

# The Opioid Epidemic, Neonatal Abstinence Syndrome, and Estimated Costs for Special Education Services

Paul L. Morgan, PhD; and Yangyang Wang, MA

## Conceptual Framework

Maternal opioid use is hypothesized to result in neonatal abstinence syndrome (NAS), as well as in cognitive, physical, and behavioral impairments that contribute to academic and behavioral difficulties in school. **Figure 1** displays a conceptual model that summarizes hypothesized or reported linkages between early exposure to opioids, including maternal prescribed use, and children's subsequent risk for disability identification that results in receiving special education services. We summarize findings from empirical studies reporting on these linkages below.

## Opioid Misuse and Children's Risk for Disability Identification

Children who are prenatally exposed to opioids are about twice as likely as nonexposed children to display intellectual disabilities and mild developmental impairments at 1 year of age.<sup>1</sup> Exposed children are at a greater risk for attention-deficit/hyperactivity disorder (ADHD) and other types of behavioral disorders<sup>2</sup> that can occur up to 8 years after birth.<sup>3</sup> Children born to parents addicted to opioids display risk alleles for ADHD.<sup>4</sup> These children also experience cognitive delays not fully explained by other factors (eg, low birth weight),<sup>5</sup> which become increasingly more severe over time. For example, at 8 years of age, both boys and girls who were prenatally exposed to opioids demonstrated levels of general cognitive functioning that averaged about 1 standard deviation lower than those of children who were not exposed.<sup>6</sup> A linear relationship between increased prescription opioid dosage and greater risk for adverse clinical outcomes among infants is evident, including an increased risk for prematurity and longer postdelivery hospitalization despite statistical control for a range of covariates.<sup>7</sup>

Opioid misuse is likely intergenerational. Children born to mothers using opioids are more likely to misuse opioids as adults.<sup>8</sup> Clinical practice recommendations suggest that children with ADHD, speech or language impairments, specific learning disabilities, or other types of disorders or disabilities that impair their major life activities (eg, schooling) should be provided with specialized services and interventions. Doing so may improve educational

## ABSTRACT

Children whose mothers used or misused opioids during their pregnancies are at an increased risk of exhibiting cognitive or behavioral impairments in the future, which may result in identifiable disabilities that require special education services in school. The costs associated with these additional educational services, however, have remained unknown. Using data from available empirical work, we calculated a preliminary set of cost estimates of special education and related services for children diagnosed with neonatal abstinence syndrome (NAS). We estimated these costs for a single cohort of children from the Commonwealth of Pennsylvania with a diagnosis of NAS. The resulting cost estimates were \$16,506,916 (2017 US\$) in total educational services provisions, with \$8,253,458 (2017 US\$) of these costs attributable to the additional provision of special education services. This estimate includes both opioid use during pregnancy that was linked to NAS in general and NAS that resulted specifically from prescription opioid use. We estimate the total annual education costs for children born in Pennsylvania with NAS associated with maternal use of prescription opioids to be \$1,012,506 (2017 US\$). Of these costs, we estimate that \$506,253 (2017 US\$) are attributable to the additional provision of special education services. We detail the calculation of these cost estimates and provide an expanded set of estimates for additional years of special education services (3-year, 5-year, and 13-year, or the K-12 educational time frame). We conclude with a discussion of limitations and suggestions for future work.

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opportunities over time and reduce the risk for opioid use during adolescence or adulthood.<sup>4</sup>

**NAS and Increased Risk for Academic and Behavioral Difficulties**

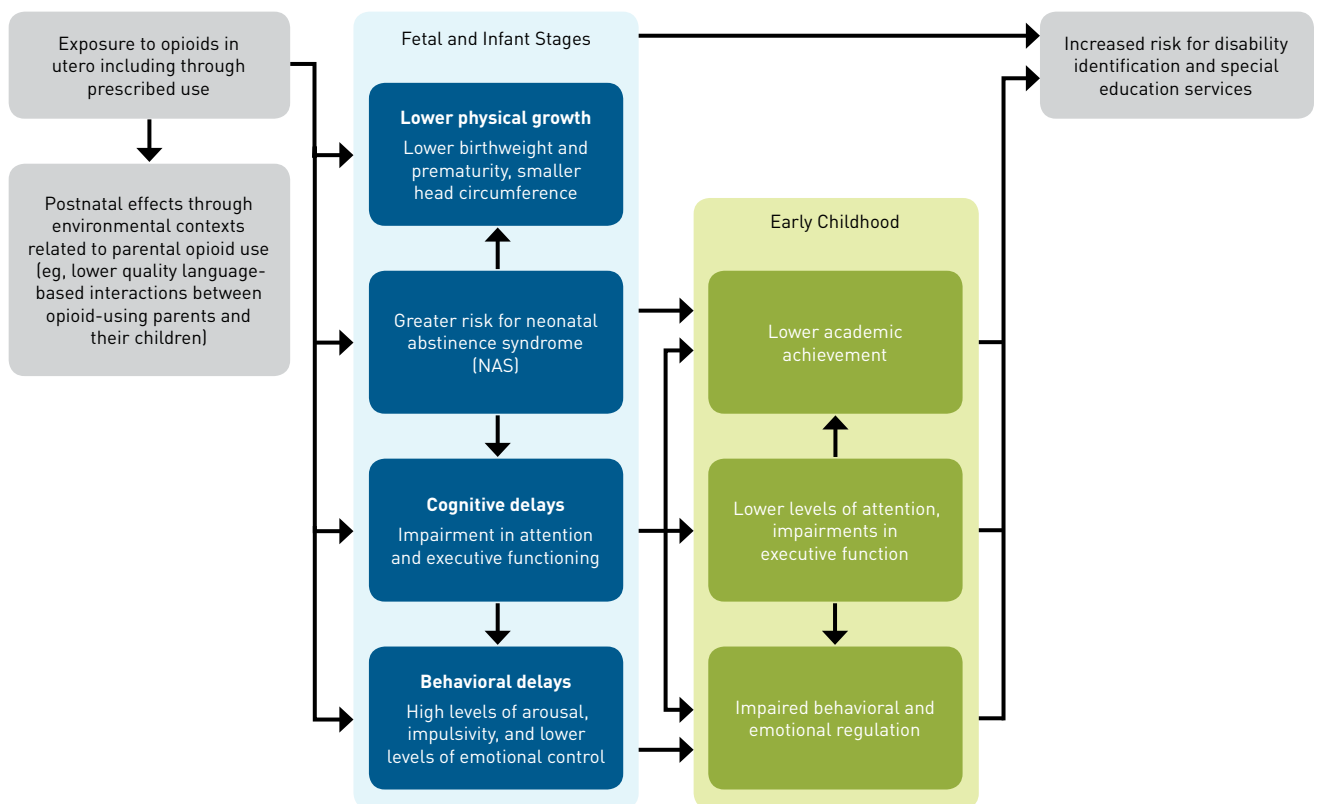
NAS is a general multisystem disorder that predominantly involves the central and automatic nervous systems. NAS results from a sudden discontinuation of fetal exposure to substances used or misused by mothers during their pregnancies, including prescription opioids.<sup>9</sup> Infants with NAS experience sudden withdrawal symptoms and later exhibit high levels of stress, dysregulated behavior, hyperactivity, poor sleep, rapid respiration, and other indicators of nervous system distress. About 75% to 90% of prenatal opioid-exposed infants are diagnosed with NAS.<sup>10,11</sup> NAS is considered an expected and treatable condition in these infants.<sup>12</sup> Opioid agonist pharmacotherapy can help manage the neurobiological effects of opioid exposure or social impacts of maternal addiction that may result in NAS. Opioid agonist pharmacotherapy can also help to improve adherence to addiction treatment as well as prenatal care.<sup>12</sup>

Use of opioids by women during their pregnancies, including as prescribed by a physician, is associated with a greater risk for NAS. Current estimates of NAS are 5.9 per every 1000 deliveries (95%

CI, 5.6 to 6.2).<sup>13</sup> A dose-response relationship has been observed between the use of prescription opioids and a child’s risk for NAS.<sup>13</sup> The risk for NAS increases with a cumulative dose of opioids as well as with later (eg, third trimester) versus earlier (eg, first trimester) use. Absolute risk for NAS among mothers who are long-term users of prescription opioids with no other measured risk factors (eg, history of alcohol, smoking, substance misuse, or use of other psychotropic medications) is estimated to be 4.2 per 1000 live births (95% CI, 3.3 to 5.4).<sup>13</sup> The adjusted relative risk for long-term versus short-term users in propensity score–matched analyses is estimated to be 5.67 per 1000 live births (95% CI, 3.07 to 10.47).<sup>13</sup> The risk for NAS, however, increases in mothers who use prescription opioids and present with other risk factors.

The incidence of NAS has been increasing rapidly throughout the United States. The Centers for Disease Control and Prevention (CDC) estimated that the overall incidence rate of NAS in 2013 increased by 300%—from 1.5 per 1000 live births to 6.0 per 1000 live births.<sup>14</sup> In 2011, it was estimated that the Middle Atlantic region (ie, New York, Pennsylvania, and New Jersey) had a mean NAS incidence rate of 6.8 per 1000 live births.<sup>14</sup> Between 2000 and 2013, the incidence rates of NAS in West Virginia increased sharply—from 0.5 per 1000 live births to 33.4 per 1000 live births. The rise in NAS incidence

**FIGURE 1.** Special Education Conceptual Framework



rate occurred simultaneously with a similar increase in the rate of delivering mothers diagnosed as opioid-dependent or using opioids at the time of delivery—from 1.19 per 1000 hospital births to 5.63 per 1000 hospital births nationally between 2000 and 2009.<sup>15</sup> The incidence of both maternal opioid use and NAS has been on the rise, particularly in rural counties in the United States,<sup>16,17</sup> suggesting that rural communities are disproportionately affected.

Children with NAS have a lower birth weight, length, and mean head circumference at birth, and they are more likely to be born with birth defects.<sup>18</sup> Children with NAS are also more likely to be hospitalized,<sup>19</sup> and to exhibit significantly lower levels of language ability and general cognitive functioning over time. This includes low levels of functioning and a greater likelihood of displaying extremely low levels of functioning, which increases the risk for disability identification among these children and may result in the receipt of special education services. For example, in 2015, Beckwith and Burke reported that 14.3% and 7.1% of children with NAS exhibited extremely low levels of language and general cognitive functioning, respectively.<sup>20</sup> The contrasting percentages from a general sample of children were 3.7% and 2.4%, respectively,<sup>20</sup> suggesting that infants and toddlers with NAS are approximately 3 to 4 times more likely to exhibit extremely low levels of language and general cognitive functioning. Neurodevelopmental impairment is evident as early as 6 months of age<sup>21</sup> and remains evident at 3 years of age,<sup>22</sup> as indicated across multiple measures of cognitive functioning, intelligence, social maturity, and psychomotor abilities.

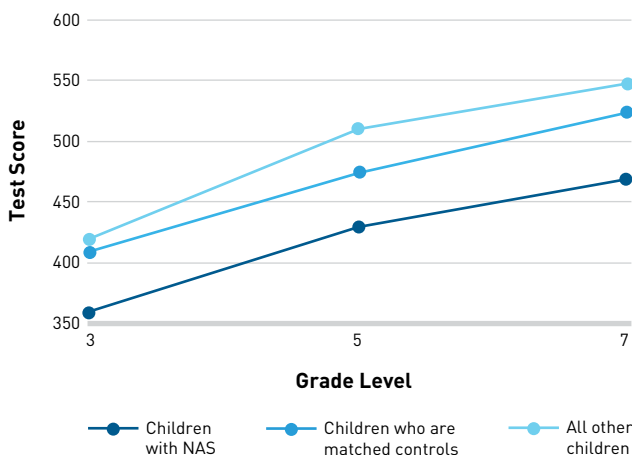
Children with NAS display declining academic achievement relative to their peers during elementary and middle school.<sup>23</sup> This group of children average lower levels of reading, mathematics, and writing achievement compared with children without

NAS who are similar in gestational age, year of birth, gender, and socioeconomic status. Children with NAS are approximately 2 to 3 times more likely to fail to attain grade-level achievement, and are also more likely to require additional specialized support and intervention throughout school compared with children without NAS. Specifically, children with NAS had odds that were 3.5 (95% CI, 2.8 to 4.4), 2.8 (95% CI, 2.4 to 3.2), and 2.4 (95% CI, 1.9 to 2.9) times higher of failing to attain grade-level achievement in third, fifth, and eighth grade, respectively, compared with controls.<sup>23</sup> In fact, children with NAS had odds that were 2.5 (95% CI, 2.2 to 2.7) times higher of failing to attain grade-level achievement at any one of the study's measured time periods (Figure 2).<sup>23</sup>

A 2016 longitudinal study reported that children with NAS are also more likely to exhibit a general set of behavioral deficits (eg, more frequent externalizing and internalizing problem behaviors; greater levels of impulsivity, inattention, and other behavioral indicators of ADHD) as they attend school, as reported by both teachers and caregivers.<sup>3</sup> Children who struggle academically are at greater risk for having disabilities and requiring special education services.<sup>24</sup>

Recent longitudinal analysis also finds that children with NAS are at a greater risk of being identified as having disabilities and receiving special education services in school. In 2018, Fill and colleagues reported that children with a history of NAS were approximately 1.3 to 1.4 times more likely to meet the criteria for exhibiting a disability and receiving special education services for the specific conditions of developmental delays and speech or language impairments during early childhood compared with children without a history of NAS, who were matched for gender, age, birth region, race/ethnicity, and medical enrollment status.<sup>25</sup> Children with a history of NAS had a significantly higher risk of being identified with educational disabilities compared with matched controls without NAS. An increased risk associated with NAS was evident after accounting for potential confounders, including maternal education status, maternal tobacco use, gestational age, and birth weight.<sup>25</sup>

**FIGURE 2.** Academic Achievement by Grade Level for Children With NAS, Matched Controls, and All Other Children<sup>23</sup>



NAS indicates neonatal abstinence syndrome.

## Opioid Use in Pennsylvania

Although the aforementioned empirical work indicates that children of mothers using opioids are at a greater risk for later being identified as having disabilities, the expected costs of special education services have been largely unknown. Therefore, we calculated a preliminary set of cost estimates of special education and related services for children diagnosed with NAS—specifically, costs for a single cohort of children from Pennsylvania with an NAS diagnosis. The Commonwealth of Pennsylvania currently ranks high in the United States for the prescription of opioid pain relievers, long-acting/extended-release opioids, high-dose opioids, and benzodiazepines. For example, the CDC estimates that Pennsylvania ranked 21st and 14th in the United States for the prescription of opioids and high-dose opioids, respectively, in 2014.<sup>26</sup>

**Gross Cost Estimates**

**Costs for Special Education Services in the Commonwealth of Pennsylvania**

In 2015, public school expenditures per student in Pennsylvania were \$14,717 (2015 US\$).<sup>27</sup> The cost to educate a student in special education is typically estimated to be, on average, about twice that of educating a student in general education.<sup>28</sup> Thus, a reasonable cost estimate per student who receives both general and special education in Pennsylvania in 2015 would \$29,434 (2015 US\$) or \$30,682 (2017 US\$), using a Bureau of Labor Statistics Consumer Price Index (BLS CPI) correction factor for inflation.

**Increased Special Education Costs for Children in Pennsylvania With NAS**

In 2015, a total of 2691 children were diagnosed with NAS in Pennsylvania, which translates to about 2% of recorded births.<sup>29</sup> Approximately 80% of hospital costs for NAS, which averaged \$66,693 per child in 2012 (BLS CPI: \$73,262.11 in 2017 US\$), are currently being charged to state Medicaid programs.<sup>14</sup> About 20% of children with NAS subsequently receive special education services<sup>25</sup> because of identified disabilities. A reasonable estimate of the educational costs to the Commonwealth of Pennsylvania for children with NAS who experienced prenatal opioid exposure and have identified disabilities would be more than \$16.5 million (2017 US\$; n = 538). The additional cost to provide special education services to children with NAS who are identified as having disabilities (ie, above the cost to provide a student with a general education) would be \$8,253,458 (2017 US\$) for this cohort. **Table 1**<sup>14,25,27,29</sup> illustrates these cost estimates.

A conservative estimate based on a limited provision of 3 to 5 years of special education services for children in Pennsylvania born with NAS would result in a lower bound estimate of additional expenses due to NAS-related disability services of \$24.8 million and an upper bound estimate of \$41.3 million (2017 US\$). Currently, the federal government would be expected to provide approximately 15% of these special education costs<sup>28</sup>; the remaining 85% of the costs would be paid for by the Commonwealth of Pennsylvania’s local and state governments. Total costs to the Commonwealth of Pennsylvania for 3-year and 5-year time periods would amount to \$21,046,318 (2017 US\$) and \$35,077,197 (2017 US\$), respectively. These figures do not account for inflation during the 3-year and 5-year time periods.

A liberal estimate of 13-year costs of special education services (ie, kindergarten through 12th grade, assuming both early and stable disability identification and receipt of services) would amount to \$91,200,711 (2017 US\$), accounting for inflation each year from 2003 to 2015 (using 2017 as the reference year), as well as an 85% responsibility by the state and local governments of the Commonwealth of Pennsylvania. These cost estimates are specific to one cohort

of children from Pennsylvania. Additional costs would then be entailed to provide services to both historical and future cohorts of Pennsylvania children, as well as to those in other states diagnosed with NAS and subsequently identified as requiring additional special education services.

**Estimated Special Education Costs for a Single Cohort of Pennsylvania Children With NAS Born to Mothers Using Prescription Opioids During Their Pregnancies**

We also estimated a more conservative set of costs based on NAS associated with maternal prescription opioid use during pregnancy.<sup>13,30</sup> These would be based on the following prevalence estimates: Of recorded births in the Commonwealth in 2015, an estimated 20%<sup>31</sup> of these births were from mothers using prescription opioids (n = 27,600).<sup>30</sup> Of the 27,600 mothers, 166 would conservatively be expected to give birth to children with NAS, using a current absolute risk rate of 6 per 1000 births. Of these 166 children with NAS

**TABLE 1:** Estimates of Increased Special Education Costs for Pennsylvania Children With NAS<sup>14,25,27,29</sup>

Public school expenditures per student, 2015	\$14,717 (2015 US\$)
Estimated costs per student in special education, 2015	\$29,434 (2015 US\$)
Estimated costs per student in special education, corrected for inflation	\$30,682 (2017 US\$)
Number of children diagnosed with NAS, 2015	2691
Percent of children with NAS who subsequently received special education services	20%
Number of children diagnosed with NAS in 2015 who subsequently received special education services	538
Estimated educational costs for children with NAS receiving special education services	\$16,506,916 (2017 US\$)
1-year additional costs for children with NAS in special education compared with the 2015 cohort of children in general education	8,253,458 (2017 US\$)
3-year to-5-year additional costs for children with NAS in special education compared with the 2015 cohort of children in general education	\$24,760,374 (2017 US\$) to \$41,267,290 (2017 US\$)
3-year to-5-year additional costs for children with NAS in special education estimated to be paid for by the Commonwealth of Pennsylvania’s local and state governments (85% of total)	\$21,046,318 (2017 US\$) to \$35,077,197 (2017 US\$)
13-year additional costs for children with NAS in special education estimated to be paid for by the Commonwealth of Pennsylvania’s local and state governments (85% of total)	\$91,200,711 (2017 US\$)

NAS indicates neonatal abstinence syndrome.

born to mothers in Pennsylvania who were prescribed opioids during their pregnancies, 20% (n = 33) of these children would be expected to receive special education services because of identified disabilities. The resulting costs attributable to the additional provision of special education services for this single cohort of children are calculated as \$506,253 (2017 US\$) (Table 2).<sup>13,30,31</sup>

Assuming that the Commonwealth of Pennsylvania would be responsible for 85% of costs, the estimates of 3-year and 5-year time frames are \$1.3 million and \$2.2 million, respectively—that is, \$1,290,945 (2017 US\$) and \$2,151,575 (2017 US\$), respectively—to provide special education services to children born with NAS to

**TABLE 2:** Estimated Special Education Costs for a Single Cohort of Pennsylvania Children With NAS Born to Mothers Using Prescription Opioids During Their Pregnancies<sup>13,30,31</sup>

Number of births to mothers using prescription opioids in 2015	27,600
Number of mothers expected to give birth to children with NAS	166
Number of children with NAS expected to receive special education services	33
1-year additional costs of special education services for the 2015 cohort of children with NAS compared with children in general education	\$506,253 (2017 US\$)
3-year to-5-year additional costs for children with NAS in special education estimated to be paid for by the Commonwealth of Pennsylvania's local and state governments (85% of total)	\$1,290,945 (2017 US\$) to \$2,151,575 (2017 US\$)
13-year additional costs for children with NAS in special education estimated to be paid for by the Commonwealth of Pennsylvania's local and state governments (85% of total)	\$5,594,096 (2017 US\$)

NAS indicates neonatal abstinence syndrome.

**TABLE 3:** Estimates of Increased Special Education Costs for Children With NAS in a New York State, 2015 Cohort<sup>34</sup>

Public school expenditures per student	\$22,593 (2015 US\$)
Estimated costs per student in special education	\$45,186 (2015 US\$)
Number of children born with NAS	1068
Number of children born with NAS in 2015 who subsequently received special education	21
1-year additional costs for children with NAS in special education compared with the 2015 cohort of children in general education paid by New York State's local and state governments (85% of total)	\$8,219,333 (2015 US\$)
Number of children born to mothers using prescription opioids during their pregnancies	43

NAS indicates neonatal abstinence syndrome.

mothers who used prescription opioids during their pregnancies. Further costs would be incurred for additional service years or additional Pennsylvania cohorts, as well as for cohorts from other states. These figures do not account for inflation during the 3-year and 5-year time periods.

If the single cohort of Pennsylvania children born with NAS from mothers who used prescription opioids received 13 years of special education services (ie, from kindergarten through 12th grade), the resulting upper bound of estimated costs would be \$5,594,096 (2017 US\$; Table 2).<sup>13,30,31</sup> This estimate accounts for inflation from 2003 to 2015, using 2017 as the reference, and assumes that the state and local government would have 85% financial responsibility. Additional costs would be incurred for historical and future cohorts of Pennsylvania children, as well as for children with NAS in other states who were born to mothers using prescription opioids during their pregnancies.

### Example Extension of Cost Estimates to an Additional State

These cost estimates can be applied to additional states using similar calculations. For example, an estimated 237,274 children were born in New York State in 2017.<sup>32</sup> Using a conservatively estimated absolute risk ratio<sup>33</sup> of 4.5 children born with NAS per every 1000 births, this would suggest that 1068 children would be diagnosed with NAS in 2015. Of this population, approximately 20% would be expected to subsequently receive special education services because of identified disabilities (n = 214). New York State currently spends an average of \$22,593 per student to provide general education services, with additional special education costs resulting in \$45,186 in total expenditures (Table 3).<sup>34</sup> To provide 214 children with NAS with special education services, New York State would be expected to pay 85% of these special education costs for this single cohort, or \$8,219,333 for one school year. Additional costs would be incurred for additional school years. For children with NAS born to mothers using prescription opioids during their pregnancies (20% of the number of children with NAS with special education services, or n = 43), this calculation would amount to \$1,651,548 for a single school year.

### Limitations and Future Directions

Few longitudinal studies have followed children born to opioid-using mothers throughout school. We extrapolated preliminary cost estimates based on this limited empirical work. These estimates may change as additional longitudinal studies become available. We did not formally search the available empirical research using a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) review protocol.

Our assessments estimate the costs for children who were independently evaluated by healthcare professionals as being born with NAS. The advantage of using a diagnosis of NAS is that

it more clearly establishes that the children were born to mothers who used opioids as well as other types of substances (eg, heroin), including possible prescription opioids. The negative impact of opioid use on a child's cognitive and behavioral development can be rendered more accurately because the estimates do not rely on maternal self-reports. Maternal self-reporting might result in a less accurate history of opioid use and present an unclear picture of the impact of opioid use on a child's neurobehavioral development. Restricting the estimates to children with NAS at birth, however, also indicates that our estimates are limited to children diagnosed with this specific condition. For example, we do not estimate the costs attributable to postnatal exposure to parental opioid use, as such estimates would likely be confounded by other factors, (eg, chaotic home environments, parental mental health, unemployment, divorce) and thus result in less reliable cost estimates. We are unable to disaggregate the costs attributable to being born with NAS that result from the neurobiological effects of opioid exposure, including through opioid agonist pharmacotherapy, from the social impacts of maternal addiction and substance misuse more generally, which pharmacotherapy is designed to manage.

Additional longitudinal studies are warranted to evaluate: prenatal exposure to opioid prescription use; NAS; children's risk for cognitive, physical, and behavioral impairments; later disability identification; and opioid-related special education services. We were able to identify only 1 peer-reviewed longitudinal study that reported on a sample of children in the United States diagnosed with NAS, their risks for disability identification, and their receipt of special education services.<sup>25</sup> This study was limited to estimates of disability identification risk during early childhood and analyses of a state-specific cohort. Investigations of additional longitudinal datasets would allow for more precise estimates of the extent to which children diagnosed with NAS are more likely to later receive special education services because of disabilities identified throughout their early life course. Additional studies that examine the risk for disability identification among children with NAS over time (eg, middle school and high school into adulthood), as well as investigations that report on the NAS-related risk across a wide range of specific disability conditions would also enhance the field's currently limited knowledge. ■

**Author affiliations:** The Pennsylvania State University (PLM; YW).

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**Authorship information:** Concept and design (PLM); acquisition of data (PLM); analysis and interpretation of data (PLM); drafting of the manuscript (PLM; YW); critical revision of the manuscript for important intellectual content (PLM; YW); statistical analysis (PLM; YW); provision of study materials or patients (YW).

**Address correspondence:** paul.l.morgan@gmail.com.

## REFERENCES

- Bunikowski R, Grimmer I, Heiser A, Metzke B, Schäfer A, Obladen M. Neurodevelopmental outcome after prenatal exposure to opiates. *Eur J Pediatr*. 1998;157(9):724-730.
- Ornoy A. The impact of intrauterine exposure versus postnatal environment in neurodevelopmental toxicity: long-term neurobehavioral studies in children at risk for developmental disorders. *Toxicol Lett*. 2003;140-141:171-181.
- Nygaard E, Stinning K, Moe V, Walhovd KB. Behavior and attention problems in eight-year-old children with prenatal opiate and poly-substance exposure: a longitudinal study. *PLoS One*. 2016;11(6):e0158054.
- Ornoy A, Finkel-Pekarsky V, Peles E, Adelson M, Schreiber S, Ebstein PR. ADHD risk alleles associated with opiate addiction: study of addicted parents and their children. *Pediatr Res*. 2016;80(2):228-236.
- Nygaard E, Stinning K, Moe V, Walhovd KB. Cognitive function of youths born to mothers with opioid and poly-substance abuse problems during pregnancy. *Child Neuropsychol*. 2017;23(2):159-187.
- Nygaard E, Moe V, Stinning K, Walhovd KB. Longitudinal cognitive development of children born to mothers with opioid and polysubstance use. *Pediatr Res*. 2015;78(3):330-335.
- Wouldes TA, Woodward LJ. Maternal methadone dose during pregnancy and infant clinical outcome. *Neurotoxicol Teratol*. 2010;32(3):406-413.
- Log T, Skurtveit S, Selmer R, Tverdal A, Furu K, Hartz I. The association between prescribed opioid use for mothers and children: a record-linkage study. *Eur J Clin Pharmacol*. 2013;69(1):111-118.
- Kocherlakota P. Neonatal abstinence syndrome. *Pediatrics*. 2014;134(2):e547-e561.
- Hudak ML, Tan RC; Committee on Drugs; Committee on Fetus and Newborn; American Academy of Pediatrics. Neonatal drug withdrawal. *Pediatrics*. 2012;129(2):e540-e560.
- Jansson LM, Velez M, Harrow C. The opioid-exposed newborn: assessment and pharmacologic management. *J Opioid Manag*. 2009;5(1):47-55.
- American College of Obstetricians and Gynecologists (ACOG), Committee on Obstetric Practice; American Society of Addiction Medicine. Opioid use and opioid use disorder in pregnancy. American College of Obstetricians and Gynecologists website. <https://www.acog.org/Clinical-Guidance-and-Publications/Committee-Opinions/Committee-on-Obstetric-Practice/Opioid-Use-and-Opioid-Use-Disorder-in-Pregnancy>. Number 711; Published August 2017. Accessed June 20, 2019.
- Desai RJ, Huybrechts KF, Hernandez-Diaz S, et al. Exposure to prescription opioid analgesics in utero and risk of neonatal abstinence syndrome: population based cohort study. *BMJ*. 2015;350:h2102. doi: 10.1136/bmj.h2102.
- Patrick SW, Davis MM, Lehmann CU, Cooper WO. Increasing incidence and geographic distribution of neonatal abstinence syndrome: United States 2009 to 2012. *J Perinatol*. 2015;35(8):650-655.
- Patrick SW, Schumacher RE, Benneworth BD, Krans EE, McAllister JM, Davis MM. Neonatal abstinence syndrome and associated health care expenditures: United States, 2000-2009. *JAMA*. 2012;307(18):1934-1940.
- Kozhimannil KB, Chantarat T, Ecklund AM, Henning-Smith C, Jones C. Maternal opioid use disorder and neonatal abstinence syndrome among rural US residents, 2007-2014. *J Rural Health*. 2019;35(1):122-132.
- Villapiano NL, Winkelman TN, Kozhimannil KB, Davis MM, Patrick SW. Rural and urban differences in neonatal abstinence syndrome and maternal opioid use, 2004 to 2013. *JAMA Pediatr*. 2017;171(2):194-196.
- Auger N, Luu TM, Healy-Profittos J, Gauthier A, Lo E, Fraser WD. Correlation of neonatal abstinence syndrome with risk of birth defects and infant morbidity. *J Stud Alcohol Drugs*. 2018;79(4):553-560.
- Liu GD, Kong L, Leslie DL, Corr TE. A longitudinal healthcare use profile of children with a history of neonatal abstinence syndrome. *J Pediatr*. 2019;204:111-117.
- Beckwith AM, Burke SA. Identification of early developmental deficits in infants with prenatal heroin, methadone, and other opioid exposure. *Clin Pediatr (Phila)*. 2015;54(4):328-335.
- McGlone L, Mactier H. Infants of opioid-dependent mothers: neurodevelopment at six months. *Early Hum Dev*. 2015;91(1):19-21.
- Hunt RW, Tzioumi D, Collins E, Jeffery HE. Adverse neurodevelopmental outcome of infants exposed to opiate in-utero. *Early Hum Dev*. 2008;84(1):29-35.
- Oei JL, Melhuish E, Uebel H, et al. Neonatal abstinence syndrome and high school performance. *Pediatrics*. 2017;139(2). pii: e20162651. doi: 10.1542/peds.2016-2651.
- Morgan PL, Farkas G, Hillemeier MM, Maczuga S. Replicated evidence of racial and ethnic disparities in disability identification in U.S. schools. *Educ Res*. 2017;46(6):305-322.
- Fill MA, Miller AM, Wilkinson RH, et al. Educational disabilities among children born with neonatal abstinence syndrome. *Pediatrics*. 2018;142(3). pii: e20180562. doi: 10.1542/peds.2018-0562.
- Paulozzi LJ, Mack KA, Hockenberry JM; Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, CDC. Vital signs: variation among States in prescribing of opioid pain relievers and benzodiazepines — United States, 2012. *MMWR Morb Mortal Wkly Rep*. 2014;63(26):563-568.
- Education spending per student by state. Governing the States and Localities website. <http://www.governing.com/gov-data/education-data/state-education-spending-per-pupil-data.html>. Updated June 1, 2018. Accessed June 20, 2019.
- Griffith M. A look at funding for students with disabilities. Education Commission of the States website. <https://www.ecs.org/clearinghouse/01/17/72/11772.pdf>. Published 2015. Accessed June 20, 2019.
- Martin J. PHC4 data shows large increases in neonatal and maternal hospitalizations related to substance use. Pennsylvania Health Care Cost Containment Council (PHC4) website. <http://www.phc4.org/reports/ResearchBriefs/neonatal/092716/nr092716.htm>. Published September 27, 2016. Accessed June 20, 2019.
- Yazdy MM, Desai RJ, Brogly SB. Prescription opioids in pregnancy and birth outcomes: a review of the literature. *J Pediatr Genet*. 2015;4(2):56-70.
- Volkow ND. Opioids in pregnancy. *BMJ*. 2016;352:i19. doi: 10.1136/bmj.i19.
- Henry J Kaiser Family Foundation. State health facts. Total number of births (2017). <https://www.kff.org/other/state-indicator/number-of-births/?currentTimeframe=0&sortModel=%7B%22colId%22%3A%22location%22%22sort%22%3A%22asc%22%7D>. Accessed June 20, 2019.
- Ko JY, Patrick SW, Tong VT, Patel R, Lind JN, Barfield WD. Incidence of neonatal abstinence syndrome — 28 states, 1999-2013. *MMWR Morb Mortal Wkly Rep*. 2016;65(31):799-802.
- Spector J. NY spends \$22,593 per pupil, but there's wide disparity. Lohud website. <https://www.lohud.com/story/news/politics/politics-on-the-hudson/2016/12/07/ny-spends-22593-per-pupil-but-theres-wide-disparity/95088028/>. Published December 7, 2016. Accessed June 20, 2019.