Hospital costs among infants with NAS covered by Medicaid accounted for 79.4% of all NAS-related hospital costs during our study period.

As hospital costs for infants with NAS who were covered by Medicaid increased from 2004 through 2014, the proportion of birth-related costs due to NAS also increased (Fig 3). In 2004, 1.6% of hospital costs for births covered by Medicaid were for the births of infants with NAS. By 2014, NAS accounted for 6.7% of all birth-related hospital costs among infants who were covered by Medicaid. The proportion of birth-related costs among all payers due to NAS can be found in the Supplemental Information.

DISCUSSION

From 2004 to 2014, the incidence of NAS increased fivefold among infants who were covered by Medicaid, reaching 14.4 per 1000

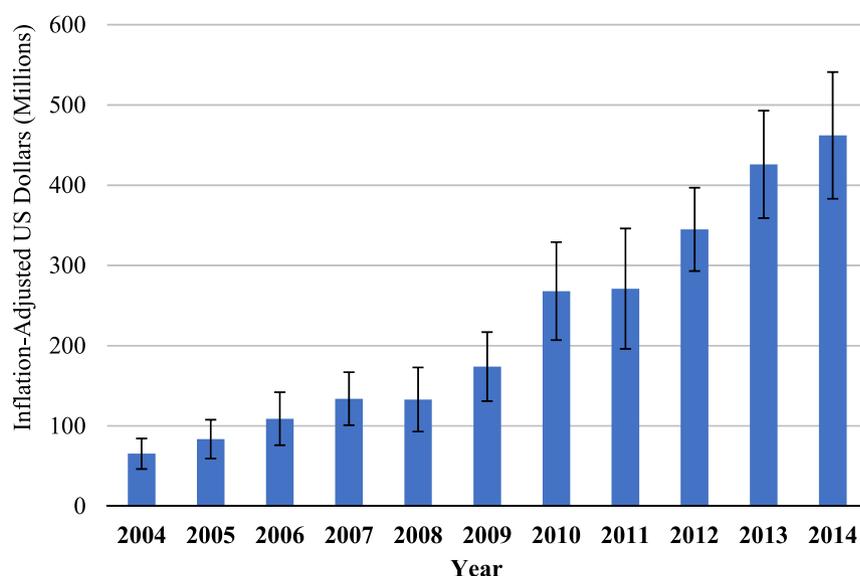


FIGURE 2

Total hospital costs for NAS among infants who were enrolled in Medicaid.

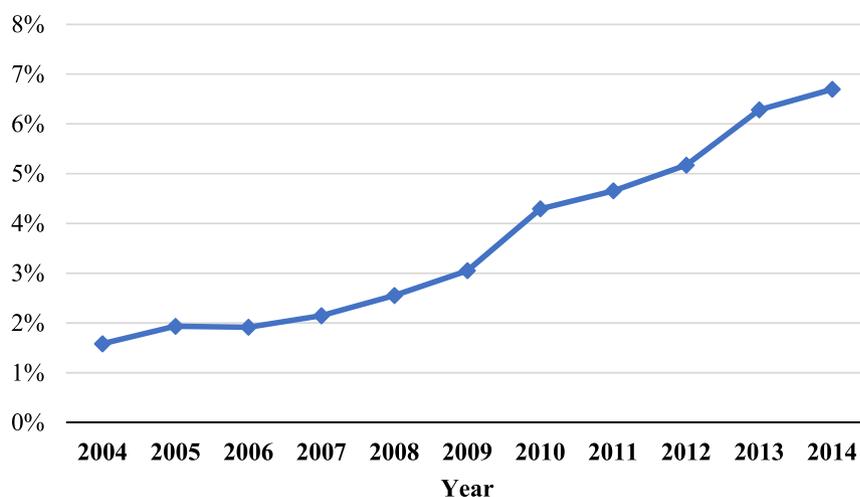


FIGURE 3

Proportion of birth-related hospital costs due to NAS among infants who were enrolled in Medicaid.

births in 2014. As the number of infants enrolled in Medicaid with the syndrome grew, so did hospital costs. The proportion of birth-related costs due to NAS grew from 1.6% in 2004 to 6.7% in 2014 among infants enrolled in Medicaid, with annual costs of ~\$462 million in the final year of available data. The opioid epidemic is increasingly and disproportionately affecting families and infants covered by Medicaid, along with state and federal budgets.

The overall incidence of NAS in the United States, regardless of insurance coverage, increased substantially between 2004 and 2014. However, the incidence of NAS was over 7 times higher among infants who were covered by Medicaid compared with infants who were covered by private insurance in 2014. Although other studies have reported a large proportion of infants with NAS are insured by Medicaid, ours is the first to quantify incidence differences between infants who are covered by Medicaid and private insurance over time.^{3,5,7} With the disproportionate impact of NAS on the Medicaid population, we suggest that NAS incidence rates are unlikely to improve without interventions targeted at low-income mothers and infants.

Infants with NAS who were covered by Medicaid also had higher rates of hospital transfer (between 2010 and 2014) and longer lengths of stay compared with infants with NAS who were privately insured, even after adjustment. However, we were unable to account for some differences between infants who were covered by Medicaid and private insurance that may delay discharge and prolong hospitalization (eg, social factors like housing or transportation). Authors of future work should evaluate factors that contribute to differences in transfer rates and length of stay among infants with NAS to identify

opportunities for care improvement and cost savings.

Rising NAS incidence led to higher NAS-associated hospital costs over the study period, both in aggregate and as an overall proportion of birth-related costs for state Medicaid programs. Hospital costs associated with care of infants with NAS who were enrolled in Medicaid accounted for ~\$2.5 billion over the course of our 10-year study period. As the nation's leading payer of NAS-related care, the Centers for Medicare and Medicaid Services and state Medicaid programs have an opportunity to set national standards to advance the "triple aim" of reduced costs, improved outcomes, and enhanced experience for infants with NAS and their families.¹⁴ Although such a goal is ambitious, the Centers for Medicare and Medicaid Services and state Medicaid programs have shown through their work to reduce early elective deliveries that it is possible to improve maternal and infant outcomes while reducing costs.¹⁵

Medicaid programs could promote standardization of clinical protocols to reduce hospital costs and improve outcomes for infants with NAS.⁵ Mounting evidence supports nonpharmacologic treatment of infants diagnosed with NAS. Systematic implementation of policies that support rooming-in, breastfeeding, swaddling, on-demand feeding schedules, and minimization of sleep disruption may reduce symptoms of NAS and reduce the duration of, or even eliminate the need for, pharmacologic treatment of NAS.¹⁶⁻²² Opportunities for improved newborn care and reduced costs exist even among infants who require pharmacologic treatment of the management of NAS. Pharmacologic treatment with buprenorphine, for example, has been shown to reduce hospital length of stay by 35%.²³

Policies that improve access to opioid use disorder treatment for women before, during, and after pregnancy may also reduce NAS-related morbidity and costs.²⁴ Medication-assisted treatment (MAT) during pregnancy improves outcomes and reduces costs associated with NAS compared with attempted abstinence.^{22,25-28} Although MAT does not necessarily reduce the incidence of NAS, it may prevent prolonged hospital stays due to preterm birth, reduce NICU admissions, decrease the severity of NAS symptoms, and improve birth outcomes for some infants. States could rapidly expand access to MAT for reproductive-aged women by using funding made available by recent federal legislation.^{10,29}

Ultimately, a public health approach that targets patient-, family-, and community-level factors will be necessary to prevent women from developing opioid use disorders.³⁰ Individual level predictors of opioid use disorders include mental health disorders and preexisting substance use disorders.³¹ Screening, referral, and treatment for these conditions may reduce the incidence of opioid use disorders among reproductive-age women. At the family level, adolescents with strained parental relationships are at increased risk of opioid use disorders and may benefit from family-based therapy.³² At the community-level, low socioeconomic status and unemployment are strong predictors of opioid use.³³ Collaboration among a diverse set of stakeholders will be required at each level to reduce factors that contribute to opioid use among reproductive-aged women.

This study has several important limitations. NIS data are aggregated from hospital discharge information and reflect coding practices in which misclassification bias is possible. Current evidence suggests NAS is underreported in hospital billing data.³⁴ Therefore, the incidence

and costs associated with NAS we report here are likely conservative. Alternatively, rising NAS incidence may be because of an improved awareness and recognition of the clinical syndrome over time or iatrogenic cases of NAS not accounted for in our exclusion criteria. However, the associated increase in maternal opioid use described elsewhere^{3,5} and opioid use trends among the general population³⁵ do not suggest a progressive diagnostic bias in NAS. Finally, because of data limitations, we were not able to calculate state-level cost variation.

CONCLUSIONS

Federal and state Medicaid program administrators have the opportunity to implement policies that promote prevention and treatment of NAS. Reducing NAS incidence will require the adoption of a public health approach to opioid use disorders among reproductive-aged women.

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ABBREVIATIONS

CI: confidence interval
ICD-9-CM: *International Classification of Diseases, Ninth Revision, Clinical Modification*
MAT: medication-assisted treatment
NAS: neonatal abstinence syndrome
NIS: National Inpatient Sample

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Address correspondence to Tyler N.A. Winkelman, MD, MSc, Hennepin County Medical Center, 701 Park Ave, S2.309, Minneapolis, MN 55415. E-mail: tyler.winkelman@hcmcd.org

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