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ORIGINAL RESEARCH

Trends in Diagnoses of Neonatal Abstinence Syndrome at Newborn Hospitalization in Maine, 2009-2018

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Introduction:	Incidence rates of neonatal abstinence syndrome (NAS) have increased in Maine, but whether this increase can be explained by use of different diagnosis codes over time is unknown. Our objective was to estimate trends in diagnoses of NAS at newborn hospitalization in Maine using different NAS case definitions.
Methods:	We used International Classification of Diseases (ICD) diagnosis codes to identify newborns diagnosed with NAS in Maine between 2009 and 2018 using state-level hospital discharge data (n = 123 519). First, we considered only ICD-9 and ICD-10 codes used for confirmed NAS. Then we used an expanded ICD-10 NAS case definition that included codes for neonates suspected to have NAS and affected by an unspecified "other maternal medication." We used joinpoint regression to model trends over time and identified changes in slope.
Results:	Using the case definition for confirmed NAS, diagnoses of NAS increased from 2009 to 2013 (from 20 to 38 per 1000 births), and then decreased from 2013 to 2018 (from 38 to 28 per 1000 births). Using our expanded ICD-10 NAS case definition, NAS increased linearly from 2009 to 2018 (from 24 to 50 per 1000 births).
Discussion:	The trends in diagnoses of NAS were different when based on the expanded or confirmed NAS case definition.
Conclusions:	Validation studies are needed to understand which infants are coded using the expanded versus confirmed NAS case definition. Caution should be used when interpreting rates of NAS in Maine using hospital discharge data.
Keywords:	neonatal abstinence syndrome, International Classification of Diseases, ICD-9, ICD-10

Neonatal abstinence syndrome (NAS) is a condition of withdrawal symptoms in infants that is most commonly caused by exposure to opioids in utero.[1] Rates of NAS increased more than 5-fold in the United States from 2004 to 2014 (from 1.5 to 8.0 per 1000 hospital births).[2] Maine had the second highest annual increase in incidence of NAS between 1999 and 2013, with incidence rates increasing from 1.1 to 30.4 per 1,000 hospital births during 1999 to 2012.[3] Current data are needed to estimate state-level trends in NAS in Maine after 2012. Also, while NAS surveillance and other research[2,4,5] often identifies NAS cases from hospital billing data using diagnosis codes, little is known about how the use of different diagnosis codes for NAS has changed over time.

Recent coding changes for NAS may have introduced discrepancies in NAS classification over time. On October 1, 2015, the International Classification of Diseases changed the diagnosis codes used to identify NAS in-hospital discharge data from Clinical Modification ninth revision (ICD-9) to the tenth revision (ICD-10). In 2018, certain NAS-related diagnosis codes were introduced or expanded to capture more detailed information on neonatal in utero exposure to maternal medication and drug use.[6,7] While ICD-9 and ICD-10 diagnosis

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codes for NAS were found to have high positive predictive value (> 90%) in a study validating Tennessee Medicaid data against medical records,[8] ICD-9/10 codes have not been validated more broadly and may vary in accuracy depending on the true prevalence of NAS and other factors. States lack standardized definitions of and surveillance practices for NAS, which could lead to different estimates for this condition across the United States.[9]

Our objective was to estimate trends in diagnoses of NAS at newborn hospitalization in Maine using state-level hospital discharge data. We examined trends using 3 NAS case definitions created based on ICD-9/10 diagnosis codes: 1) a primary definition, which was restricted to confirmed cases; 2) a secondary definition, which included neonates suspected to have NAS; and 3) an expanded ICD-10 definition, which additionally included codes for unspecified maternal drug use during pregnancy. We also evaluated whether newborns defined as having NAS using the confirmed/suspect versus expanded ICD-10 case definitions differed according to medical and hospital characteristics.

METHODS

Data source

We examined newborn hospitalizations in Maine from 2009 to 2018 using individual-level inpatient discharge data provided by the Maine Health Data Organization, a state agency that maintains a comprehensive health information database of every inpatient hospital encounter in the state.[10] The University of Southern Maine's Institutional Review Board approved the study protocol.

NAS identification

First, we identified newborn hospitalizations by restricting hospital discharge data to persons under 1 year of age with an ICD diagnosis code indicating a live birth[11] or whose date of birth matched the date of hospital admission. We then compared the number of births we identified each year from the hospital discharge data to the total number of births in hospitals or clinical settings among Maine residents each year.[12]

Next, we scanned hospital reported diagnosis codes for any code that matched our NAS definitions. For ICD-10 (October 2015 through 2018), we used the 2019 Council of State and Territorial Epidemiologists (CSTE) Tier 2 case definition for confirmed and suspect NAS when using administrative data (see CSTE reference's Appendix 4).[6] Our primary NAS case definition was the 'confirmed and probable' CTSE NAS case definition ICD-10 codes (P96.1, neonatal abstinence syndrome). As a secondary definition, we additionally included the CSTE 'suspect' NAS case definition ICD-10 codes (P04.14, newborn affected by maternal use of opiates; P04.17, newborn affected by maternal use of sedative-hypnotics; and P04.1A, newborn affected by maternal use of anxiolytics) (Table 1). For the third definition, we reviewed the NAS-related 'of interest' codes compiled by CSTE to identify codes for unspecified maternal medication or drug use that may have indicated in utero exposure to opioids. These codes could have been used to capture polysubstance use involving opioids or medication-assisted treatment with opioids, neither of which is specifically listed as an ICD-10 in utero exposure code. The third definition, which we called 'expanded ICD-10', therefore included our confirmed and suspect NAS case definition codes plus codes for newborns that indicated they were affected by unspecified maternal medication or drug use (Table 1).

The CSTE case definitions for NAS do not include ICD-9 codes; therefore, we selected ICD-9 codes for each NAS definition that were consistent with our 3 ICD-10 definitions. For the primary definition, we used ICD-9 (2009 through September 2015) code 779.5, which was used in previous studies to identify confirmed cases.[8,13] For both the suspect and expanded NAS case definitions, we also included codes 779.4 (drug reactions and intoxications specific to newborn) and 760.72 (narcotics affecting fetus or newborn via placenta or breast milk). These codes align with ICD-10 codes for suspect NAS and unspecified maternal medication/drug use. Code 760.72 was previously identified as an ICD-9 code equivalent for 2 of the ICD-10 codes used in our expanded ICD-10 definition (P04.40 and P04.49).[14]

Table 1. ICD-9/ICD-10 Diagnosis Codes Used for Primary and Secondary Definitions of Neonatal Abstinence Syndrome.

NAS case definition	ICD version	Diagnosis code and description
Primary case definition		
• Confirmed NAS	ICD-9 ICD-10	779.5 – Drug withdrawal syndrome in newborn P96.1 – NAS
Secondary case definition		
• Confirmed or suspect NAS*	ICD-9	779.5 – Drug withdrawal syndrome in newborn 779.4 – Drug reactions and intoxications specific to newborn 760.72 – Narcotics affecting fetus or newborn via placenta or breast milk
	ICD-10	P96.1 – NAS P04.14 – Newborn affected by maternal use of opiates P04.17 – Newborn affected by maternal use of sedative-hypnotics P04.1A – Newborn affected by maternal use of anxiolytics
Expanded ICD-10 definition		
• Confirmed or suspect NAS*	ICD-9	779.5 – Drug withdrawal syndrome in newborn 779.4 – Drug reactions and intoxications specific to newborn 760.72 – Narcotics affecting fetus or newborn via placenta or breast milk
	ICD-10	P96.1 – NAS P04.14 – Newborn affected by maternal use of opiates P04.17 – Newborn affected by maternal use of sedative-hypnotics P04.1A – Newborn affected by maternal use of anxiolytics
• Unspecified newborn affected by maternal medication/drug use codes†	ICD-10	P04.1 – Newborn affected by other maternal medication P04.18 – Newborn affected by other maternal medication‡ P04.19 – Newborn affected by maternal use of unspecified medication‡ P04.40 – Newborn affected by maternal use of unspecified drugs of addiction‡ P04.49 – Newborn affected by maternal use of other drugs of addiction

Abbreviations: ICD, International Classification of Diseases; NAS, neonatal abstinence syndrome.
* ICD-10 codes for "Confirmed or Suspect Case", Appendix 4.[6]
† Subset of ICD-10 codes for "Exposed but no clinical signs of withdrawal", Appendix 5.[6]
‡ ICD-10 codes introduced in October 2018; *P04.18* and *P04.19* are 2 of 9 expansion codes of the existing code *P04.1*

Table 2. Characteristics of Newborns according to Categorization by ICD-10 Definition of Neonatal Abstinence Syndrome: Maine hospitals, October 2015-December 2018 (n = 39 021).

	Confirmed or suspect NAS, No. (%)	Unspecified maternal drug use codes and no confirmed or suspect NAS, No. (%)	Comparison of confirmed/ suspect NAS vs unspecified maternal drug codes only	No confirmed NAS, suspect NAS, or unspecified maternal drug use codes, No. (%)
	(n = 1247)	(n = 999)	P value	(n = 36 775)
Birth year				
2015	104 (8.3)	80 (8.0)	.55	2778 (7.6)
2016	423 (33.9)	342 (34.2)		11521 (31.3)
2017	382 (30.6)	329 (32.9)		11201 (30.5)
2018	338 (27.1)	248 (24.8)		11275 (30.7)
Rurality of residence*			<.001	
Metro	435 (34.9)	261 (26.1)		13078 (35.6)
Large rural	387 (31.0)	366 (36.6)		13371 (36.4)
Small rural	350 (28.1)	269 (26.9)		7985 (21.7)
Isolated rural	62 (5.0)	88 (8.8)		1816 (4.9)
Other/out of state	13 (1.0)	15 (1.5)		522 (1.4)
Preterm birth				
Yes	166 (13.3)	201 (20.1)	<.001	3054 (8.3)
No	1081 (86.7)	798 (79.9)		33721 (91.7)
Intrauterine growth restriction				
Yes	156 (12.5)	107 (10.7)	.19	1399 (3.8)
No	1091 (87.5)	892 (89.3)		35376 (96.2)
In-hospital infant death				
Yes	Suppressed	0	NC	102 (0.3)
No	1246 (99.9)	999 (100.0)		36673 (99.7)

Table 2. (continued)

Any codes for "affected by"				
Maternal tobacco use, *P04.2*	193 (15.5)	233 (23.3)	<.001	306 (0.8)
Maternal cannabis use, *P04.81*	Suppressed	Suppressed	NC	21 (0.1)
Maternal alcohol use, *P04.3*	Suppressed	10 (1.0)	<.01	12 (0)
Maternal antidepressant use,*P04.15*[†]	0	0	NC	Suppressed
Maternal amphetamine use, *P04.16*[†]	0	0	NC	0
All other maternal drug use[‡]	25 (2.0)	20 (2.0)	.99	60 (0.2)
Length of stay				
Mean (SE)	10.2 (0.26)	5.4 (0.22)	<.001	3.6 (0.04)
Median (interquartile range)	6.0 (5.0, 13.0)	3.0 (2.0, 6.0)		2.0 (2.0, 3.0)
Readmission within 1 year (rate per 1000 births)[§]	72 (57.8)	35 (35.1)	.01	1248 (33.9)
Hospital				
Northern Light Eastern Maine Medical Center	432 (34.6)	62 (6.2)	<.001	5314 (14.5)
Maine Medical Center	281 (22.5)	293 (29.3)	<.01	8980 (24.4)
MaineGeneral Medical Center	129 (10.3)	125 (12.5)	.11	3104 (8.4)
St. Mary's Regional Medical Center	66 (5.3)	19 (1.9)	<.001	1827 (5.0)
Central Maine Medical Center	60 (4.8)	80 (8.0)	<.01	1946 (5.3)
All other hospitals[‖]	279 (22.4)	420 (42.0)	<.001	15604 (42.4)

Abbreviations: NAS, neonatal abstinence syndrome; NC, not calculated due to small cell size; SE, standard error.

Suppressed cells indicate n ≤ 10 observations.

* Rural-urban designations were determined using a 4-category classification based on 2010 rural-urban community area codes, a census tract–based classification system: all metro (1, 1.1); large rural (2, 2.1, 3, 4, 4.1, 5, 5.1, 6); small rural (7, 7.1, 7.2, 8, 8.1, 8.2, 9, 10.1, 10.2, 10.3); and isolated rural (10). Three observations were missing zip code information.

[†] These ICD-10 codes were introduced in October 2018 and are 2 of 9 expansion codes of the existing code P04.1.

[‡] Separate ICD-10-CM codes exist for newborns affected by maternal use of chemotherapy, cytotoxic drugs, anticonvulsants, sedative-hypnotics, anxiolytics, cocaine, hallucinogens, nutritional chemical substances, environmental chemical substances, noxious substances, other maternal noxious substances, and unspecified noxious substances.

[§] Potential duplicate newborn hospitalizations (n = 8) were removed from the readmission rate denominator.

[‖] Other hospitals include: Bridgton Hospital, Northern Light Mercy Hospital, Redington-Fairview General Hospital, Waldo County General Hospital, Rumford Hospital, Norther Light AR Gould Hospital, Southern Maine Health Care, York Hospital, Houlton Regional Hospital, Down East Community Hospital, Cary Medical Center, Stephens Memorial Hospital, Franklin Memorial Hospital, Mount Desert Island Hospital, Northern Light Inland Hospital, Mid Coast Hospital, Northern Light Maine Coast Hospital, Northern Maine Medical Center, Calais Regional Hospital, Pen Bay Medical Center, Mayo Regional Hospital, and LincolnHealth.

Newborn medical and hospital characteristics

We compared several medical and hospital characteristics between newborns who were identified as having NAS using the confirmed/suspect case definition and the expanded ICD-10 case definition. We restricted this comparison to October 2015 through December 2018 because, by design, it was only after the ICD-9/ICD-10 transition that the expanded definition identified a unique group of newborns. We used diagnosis codes to categorize infants by preterm birth (< 37 completed weeks' gestation) and intrauterine growth restriction using previously published code lists and online ICD-9/10 crosswalks.[15-18] We also scanned diagnosis codes to identify newborns affected by maternal tobacco use, cannabis use, alcohol use, antidepressant use, amphetamine use, and all other maternal drug use codes (see CSTE Appendix 5).[6] We then categorized infants by year of birth, hospital of birth, length of newborn hospitalization stay, and if they died during their newborn hospitalization (using discharge status codes). We used residential zip code to categorize infants by rurality of residence based on the 2014 rural tier assignments published by the New England Rural Health Roundtable.[19] These assignments use the 2010 United States Department of Agriculture Rural-Urban Commuting Area codes, a census tract-based classification system that takes into account population density, urbanization, and daily commuting.[20] Finally, we calculated the rate of readmission to the birth hospital within the first 12 months of life. Only readmissions to the birth hospital could be reliably identified in these data because different hospitals use different identifying numbers for each patient.

Statistical analysis

Linear trends in the rate of NAS at newborn hospitalization were estimated using Joinpoint Regression Program 4.8.01. We allowed for up to 2 joinpoints (ie, changes in slope) to be detected, and specified that the software calculate crude rates (and standard errors) per 1000 births and plot trends without log transformation. We analyzed differences in select medical and hospital characteristics of the newborns by NAS case definitions with chi-square and t-tests using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

We identified 123 519 infants from 2009 to 2018 Maine hospital data, which corresponded closely with the number of births in hospitals/clinical settings from 2009 to 2018 for Maine residents (n = 124 798).[12]

Figure 1 shows the time trends from the joinpoint regression analyses for the 3 NAS case definitions. Using our primary NAS case definition (confirmed cases), diagnoses of NAS increased from 2009 to 2014 (observed: 20 to 38 per 1000 births; annual percentage increase: 4.0 per 1000 births [segment linear trend P < .01]). It then decreased from 2014 to 2018 (observed: 38 to 28 per 1000 births; annual percentage decrease: 2.5 per 1000 births [P < .01]) (Figure 1A). Using our secondary NAS case definition (confirmed/suspect cases), diagnoses of NAS increased from 2009 to 2013 (observed: 24 to 43 per 1000 births; annual percentage increase: 5.3 per 1000 births [P < .01]), and then decreased from 2013 to 2018 (observed: 43 to 29 per 1000 births; annual percentage decrease: 3.2 per 1000 births [P < .01]) (Figure 1B). In contrast, when we used our expanded ICD-10 NAS definition, diagnoses of NAS increased linearly from 2009 to 2018 (observed: 24 to 50 per 1000 births; annual percentage increase: 3.8 per 1000 births [P < .01]) (Figure 1C).

Of the 39 021 newborn hospitalizations with ICD-10 codes (October 2015 to December 2018), 1240 (3.2%) met the primary NAS definition, 1247 (3.2%) met the secondary NAS definition, and 2246 (5.8%) met the expanded ICD-10 NAS definition (Figure 2). We compared newborns who met the secondary definition (confirmed/suspect cases) (n = 1247) to those identified only by unspecified maternal drug use codes (n = 999; a subset of the expanded ICD-10 definition group). The latter were more likely to be born preterm (13% vs 20%; P < .001), more likely to have a diagnosis code for newborn affected by maternal tobacco use (16% vs 23%; P < .001), had a shorter length of stay for newborn hospitalization (10.2 vs 5.4 mean days; P < .001), and had a lower rate of at least one hospital readmission within the first 12 months of life (58 vs 35 per 1000 births; P < .01) (Table 2). They were also more likely to among the infants born at Maine Medical Center (23% vs 30%; P < .001) or Central Maine Medical Center (5% vs 8%; P < .001), and less likely to be among the infants born at Northern Light Eastern Maine Medical Center (35% vs 6%; P < .001) and St. Mary's Regional Medical Center (5% vs 2%; P < .001) (Table 2).
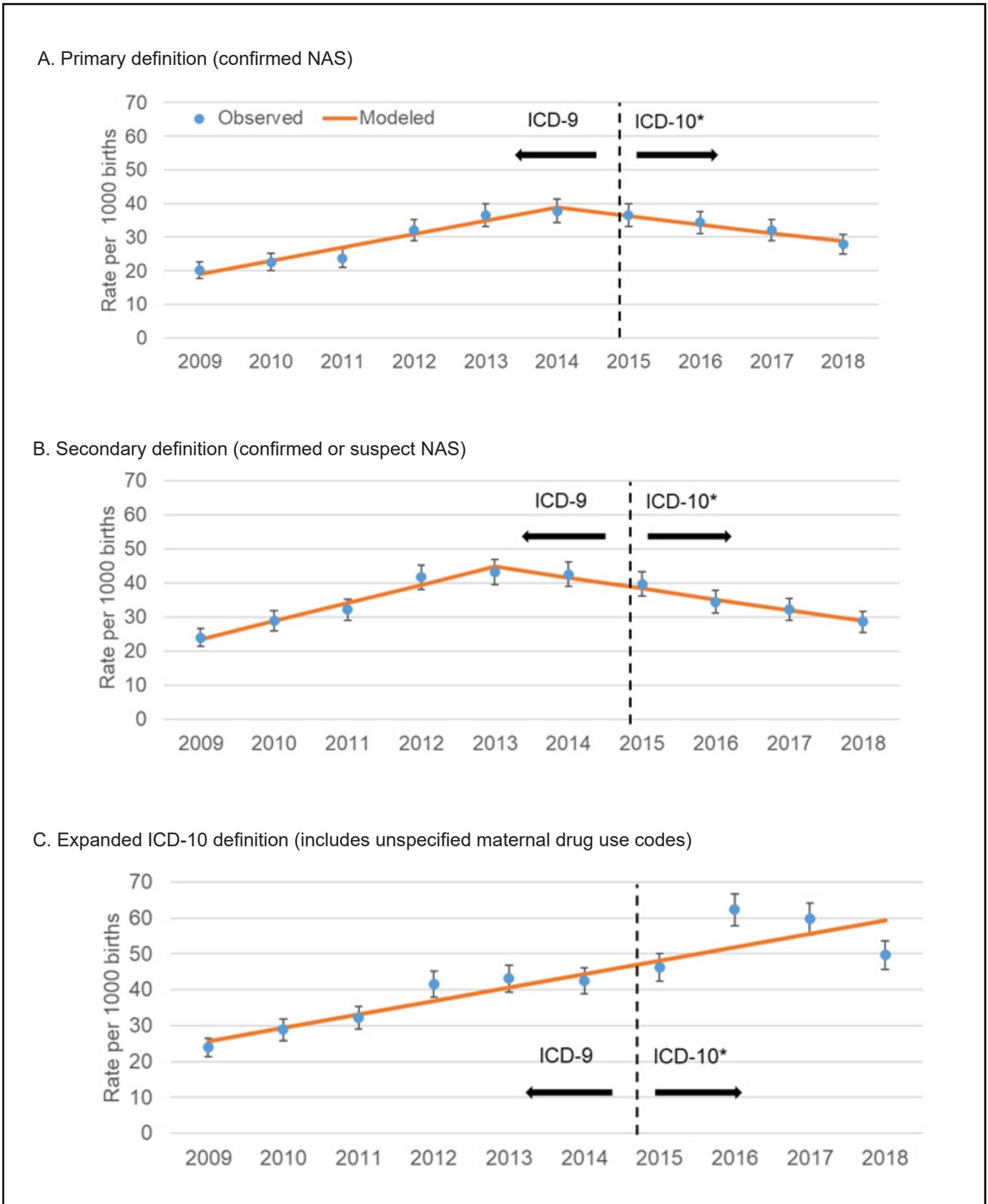
Figure 1. Observed and modeled rate of neonatal abstinence syndrome diagnosis among Maine hospital births using 3 ICD diagnosis code definitions, 2009-2018 (n = 123 519). Vertical dashed line indicates the data transition from ICD-9 to ICD-10 on October 1, 2015.
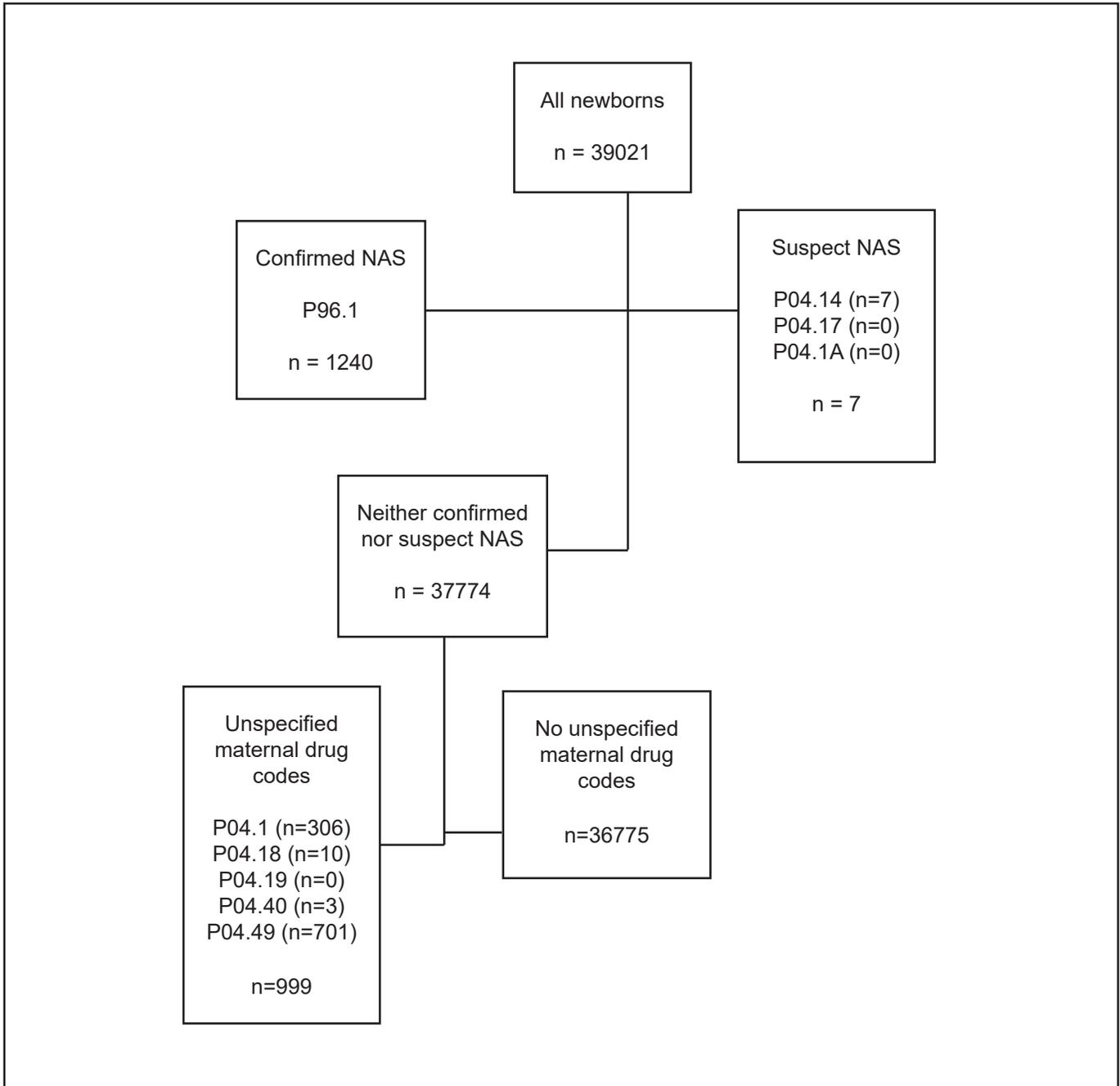
Figure 2. Flow chart showing categorization of newborns by ICD-10 neonatal abstinence syndrome definition: Maine hospitals, October 2015 to December 2018. NAS, neonatal abstinence syndrome.

DISCUSSION

We found that trends in NAS were different based on whether the ICD-10 diagnosis codes used to define NAS included codes used for newborns affected by unspecified maternal drug/medication use. When we excluded those codes, the incidence of NAS increased from 2009 to 2013/2014 and then decreased from 2013/2014 to 2018. When we included those codes, NAS showed a linear increase from 2009 to 2018, more than doubling from a predicted incidence of 26 to 59 per 1000 births (observed: 24 to 50 per 1000 births), with an annual percentage increase of 3.8 per 1000 births. Trends for confirmed and confirmed/suspect NAS were similar. Several characteristics of infants with only unspecified maternal drug use codes were different from those of infants with confirmed/ suspect NAS. These differences include having a higher risk of preterm birth, being more likely to have exposure to maternal tobacco use, and having a shorter newborn hospitalization and readmission rate. They also include being more likely to be among the infants born at Maine Medical Center and Central Maine Medical Center, and less likely to be among the infants born at Northern Light Eastern Maine Medical Center and St. Mary's Regional Medical Center.

Our findings regarding the confirmed/suspect NAS case definition are generally consistent with previous findings, supporting the absence of artifactual changes in NAS diagnosis around the time of the ICD-9/ICD-10 transition (October 2015). A recent publication examined national trends in the number of NAS births between 2008 and 2019, using ICD-10 codes for confirmed NAS plus one of the suspect ICD-10 codes (P04.14; newborn affected by maternal use of opiates),[21] and found the number of NAS cases in the United States increased until 2017, after which it decreased. In Maine, we found a decrease in confirmed NAS cases beginning in 2014. We expected that an artifactual change in the rate of NAS due to the ICD-9/ICD-10 transition would change the trend in 2015 or 2016, but we did not observe this effect. A true decline in NAS cases in Maine since 2014 is also supported by studies in Tennessee,[8] Illinois, New Mexico, Vermont[22] and Florida[13]. These studies compared NAS cases identified from hospital discharge data to medical record data (as the gold standard), and they found high positive predictive values for the confirmed NAS case definition codes across the ICD-9/ICD-10 transition. Although the more granular nature of the tenth revision codes may allow for the correct assignment of unspecified maternal drug/medication use codes that would have been erroneously assigned as confirmed NAS during ICD-9 (ie, false discovery rate), this explanation is not supported by the high positive predictive value observed across the ICD-9/ICD-10 transition.[8,13,22]

Data from Illinois, New Mexico, Vermont[22] and Florida[13] also suggest that cases identified using diagnosis codes for confirmed NAS were more likely to be true NAS cases than those identified using other diagnosis codes, including 760.72 (noxious influences affecting fetus or newborn placenta or breast milk, narcotics). These findings suggest that some of the cases we identified using diagnosis codes for suspect or unspecified NAS may not have actually been NAS cases. The other ICD-9/ICD-10 diagnosis codes we used to define suspect NAS cases and the ICD-10 codes we used to identify expanded ICD-10 NAS cases have yet to be validated.

Our findings for confirmed/suspect NAS cases generally align with those from a recent trend analysis of the prevalence of opioid use disorder among women delivering in Maine hospitals from 2009 to 2018 (using the same data source).[23] Although a linear increase of 1.6 cases per 1000 deliveries per year was detected among women (from 22.7 to 34.9 per 1000 deliveries [$P < .01$]), non-linear trends were not investigated. Thus, it is possible that there was a change in slope around 2013 that mirrored what we observed in this study. In utero exposure to opioids in pregnancy, whether for treatment or due to illicit use, is associated with a 60% to 80% risk of NAS, and long-term childhood health outcomes are largely unknown. Monitoring the prevalence of maternal opioid use disorder is therefore one way to assess trends in NAS.[24,25]

Thus, one explanation for our findings is that unspecified drug codes (eg, P04.40 and P04.49) may have been used for infants thought to be exposed to opioids in utero, but who did not display signs or symptoms of drug withdrawal and therefore were not true NAS cases. However, coding exposed but *asymptomatic* newborns with a maternal medication/drug use code would be inconsistent with billing practice recommendations, which state that use of any 'newborn affected by' diagnosis code be reserved for newborns

displaying signs or symptoms of drug withdrawal following in utero exposure.[7] The long descriptions of the maternal medication and drug use diagnosis codes that were introduced in ICD-10 initially contained the qualifier 'suspected to be' before 'affected'. This qualifier may have encouraged the practice of coding asymptomatic infants thought to be exposed to opioids with these unspecified maternal drug use codes.[14] This scenario could explain the sudden increase in NAS diagnoses (which included P04.40 and P04.49) observed in Missouri after the ICD-9/ICD-10 transition.[14] Coding exposed but asymptomatic infants with the unspecified drug codes is further supported by our observation that infants identified as having NAS based on unspecified ICD-10 codes alone tended to be hospitalized for a shorter period and were less likely to be readmitted within 1 year compared with infants with confirmed NAS.[2,20]

An alternative explanation for our findings is that *symptomatic* infants suspected of exposure to opioids in utero were coded with the unspecified drug codes instead of the confirmed/suspect NAS codes starting in the ICD-10 period. One reason could be because there are no specific codes for symptomatic infants exposed in utero to maternal medication-assisted treatment for opioid use disorder. Thus, in an attempt to differentiate these infants from those born to mothers with illicit opioid use, these cases may have been recorded in the billing claims data using one of the unspecified maternal drug use codes rather than the code for confirmed NAS (P96.1).[7] This practice could have increased over time because of increases in the prevalence of medication-assisted treatment in pregnant women[26] and in the general population.[27] Similarly, it is possible that unspecified maternal drug use codes were used to distinguish infants with NAS treated using the Eat Sleep Console method, which was implemented by most Maine hospitals between 2018 and 2019,[28] from those receiving standard pharmacological treatment. Infants born to mothers using medication-assisted treatment and those treated using Eat Sleep Console receive less pharmacological treatment and have shorter hospital stays on average than other infants with NAS.[28] These data are consistent with our observation of shorter hospital stays in infants assigned unspecified maternal drug use codes. Finally, the rise in use of unspecified maternal drug use codes could be due to a recent increase (since 2015) in polysubstance use, drug

use of unknown type, or use of another drug or medication among women delivering in Maine. Polysubstance use is common among opioid users, and co-use of methamphetamine increased between 2011 and 2018.[29] Further, polysubstance use can influence withdrawal timing and severity in infants.[30] Although medical cannabis was legalized for adult recreational use in Maine in 2017,[31] we considered cannabis use unlikely to account for the increase in use of unspecified drug codes because there is an ICD-10 code specifically for newborns affected by maternal cannabis use (P04.81).

Hospital discharge data are convenient for monitoring trends in NAS because they are multiyear population-based administrative data. They represent all hospitalizations at the state or national-level, are free or of low cost to use, and represent nearly all infants born in the state each year.[32] However, before incorporating unspecified maternal drug use codes into an expanded ICD-10 NAS case definition, we recommend additional validation of these cases. This validation could include electronic and paper-based chart reviews, as well as interviews with medical records staff.

Our study has several strengths and limitations. Strengths include our examination of trends for multiple case definitions for NAS following recent CSTE recommendations for case definitions.[6] We provide 6 years of updated estimates for NAS incidence in Maine, beyond the most recently published estimates,[3] which is critical for making up-to-date assessments of the public health burden of NAS in Maine. However, our data represent only one state, and different patterns in NAS coding may occur in other states due to factors including education of medical staff regarding NAS coding, trends in polysubstance use, and pharmacological treatment for NAS.

CONCLUSIONS

Due to differences in trends and characteristics observed between infants identified using confirmed and more expanded NAS definitions, caution should be used when interpreting surveillance or research findings for NAS in Maine and possibly other states based on hospital discharge data alone. This caution is particularly important for findings that incorporate expanded ICD-10 case definitions for NAS. Validation of billing codes against hospital-level electronic medical records is needed to accurately assess the incidence rate of NAS among

newborns, while also taking into account changes in coding, updates to clinical practices related to treatment of mothers and infants, and trends in substance use.

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