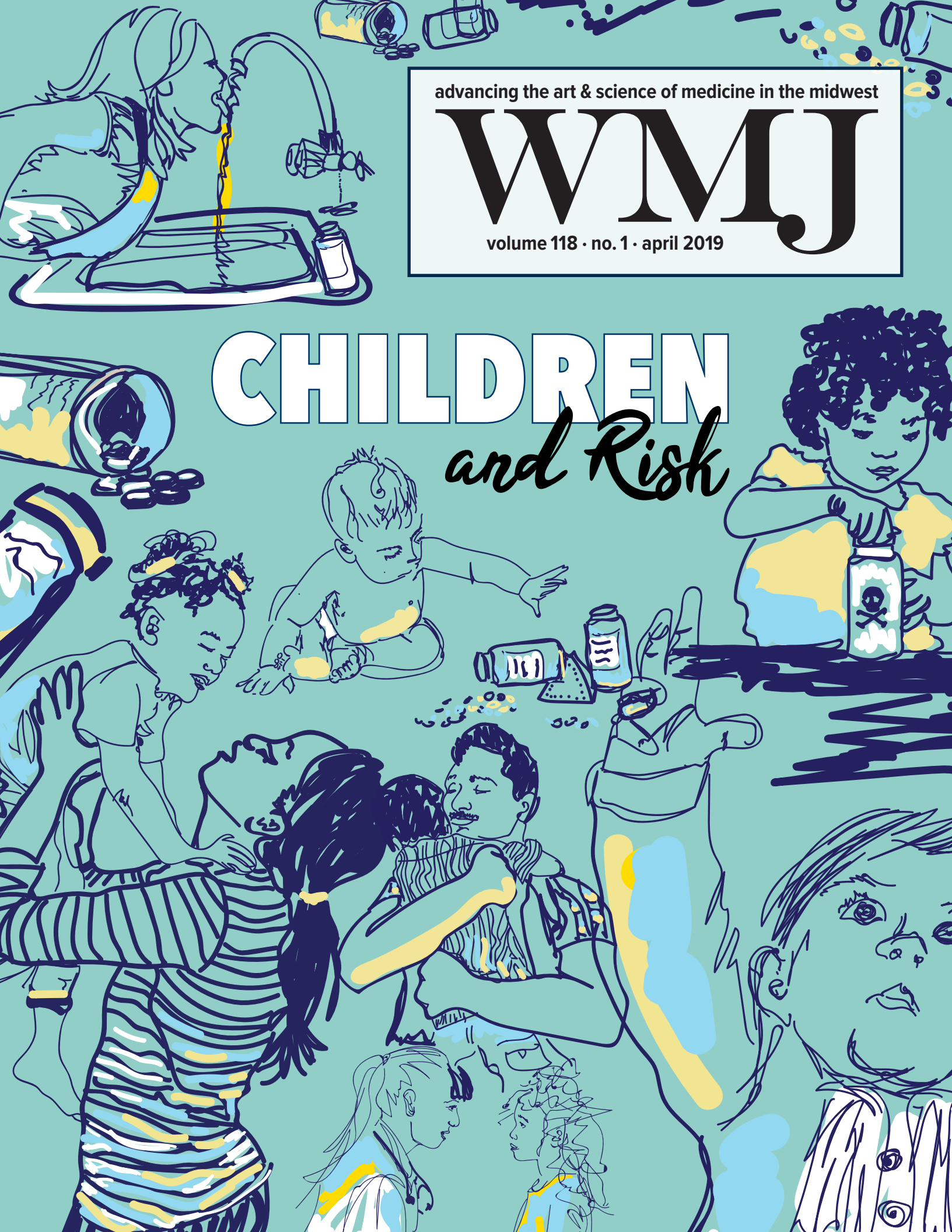
advancing the art & science of medicine in the midwest

WMJ

volume 118 · no. 1 · april 2019

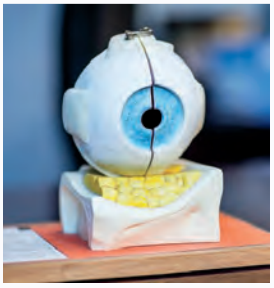


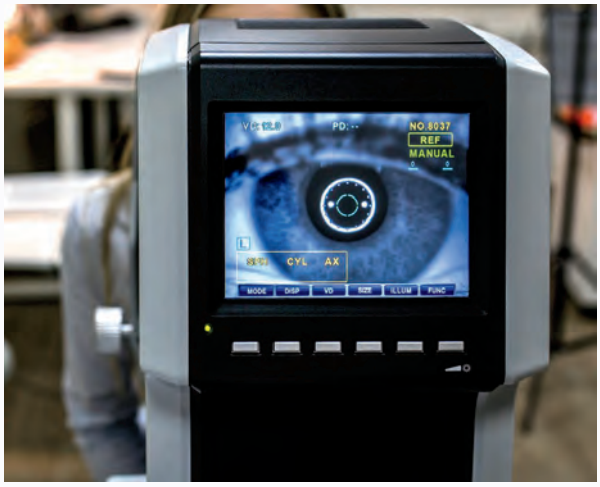
# CHILDREN and Risk

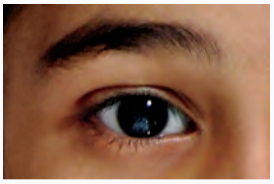
When helping your patients see clearly, **make each moment matter.**

—

**PNC can help.**





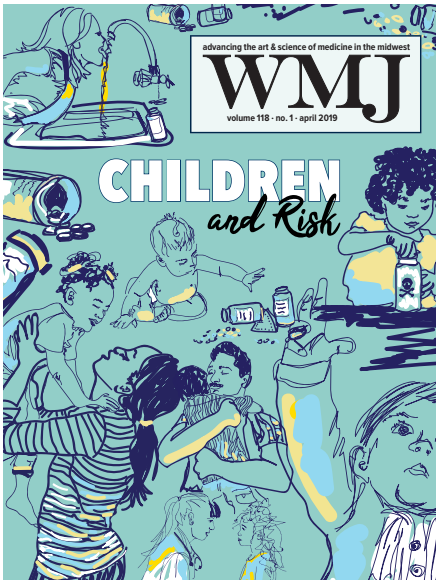
**We're making business banking easier.**

At PNC, our team of dedicated Healthcare Business Bankers understands your business challenges and the important role that cash flow plays in your success. That's why we offer a range of solutions to help optimize management of your practice's revenue cycle and payables, so your business can run with less complexity and payments can be received promptly.

*Learn more at pnc.com/hcprofessionals or by calling 877-566-1355*

PNC BANK

Make today the day.℠




## COVER THEME
## Children and Risk

Parents desire to protect their children, but some risks to children's health and safety are beyond a parent's control. In this issue of *WMJ*, authors discuss the impact of some of those risks, reminding clinicians that they can also help their patients outside of the clinic.

**Cover illustration and design by Jane Lee.**

Volume 118, no. 1 • April 2019

WMJ

advancing the art & science of medicine in the midwest

## EDITORIAL



## ORIGINAL RESEARCH



The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues. *WMJ* is published through a partnership between the Wisconsin Medical Society, the Medical College of Wisconsin, and the University of Wisconsin School of Medicine and Public Health.

The *WMJ* (ISSN 1098-1861) is published by the Wisconsin Medical Society and is devoted to the interests of the medical profession and health care in the Midwest. The managing editor is responsible for overseeing the production, business operation and contents of the *WMJ.* The editorial board, chaired by the medical editor, solicits and peer reviews all scientific articles; it does not screen public health, socioeconomic, or organizational articles. All articles published herein, including commentaries, letters to the editor, and editorials represent the views of the authors, for which neither *WMJ* nor the Wisconsin Medical Society take responsibility, unless clearly stated. Advertising content is the responsibility of the advertiser and does not imply an endorsement or sponsorship by *WMJ* or the Wisconsin Medical Society and its affiliates unless specified. *WMJ* is indexed in Index Medicus, Hospital Literature Index, and Cambridge Scientific Abstracts.

**Submit manuscripts at www.wmjonline.org;** call 866.442.3800 or email wmj@wismed.org.



**SUBSCRIPTION RATES**
Print subscription: $149. Digital subscription for Wisconsin Medical Society members included in membership dues. Current year single copies, $25 each. Previous years' single copies, when available, $12 each.

Published 4 times a year and online, beginning in February. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917. Authorized August 7, 1918.

Address all correspondence to *WMJ*, PO Box 1109, Madison, WI 53701. Street address: 330 E Lakeside St, Madison, WI 53715; e-mail: wmj@wismed.org

**POSTMASTER**
Send address changes to: *WMJ,* PO Box 1109, Madison, WI 53701

ISSN 1098-1861
Established 1903





## BRIEF REPORTS



## CASE REPORTS

# The Illusion of Selection Bias in Matters of Students' Mental Health

Dear Editor:

We read, with significant interest, the study by Van Remortel et al that described the state of mental health of Wisconsin medical students.[1] We applaud the authors for shining a bright light on a common, yet often overlooked, problem plaguing medical education. They humbly suggest, "Voluntary participation may have resulted in selection bias, as distressed medical students may have been more likely to complete the survey." Here, we offer 2 scenarios that consider the implications of full survey participation and boldly suggest that, even if selection bias were present, the findings remain germane.

In the University of Wisconsin cohort, if the 455 nonrespondents had indicated "medical school did not have a negative impact on their mental health," 20% still would have indicated that medical school had had a negative impact on their mental health.

Similarly, in the Medical College of Wisconsin cohort, if the 510 nonrespondents had not reported having a "mental health condition while in medical school," 12% still would have reported that they did have a mental health condition while in medical school.

These calculations might be interpreted as best-case scenarios. Nevertheless, the numbers remain alarming, and we speculate the report underestimates the scope of the problem. Ironically, barriers to survey participation may mirror those identified for not pursuing mental health services (eg, lack of time and fear of stigma) or those encountered in reporting mistreatment (eg, fear of reprisal).[2]

Medical educators must be vigilant of the "hidden" mental health epidemic among our learners. As training progresses and rigor increases, concealed disturbances may go unnoticed, continually spiraling, and resulting in damaged relationships, injured patients, and self-harm. The authors have provided a starting point, and we should not allow limitations of a survey-based study blind us to the gravity of the findings. Instead, we should whole-heartedly congratulate them for naming (eg, depression) and calling out the impact of disrupted medical student mental health (eg, limited self-care), no matter how prevalent—a necessary first step in alleviating its burden.

To stem this epidemic, the Kern National Transformation Network at both Wisconsin medical schools is laying innovative groundwork to transform medical education by reimagining and resetting such best-case scenarios. We remain optimistic that transforming the clinical learning environment will prioritize character development, competency training, and caring. Otherwise, if we cannot optimize care to heal our learners and each other, how can we expect them to for our patients and communities?

Jayshil J. Patel, MD; Kathlyn Fletcher, MD; Erica Chou, MD; MaryAnn Gilligan, MD; Kurt Pfeifer, MD; Martin Muntz, MD

**Author Affiliations:** Medical College of Wisconsin, Milwaukee, Wis (Patel, Fletcher, Chou, Gilligan, Pfeifer, Muntz).

**Corresponding Author:** Jayshil J. Patel, MD, Associate Professor of Medicine, Medical College of Wisconsin, 8701 W Watertown Plank Road, HUB, 8th Floor, Milwaukee, WI 53226.

## REFERENCES

**1.** Van Remortel B, Dolan E, Cipriano D, McBride P. Medical student wellness in Wisconsin: Current trends and future directions. *WMJ*. 2018;117:211-213.

**2.** Chung MP, Thang CK, Vermillion M, Fried JM, Uijtdehaage S. Exploring medical students' barriers to reporting mistreatment during clerkships: a qualitative study. *Med Educ Online.* 2018;23(1):1478170. doi:10.1080/10872981.2018.1478170.

# Talking to African-American Teens About Sex

Danielle Hartwig, MD

The reduction in teen pregnancy rates in the last 27 years since its peak in 1991 has been a marked success in public health. Wisconsin has one of the lowest teen pregnancy rates in the country, a triumph of increased contraceptive use by teens. A closer look at the data, however, reveals severe racial disparities. Of the 31 states that choose to report data stratified by race, Wisconsin has the fourth-lowest rate of teen pregnancy among white teenagers and the fourth-lowest rate overall. However, for African-American teens specifically, Wisconsin ranks an appalling 27th out of those 31 states.[1] Clearly, there is essential work to be done to provide better reproductive care and education for young African-American men and women. Delivering comprehensive and accessible sex education for African-American teens requires not only quality teaching in schools, but in communities and clinics as well.

Wisconsin law currently does not require public schools to teach sex education. If a school chooses to do so, the curriculum does not explicitly require information about contraceptives, nor does it have a requirement for the age at which the education occurs, the duration of the education, or who provides it. This policy means that the quality and content of sex education that Wisconsin students receive—if any—varies widely from school to school. Furthermore, curricula that are in place often are biased, favoring sex within heterosexual married couples, a situation that is not reflective of the reality of many African-American teenagers who commonly see single and teenage parents in their communities and homes. A more inclusive and comprehensive curriculum would be more relevant for populations that do not fit this narrow mold. Moreover, approaching sex education from the lens of building healthy relationships, both physically and emotionally, removes the shame and fear inherent to many of the current curricula.

While improving the quality of sex education provided in schools would aid all students, the African-American student population would perhaps benefit even more through additional initiatives. Community-based efforts are likely to better serve this demographic, which may have a historical distrust of the medical system. In particular, peer-to-peer education makes information more accessible to teens who may not receive adequate education at school or at home. The RIPPLE study demonstrated that peer-educated teens in the United Kingdom had fewer self-reported pregnancies by age 18 when compared to teens who received teacher-led sex education.[2] Training teens to be advocates for their own sexual health and wellness improves the chance that the information being spread within the community is accurate and complete. Additionally, holding community workshops where teens and parents can learn together in a familiar, nonclinical environment ensures that parents are also educated and are able to share appropriate information with their children. Improving the availability and visibility of educated community members who may be perceived as more approachable than clinicians—and who have more thorough information than schools—will better serve the most vulnerable members of the African-American population.

Delivering comprehensive and accessible sex education for African-American teens requires not only quality teaching in schools, but in communities and clinics as well.

• • •

**Author Affiliation:** University of Wisconsin School of Medicine and Public Health, Madison, Wis (Hartwig).

**Corresponding Author:** Danielle Hartwig, University of Wisconsin School of Medicine and Public Health, 750 Highland Ave, Madison, WI 53726; phone 262.370.8191, email dhartwig@wisc.edu.

In addition to advocating for more comprehensive sex education in schools and greater support of community-based programs, physicians can also make changes in how they talk to teenage patients about sex. African-American teens may feel judged or stereotyped when their physician asks them about sex. This is particularly true when the subject is broached by a physician of a different race, culture, or sex. African-American patients tend to have greater satisfaction with their care if their physician is race-concordant,[3] and likewise tend to rate race-discordant physicians lower the more measured implicit bias the physician has against African-Americans.[4]

Normalizing the conversation about sex and approaching it in an unbiased manner is important to create a safe and comfortable space for every patient to ask questions. Spending a few minutes alone with teenage patients at every visit—even acute care appointments—optimizes opportunities to discuss sensitive topics, especially for patients who may not present for routine care. Making conversations about healthy peer relationships a routine part of visits with young children makes the transition to having conversations about sexual relationships when they are older more fluid. It also allows the clinician to establish a trusting relationship with the patient early on so that they feel more comfortable approaching their clinician with questions about sex-related topics when they arise. Finally, framing the discussion around the teen's goals and expectations for their life, both now and in the future, allows the clinician to form a partnership with the patient, gives the patient more autonomy over their health care decisions, and may help elucidate long-term direction for the teen. The American Academy of Pediatrics has published a detailed report outlining the appropriate and most effective ways to address these topics in the adolescent population.[5]

While changing the curriculum of sex education in schools and improving accessibility to community-based programs will require substantial effort and motivation from multiple agencies, making meaningful changes in how clinicians talk to their African-American teen patients can begin to reduce the disparity in the teenage pregnancy rate in this population.

**Acknowledgements:** Special thanks to Dipesh Navsaria, MD, and Kristi F. Jones MPH, CHES, for their assistance and support.

**Funding/Support:** None declared.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Power to Decide. Teen pregnancy rate comparison, 2013. https://powertodecide.org/what-we-do/information/national-state-data/teen-pregnancy-rate. Accessed February 21, 2018.

**2.** Stephenson J, Strange V, Allen E, et al. The long-term effects of a peer-led sex education programme (RIPPLE): a cluster randomised trial in schools in England. *PLoS Med.* 2008;5(11):1579-1590. doi:10.1371/journal.pmed.0050224.

**3.** LaVeist TA, Carroll T. Race of physician and satisfaction with care among African-American patients. *J Natl Med Assoc.* 2002;94(11):937-943.

**4.** Blair IV, Steiner JF, Fairclough DL, et al. Clinicians' implicit ethnic/racial bias and perceptions of care among Black and Latino patients. *Ann Fam Med.* 2013;11(1):43-52. doi:10.1370/afm.1442.

**5.** Marcell AV, Burstein GR, Committee on Adolescence. Sexual and reproductive health care services in the pediatric setting. *Pediatrics.* 2017;140(5):e20172858. doi:10.1542/peds.2017-2858.

# Children and Risk

Sarina Schrager, MD, MS, *WMJ* Associate Editor

*"The more risks you allow children to take, the better they learn to take care of themselves."*

— Roald Dahl

Taking a risk implies being exposed to some type of danger. A parent's instinctive reaction is to protect their children from risk. From birth—when they are at risk of choking, to toddlerhood—when they are at risk of falling or running away, to adolescence—when they are at risk of making bad decisions or being bullied, parents want to help their children be safe. By protecting them, we feel like we are doing our duty as parents. We don't want our children to suffer any pain or emotional hardship. However, the protection can become detrimental to a child's development. The pejorative term "helicopter parent" describes a parent who is omnipresent and overbearing. These parents are overprotective and do not allow their child to experience any risk, which may backfire as the child grows up and does not have the skills to deal with adversity.

The backlash against overprotective parents is a movement among childhood development experts (many in Europe) of creating situations that expose children to limited risks for "an experience essential to childhood development, useful in building resilience."[1] Playground designers in the United Kingdom have created play areas for children with "limited risks" that the children are allowed to experience, while at the same time not exposing them to any serious danger. These playgrounds have piles of bricks, wood boards that children can climb on, and some even have fire pits so that kids can experience burning things in a controlled environment. However, the idea that we can expose children to risks in a controlled environment seems to be a contradiction. Real risk implies real danger, not a scripted experience designed to give children the illusion of taking a chance.

Unfortunately, thousands of children in Wisconsin do not have the opportunity to be exposed to "limited risks," as they are exposed to real risks. Almost 17% of children in Wisconsin live in poverty.[2] Children who live in poverty are exposed to real risks including gun violence, homelessness, and food insecurity.

Several papers in this issue discuss risks for children in Wisconsin. Christensen, et al describe prevalence of childhood lead poisoning.[3] Exposure to high levels of lead can impair brain development and learning in small children. In 2016, over 4,000 children in Wisconsin were identified as having high lead levels. Lead has been in the news lately with the story of pervasively elevated lead in the water in Flint, Michigan, and significantly elevated levels in children who live in the area.[4] This story was triggered by a local physician who noticed that lead levels in her patients were very high. She worked with the public health department to identify the source of the lead and to take measures to decrease exposure.

Unfortunately, thousands of children in Wisconsin do not have the opportunity to be exposed to "limited risks" as they are exposed to real risks.

In another paper, Christensen, et al describe incidence of carbon monoxide exposure and poisoning between 2006 and 2016. During that time, over 3,700 people were exposed to carbon monoxide and over 2,100 were treated for carbon monoxide poisoning.[5] High levels of carbon monoxide can occur in malfunctioning or old heating systems.

In addition to the environmental exposures that endanger children in Wisconsin, there are dangers that stem from adult behavior. A paper in this issue by Creswell, et al describes exposures to opioids among children in Wisconsin between 2002 and 2016.[6] During this time period, there were over 3,300 calls to the poison control hotline and over 2,700 hospital encounters due to children or adolescents being exposed to opioids.[6] The majority of these exposures were to prescription opioids, demonstrating a different kind of risk to children.

All of these papers demonstrate risks that Wisconsin children face. They also suggest opportunities for physicians to intervene and advocate for environmental safety. Physicians should engage in public debate regarding safe housing, water supply, and disposal of potentially harmful medications. Roald Dahl was talking about allowing children to take risks in their exploration of the world around them in order to help them navigate complicated situations as they age. However, there is a range of acceptable risks. Above and beyond that, society should attempt to protect its children.

## REFERENCES


**1.** Barry E. In Britain's playgrounds, 'bringing in risk' to build resilience. *New York Times.* March 10, 2018.

**2.** Smeeding TM, Thornton KA. Wisconsin poverty report: progress against poverty stalls in 2016. Institute for research on poverty, University of Wisconsin-Madison. https://www.irp.wisc.edu/wp/wp-content/uploads/2018/06/WI-PovertyReport2018.pdf. Published June 2018. Accessed April 9, 2019.

**3.** Christensen K, Coons MJ, Walsh RO, et al. Childhood lead poisoning in Wisconsin. *WMJ.* 118(1):252-256.

**4.** Ingraham C. This is how toxic Flint's water really is. *Washington Post.* January 15, 2016.

**5.** Christensen GM, Creswell PD, Meiman JG. Carbon Monoxide Exposure and Poisoning Cases in Wisconsin, 2006–2016. *WMJ.* 118(1):257-262.

**6.** Creswell PD, Gibson C, Theobald J, Meiman JG. Exposures to opioids among Wisconsin children and adolescents, 2002–2016. *WMJ.* 118(1):245-251.

# Exposures to Opioids Among Wisconsin Children and Adolescents, 2002–2016

Paul D. Creswell, PhD; Crystal Gibson, MPH; Jillian Theobald, MD, PhD; Jon G. Meiman, MD


## ABSTRACT

**Background:** Opioid overdoses and opioid-related fatalities have increased dramatically in Wisconsin over the past decade. The observed rise in morbidity and mortality parallels increased opioid prescribing and greater use of illicit drugs such as heroin. Increased availability of both prescription and illicit opioids may increase the risk of exposure and overdose among the pediatric population.

**Methods:** We examined demographics and temporal trends in opioid exposures among children aged 0–19 years using hospital encounter and Wisconsin Poison Control Center (WPC) data. Exposures were categorized by type of opioid.

**Results:** We identified 3,320 WPC calls and 2,725 hospital encounters involving opioids during 2002–2016. Within the hospital encounter data, the rate of opioid-involved exposures increased significantly in children aged 0–5 years and adolescents aged 13–19 years. The majority of opioid-related hospital encounters involved prescription opioids. However, the proportion of hospital encounters involving heroin increased significantly among 13–19 year olds from 2002–2016. Within WPC data, the proportion of calls involving tramadol increased among 0–5 year olds and 13–19 year olds. However, calls about opioid/acetaminophen combinations decreased significantly as a proportion of opioid exposures.

**Discussion:** These findings suggest the need for caregiver education regarding safe storage and disposal of prescription opioids to prevent unintentional or intentional exposure to these substances among young children and adolescents. Overdose rates among teens continue to rise and an increasing proportion are due to heroin; comprehensive treatment and prevention strategies targeting this demographic are needed.


• • •

**Author Affiliations:** University of Wisconsin School of Medicine and Public Health, Madison, Wis (Creswell); Wisconsin Bureau of Environmental and Occupational Health, Madison, Wis (Creswell, Meiman); Wisconsin Environmental Public Health Tracking Program, Madison, Wis (Creswell, Meiman); Wisconsin Department of Health Services, Madison, Wis (Creswell, Meiman); Public Health Madison and Dane County, Madison, Wis (Gibson); Wisconsin Poison Control Center, Milwaukee, Wis (Theobald); Medical College of Wisconsin, Milwaukee, Wis (Theobald).

**Corresponding Author:** Paul D. Creswell, PhD, Wisconsin Department of Health Services, 1 W Wilson St, Room 150, Madison, WI 53703; phone 608.267.9752; fax 608.267.4853; email paul.creswell@dhs.wisconsin.gov.

## BACKGROUND

Opioid-related deaths and hospital encounters more than doubled in Wisconsin during 2006–2016.[1] The majority of these events are related to prescription opioids, which accounted for 69.0% of opioid-involved deaths and 59.0% of opioid-involved hospital encounters in 2016.[1] Nationally, trends in prescription opioid morbidity and mortality have paralleled substantial increases in opioid prescriptions.[2]

Increased prescribing of opioid analgesics in the United States has resulted in greater availability of these products to children and adolescents.[3] Nationally, Emergency Department (ED) visits and hospitalizations for opioid overdose have occurred with increasing frequency over the last decade,[4,5] and similar trends have been observed in calls to poison centers for opioid poisoning.[3] Studies indicate a bimodal distribution where young children (< 6 years) and adolescents (13+ years) are the most likely to experience an opioid exposure.[3,4] Younger children are more likely to be exposed unintentionally while teens are more likely to have an intentional exposure or a suicide attempt.[3] Despite sustained efforts to prevent and reduce opioid-related harm at the state level,[6] no analysis to date has sought to characterize opioid exposures for children and adolescents in Wisconsin.

The purpose of this investigation is to characterize opioid exposures for children and adolescents in Wisconsin using 2 data sources: hospital encounter data and Wisconsin Poison Center (WPC) data. Although hospital and emergency department data frequently are used for surveillance of nonfatal opioid poison-

**Box.** Opioids Included in the Wisconsin Poison Control Data Set

| | |
|---|---|
| Alfentanil | Hydrocodone |
| Acetaminophen with codeine | Hydromorphone |
| Acetaminophen with hydrocodone | Ibuprofen with hydrocodone |
| Acetaminophen with other narcotics or narcotic analogs | Levorphanol |
| | Meperidine |
| Acetaminophen with oxycodone | Methadone |
| Acetaminophen with propoxyphene | Morphine |
| Acetylsalicylic acid with codeine | Nalbuphine |
| Acetylsalicylic acid with other narcotics or narcotic analogs | Other or unknown narcotics |
| | Oxycodone |
| Acetylsalicylic acid with oxycodone | Oxymorphone |
| Acetylsalicylic acid with propoxyphene | Pentazocine |
| | Propoxyphene |
| Buprenorphine | Remifentanil |
| Butorphanol | Sufentanil |
| Codeine | Synthetic opioids |
| Difenoxin | Analogs and precursors (excluding pharmaceutical preparations), |
| Dihydrocodeine | |
| Fentanyl | Tapentadol |
| Heroin | Tramadol |

ings, diagnostic and external cause of injury codes provide limited information on specific substances or causative factors. Therefore, we included analysis of poison center calls to provide a more comprehensive picture of opioid exposures in the pediatric population.

## METHODS

We obtained data from the National Poison Data System (NPDS)[7] to evaluate calls to WPC. WPC receives approximately 100 calls per day that are handled by nurses and pharmacists who are specialists in poison information. These specialists often home manage exposures and will refer patients to health care facilities for further evaluation and treatment, when applicable. Basic deidentified data from each call—including age and sex, exposure substance(s), route of exposure, and outcomes—are entered into the NPDS. The NPDS is a secure data system that provides poison center data to toxicologists and other health professionals. Cases included all children aged < 20 years for whom a call was placed during 2002–2016 regarding an exposure to any prescription opioid or heroin. (See Box.) Cases were excluded if the medical outcome was listed as "confirmed nonexposure" or "unrelated effect."

Data from the Office of Health Informatics (OHI) at the Wisconsin Department of Health Services (DHS) was obtained to evaluate hospital encounters (ie, hospitalizations and ED visits) in Wisconsin facilities related to opioid poisoning for children aged < 20 years. Data cover all reporting facilities within the state and are provided to OHI by the Wisconsin Hospital Association. Non-Wisconsin residents were excluded from these analyses. This secondary analysis of existing data sets was conducted as part of routine surveillance of state-level health outcomes by DHS. As such, this study was not subject to Institutional Review Board review.

To identify opioid poisonings that occurred during January 1, 2002 through September 30, 2015, we searched across all diagnoses and the first external cause of injury field for the following ICD-9-CM codes: 965.00 (poisoning by opium [alkaloids], unspecified, 965.01 (poisoning by heroin), 965.02 (poisoning by methadone), 965.09 (poisoning by other opiates and related narcotics), E850.0 (accidental poisoning by heroin), E850.1 (accidental poisoning by methadone), or E850.2 (accidental poisoning by other opiates and related narcotics). During October 1, 2015 through December 31, 2016, we searched across all diagnosis fields for the following ICD-10-CM codes with a 5th or 6th character of 1-4 and a 7th character of A or D indicating initial or subsequent encounters: T40.0X (poisoning by opium), T40.1X (poisoning by heroin), T40.2 (poisoning by other opioids), T40.3X (poisoning by methadone), T40.4X (poisoning by synthetic narcotics), T40.60 (poisoning by other and unspecified narcotics), and T40.69 (poisoning by other narcotics). This coding is consistent with schema utilized by the Centers for Disease Control and Prevention.[2]

Identified opioid-related exposure cases were analyzed for demographics, medical outcomes, and opioid type. Medical outcomes within WPC data were categorized using standard NPDS coding: (1) minor effects include those with transient and mild symptoms with no long-term sequelae, (2) moderate effects are more prolonged and/or of a systemic nature but non-life threatening and do not result in long-term harm, and (3) major effects include those which are life threatening or result in residual disability.[8] For hospital encounter data, we categorized opioid poisonings into 2 groups: prescription opioids and heroin. Because we searched across multiple fields to identify relevant ICD-9-CM and ICD-10-CM codes, these categories are not mutually exclusive. For WPC data, we limited our analyses to exposures to specific opioids for which there were at least 30 calls in the 15 years under study. The substances that met this threshold were buprenorphine, codeine, hydrocodone, methadone, morphine, oxycodone, tramadol, opioid/acetaminophen combinations, and heroin. All other or unknown opioids were grouped together and treated as a separate category.

For both datasets, we assessed trends in counts and rates over time. Rates were calculated using the Wisconsin's 2010 census data as the denominator. The statistical significance of both count and rate trends were assessed using the Kendall Tau-p. In both datasets we examined events in 3 age categories: 0–5 years, 6–12 years, and 13–19 years. These age categories were chosen to align with infancy/early childhood, middle childhood, and adolescence. All analyses were completed using SAS software, version 9.4 for Windows.

## RESULTS

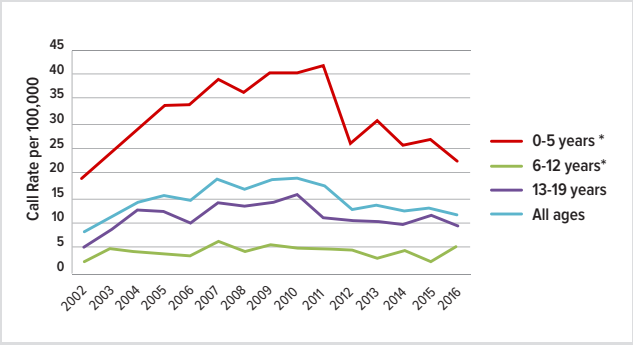
### Exposure Calls to the WPC

There were 3,320 cases involving an opioid exposure in a child or adolescent called into the WPC during 2002–2016 that met our criteria (Table 1). For exposures reported to the WPC, most involved females (50.6%), but with age-dependent shifts in proportion (Table 1). Race data were not collected by the WPC. The largest proportion of calls were regarding exposures in children aged 0–5 years (60.8%; n = 2,019). Exposures among adolescents aged 13–19 years were about half as frequent (29.0%; n = 962),

**Table 1.** Characteristics of Opioid Exposures Reported to the Wisconsin Poison Center Among Children 0–19 Years, Wisconsin, 2002–2016 (N = 3,320)

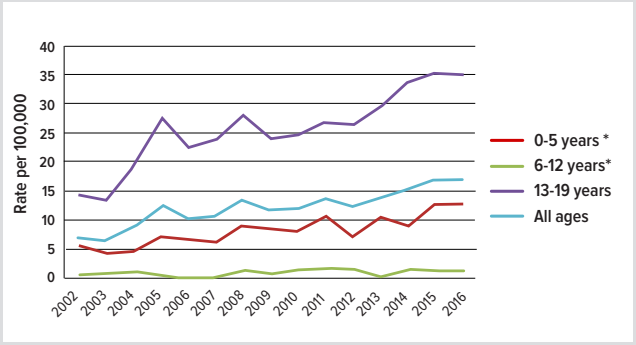
| | | Age | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0-5 | (%) | 6-12 | (%) | 13-19 | (%) | All | (%) |
| Sex | Female | 962 | 47.6% | 135 | 39.8% | 584 | 60.7% | 1681 | 50.6% |
| | Male | 1055 | 52.3% | 203 | 59.9% | 376 | 39.1% | 1634 | 49.2% |
| | Unknown | 2 | 0.1% | 1 | 0.3% | 2 | 0.2% | 5 | 0.2% |
| | **Total** | **2019** | **100.0%** | **339** | **100.0%** | **962** | **100.0%** | **3320** | **100.0%** |
| Exposure Reason | Adverse reaction | 4 | 0.2% | 5 | 1.5% | 26 | 2.7% | 35 | 1.1% |
| | Intentional | 5 | 0.2% | 17 | 5.0% | 373 | 39.0% | 395 | 11.9% |
| | Suicide attempt | 1 | 0.0% | 8 | 2.4% | 344 | 36.0% | 353 | 10.7% |
| | Therapeutic error | 265 | 13.1% | 213 | 62.8% | 135 | 14.1% | 613 | 18.5% |
| | Unintentional | 1730 | 85.7% | 90 | 26.5% | 54 | 5.6% | 1874 | 56.5% |
| | Other/unknown | 14 | 0.7% | 6 | 1.8% | 24 | 2.5% | 44 | 1.3% |
| | **Total** | **2019** | **100.0%** | **339** | **100.0%** | **956** | **100.0%** | **3314** | **100.0%** |
| Outcome | Minor effect | 324 | 16.0% | 76 | 22.4% | 485 | 50.7% | 885 | 26.7% |
| | Major effect | 13 | 0.6% | 0 | 0.0% | 21 | 2.2% | 34 | 1.0% |
| | Moderate effect | 62 | 3.1% | 9 | 2.7% | 114 | 11.9% | 185 | 5.6% |
| | Death | 2 | 0.1% | 0 | 0.0% | 1 | 0.1% | 3 | 0.1% |
| | No effect | 816 | 40.4% | 69 | 20.4% | 129 | 13.5% | 1014 | 30.6% |
| | Lost to follow-up | 802 | 39.7% | 185 | 54.6% | 207 | 21.6% | 1194 | 36.0% |
| | **Total** | **2019** | **100.0%** | **339** | **100.0%** | **957** | **100.0%** | **3315** | **100.0%** |
| Level of Care | Admitted to critical care unit | 84 | 4.2% | 6 | 1.8% | 87 | 9.0% | 177 | 5.3% |
| | Admitted to noncritical care unit | 97 | 4.8% | 6 | 1.8% | 64 | 6.7% | 167 | 5.0% |
| | Admitted to psychiatric facility | 0 | 0.0% | 0 | 0.0% | 34 | 3.5% | 34 | 1.0% |
| | Patient lost to follow-up/left against medical advice | 87 | 4.3% | 13 | 3.8% | 104 | 10.8% | 204 | 6.1% |
| | Patient refused referral/did not arrive at health care facility | 35 | 1.7% | 13 | 3.8% | 73 | 7.6% | 121 | 3.6% |
| | Treated/evaluated and released | 504 | 25.0% | 46 | 13.6% | 324 | 33.7% | 874 | 26.3% |
| | Data missing | 1212 | 60.0% | 255 | 75.2% | 276 | 28.7% | 1743 | 52.5% |
| | **Total** | **2019** | **100.0%** | **339** | **100.0%** | **962** | **100.0%** | **3320** | **100.0%** |

**Figure 1.** Rate of Opioid-Related Exposure Calls to the Wisconsin Poison Control Center by Age Category




* Trend positive and significant at $P<0.05$.

**Figure 2.** Rate of Hospital Encounters for Opioid Poisoning in Wisconsin by Age Category




* Trend positive and significant at $P<0.05$.

and children aged 6 to 12 years accounted for the remaining 10.2% of calls (n = 339). Among those aged 0–5 years, 85.7% of exposures were categorized as unintentional. In contrast, among those aged 13–19 years, 75.0% were categorized as either intentional or a suicide attempt. Those in the 0–5 group were less likely to have exposures that resulted in major and moderate effects or death (3.8%) in comparison to those 13–19 years old among whom 14.2% had major and moderate effects or death. The rate of opioid exposure calls for all age groups combined increased from 8.1 per 100,000 in 2002 and reached a peak of 19.0 per 100,000 in 2010 (Figure 1 and Figure 2). This was followed by a decline to 11.6 per 100,000 in 2016. Overall, the rate increased slightly during 2002–2016, but this overall increase was not statistically significant ($P = 0.961$).

## Hospital Encounters

We identified 2,725 hospitalizations or ED visits involving opioid poisoning among children and adolescents during 2002–2016. Children and adolescents who were hospitalized or treated in the ED for opioid poisonings were more likely to be female. This dis-

**Table 2.** Characteristics of Patients Hospitalized or Seen in the Emergency Department for Opioid Poisonings in Wisconsin Among Children 0–19 Years, Wisconsin, 2002–2016 (N = 2,725)

| | | Age | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **0-5** | **(%)** | **6-12** | **(%)** | **13-19** | **(%)** | **All** | **(%)** |
| Sex | Female | 256 | 49.2% | 40 | 48.2% | 1180 | 55.6% | 1476 | 54.2% |
| | Male | 264 | 50.8% | 43 | 51.8% | 942 | 44.4% | 1249 | 45.8% |
| | **Total** | **520** | **100.0%** | **83** | **100.0%** | **2122** | **100.0%** | **2725** | **100.0%** |
| Race | Black | 110 | 21.2% | 14 | 16.9% | 162 | 7.6% | 286 | 10.5% |
| | White | 285 | 54.8% | 47 | 56.6% | 1513 | 71.3% | 1845 | 67.7% |
| | Other | 40 | 7.7% | 4 | 4.8% | 94 | 4.4% | 138 | 5.1% |
| | Unknown/Missing | 85 | 16.3% | 18 | 21.7% | 353 | 16.6% | 456 | 16.7% |
| | **Total** | **520** | **100.0%** | **83** | **100.0%** | **2122** | **100.0%** | **2725** | **100.0%** |
| Ethnicity | Hispanic | 28 | 5.4% | 6 | 7.2% | 99 | 4.7% | 133 | 4.9% |
| | Non-Hispanic | 399 | 76.7% | 61 | 73.5% | 1666 | 78.5% | 2126 | 78.0% |
| | Unknown/Missing | 93 | 17.9% | 16 | 19.3% | 357 | 16.8% | 466 | 17.1% |
| | **Total** | **520** | **100.0%** | **83** | **100.0%** | **2122** | **100.0%** | **2725** | **100.0%** |

tribution changed depending on the age category of the patients (Table 2). Patients were primarily reported as being white (67.7%; n = 1,845). The majority of encounters (77.9%; n = 2,122) occurred among adolescents aged 13–19 years, while 19.1% (n = 520) occurred among children aged 0–5 years and 3.0% (n = 83) occurred among children aged 6–12 years. The rate of hospital encounters involving opioid poisoning among all children and adolescents increased from 7.1 per 100,000 to 16.9 per 100,000 during 2002–2016 (Figure 2, $P < 0.001$). For children aged 6–12 years, the rate increased over the time period from 0.7 per 100,000 to 1.6 per 100,000 ($P = 0.015$). The rate of hospital encounters involving opioid poisoning more than doubled during 2002–2016 for children aged 0–5 years (5.5 vs 12.8 per 100,000, $P < 0.001$) and for adolescents aged 13 to 19 years (14.2 vs 34.9 per 100,000, $P < 0.001$).

### Trends in Opioid Type

The rates of calls to the WPC for exposures to tramadol showed a significant increase for both the 0–5 year age group (2.5% vs 16.3% of calls, $P = 0.007$) and the 13–19 year group (6.5% vs 24.0% of calls, $P < 0.001$) (Table 3). These increases were also significant when considered as counts rather than rates ($P = 0.029$, $P < 0.001$, respectively). Concurrently, calls for opioid/acetaminophen combinations decreased as a proportion of opioid exposures from 69.6% to 22.8% among children aged 0–5 years ($P < 0.001$), from 42.9% to 23.1% for those aged 6–12 ($P = 0.029$), and from 71.0% to 48.0% for those aged 13–19 years ($P < 0.001$). Although the numbers were small, the proportion of exposure calls related to buprenorphine among children 0–5 years old increased from 4.6% in 2010 to 9.8% in 2016 ($P < 0.001$). This trend also was significant using raw count data ($P = 0.002$). These calls first appeared in WPC data in 2010 and averaged about 12.6 instances per year through 2016. Several other substances made up larger proportions of exposure calls during this time period for certain age groups (Table 3). Although some trends were statistically significant, changing proportions did not always reflect meaningful changes in the raw numbers.

The majority of hospital and ED encounters for opioid poisoning involved prescription opioids (85.4%, n = 2,336). All hospital encounters involving heroin occurred in adolescents aged 13–19 years (14.6%, n = 398). Case counts involving heroin increased nearly 10-fold from 6 cases in 2002 to 59 cases in 2016 ($P < 0.001$) (Table 3), while the proportion of opioid poisoning hospital encounters that involved heroin more than quadrupled from 2002 to 2016 (7.3% vs. 32.0% of exposures, $P < 0.001$) (Table 3).

## DISCUSSION

Our analysis reveals that opioids are an important cause of drug exposures and morbidity among the pediatric population in Wisconsin. Among children 0–5 years of age, unintentional exposures were the predominant reason for opioid-related calls to the WPC. Exploratory behaviors with increased hand and object-to-mouth contact are common in this age group,[9] and opioids are a leading cause of unsupervised medication exposures.[10] Encouragingly, WPC data indicate that exposure calls declined markedly for children in this age group since 2009, a trend that has been observed in a national analysis of poison center data.[3] However, the reason for the decline in Wisconsin is unknown and it occurred before declines in opioid prescribing were observed nationally in 2012.[11] Data from the Wisconsin Prescription Drug Monitoring Program (PDMP) shows a decline from a maximum of 5.2 million opioid prescriptions in 2014 to 4.8 million in 2016.[12] It is also possible that the WPC received fewer calls because of increased knowledge among medical professionals on treatment for exposed patients or because of the increased availability of online clinical reference tools. Additionally, as the proportion of acetaminophen-containing combination product exposures decreased, there was likely an associated decrease in the cases of concomitant acetaminophen toxicity. Treatment decisions regarding acetaminophen toxicity are often more complicated and difficult than those regarding opioid toxicity. Providers may be more likely to call the poison center seeking assistance

**Table 3.** Poison Center Calls and Medical Encounters for Opioid Exposures, by Age Group, Year of Exposure, and Opioid Type, Wisconsin 2002–2016

| | | Exposures Calls to Wisconsin Poison Center | | | | | | | | Hospital and Emergency Department Encounters for Oopioid Poisonings in Wisconsin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Substance:** | | **Oxycodone** | | **Tramadol[a]** | | **Heroin** | | **Opioid/Acetaminophen Combinations[b]** | | **Prescription Opioids** | | **Heroin** | |
| | | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** | **n** | **(%)** |
| Age: 0-5 | 2002 | 11 | (13.9) | 2 | (2.5) | 0 | (0.0) | 55 | (69.6) | 23 | (100.0) | 0 | (0.0) |
| years | 2003 | 6 | (6.1) | 7 | (7.1) | 0 | (0.0) | 54 | (54.5) | 19 | (100.0) | 0 | (0.0) |
| | 2004 | 11 | (9.2) | 4 | (3.3) | 0 | (0.0) | 82 | (68.3) | 20 | (100.0) | 0 | (0.0) |
| | 2005 | 13 | (9.2) | 3 | (2.1) | 1 | (0.7) | 90 | (63.8) | 30 | (100.0) | 0 | (0.0) |
| | 2006 | 18 | (12.5) | 13 | (9.0) | 0 | (0.0) | 76 | (52.8) | 29 | (100.0) | 0 | (0.0) |
| | 2007 | 12 | (7.2) | 9 | (5.4) | 0 | (0.0) | 112 | (67.1) | 27 | (100.0) | 0 | (0.0) |
| | 2008 | 17 | (10.9) | 25 | (16.0) | 0 | (0.0) | 80 | (51.3) | 39 | (100.0) | 0 | (0.0) |
| | 2009 | 17 | (9.8) | 18 | (10.3) | 0 | (0.0) | 74 | (42.5) | 37 | (100.0) | 0 | (0.0) |
| | 2010 | 12 | (6.9) | 21 | (12.1) | 1 | (0.6) | 77 | (44.5) | 35 | (100.0) | 0 | (0.0) |
| | 2011 | 16 | (9.0) | 23 | (12.9) | 0 | (0.0) | 78 | (43.8) | 46 | (100.0) | 0 | (0.0) |
| | 2012 | 4 | (3.6) | 12 | (10.8) | 0 | (0.0) | 61 | (55.0) | 30 | (100.0) | 0 | (0.0) |
| | 2013 | 17 | (13.4) | 12 | (9.4) | 1 | (0.8) | 51 | (40.2) | 44 | (100.0) | 0 | (0.0) |
| | 2014 | 20 | (18.9) | 8 | (7.5) | 0 | (0.0) | 45 | (42.5) | 38 | (100.0) | 0 | (0.0) |
| | 2015 | 27 | (24.8) | 28 | (25.7) | 0 | (0.0) | 24 | (22.0) | 51 | (100.0) | 0 | (0.0) |
| | 2016 | 23 | (25.0) | 15 | (16.3) | 1 | (1.1) | 21 | (22.8) | 52 | (100.0) | 0 | (0.0) |
| Age: 6-12 | 2002 | 2 | (14.3) | 1 | (7.1) | 0 | (0.0) | 6 | (42.9) | 4 | (100.0) | 0 | (0.0) |
| years | 2003 | 1 | (3.8) | 1 | (3.8) | 0 | (0.0) | 12 | (46.2) | 5 | (100.0) | 0 | (0.0) |
| | 2004 | 1 | (4.3) | 0 | (0.0) | 0 | (0.0) | 13 | (56.5) | 6 | (100.0) | 0 | (0.0) |
| | 2005 | 2 | (9.5) | 0 | (0.0) | 0 | (0.0) | 17 | (81.0) | 2 | (100.0) | 0 | (0.0) |
| | 2006 | 2 | (10.5) | 1 | (5.3) | 0 | (0.0) | 8 | (42.1) | 1 | (100.0) | 0 | (0.0) |
| | 2007 | 2 | (6.3) | 6 | (18.8) | 0 | (0.0) | 19 | (59.4) | 3 | (100.0) | 0 | (0.0) |
| | 2008 | 1 | (4.5) | 1 | (4.5) | 0 | (0.0) | 16 | (72.7) | 7 | (100.0) | 0 | (0.0) |
| | 2009 | 5 | (17.9) | 2 | (7.1) | 0 | (0.0) | 12 | (42.9) | 5 | (100.0) | 0 | (0.0) |
| | 2010 | 2 | (7.7) | 5 | (19.2) | 0 | (0.0) | 7 | (26.9) | 8 | (100.0) | 0 | (0.0) |
| | 2011 | 6 | (24.0) | 1 | (4.0) | 0 | (0.0) | 6 | (24.0) | 9 | (100.0) | 0 | (0.0) |
| | 2012 | 3 | (13.0) | 3 | (13.0) | 0 | (0.0) | 9 | (39.1) | 8 | (100.0) | 0 | (0.0) |
| | 2013 | 1 | (6.3) | 1 | (6.3) | 1 | (6.3) | 8 | (50.0) | 3 | (100.0) | 0 | (0.0) |
| | 2014 | 3 | (13.0) | 4 | (17.4) | 0 | (0.0) | 7 | (30.4) | 7 | (100.0) | 0 | (0.0) |
| | 2015 | 4 | (30.8) | 0 | (0.0) | 0 | (0.0) | 5 | (38.5) | 7 | (100.0) | 0 | (0.0) |
| | 2016 | 7 | (26.9) | 3 | (11.5) | 0 | (0.0) | 6 | (23.1) | 8 | (100.0) | 0 | (0.0) |
| Age: 13-19 | 2002 | 5 | (16.1) | 2 | (6.5) | 1 | (3.2) | 22 | (71.0) | 76 | (92.7) | 6 | (7.3) |
| years | 2003 | 7 | (14.3) | 1 | (2.0) | 1 | (2.0) | 35 | (71.4) | 73 | (92.4) | 6 | (7.6) |
| | 2004 | 9 | (12.2) | 1 | (1.4) | 1 | (1.4) | 50 | (67.6) | 106 | (93.8) | 7 | (6.2) |
| | 2005 | 7 | (9.9) | 5 | (7.0) | 6 | (8.5) | 45 | (63.4) | 142 | (88.8) | 18 | (11.3) |
| | 2006 | 11 | (19.0) | 5 | (8.6) | 0 | (0.0) | 31 | (53.4) | 112 | (85.5) | 19 | (14.5) |
| | 2007 | 12 | (15.0) | 9 | (11.3) | 2 | (2.5) | 49 | (61.3) | 118 | (86.8) | 18 | (13.2) |
| | 2008 | 8 | (10.4) | 11 | (14.3) | 4 | (5.2) | 43 | (55.8) | 129 | (81.6) | 29 | (18.4) |
| | 2009 | 5 | (6.3) | 9 | (11.4) | 1 | (1.3) | 50 | (63.3) | 107 | (79.3) | 28 | (20.7) |
| | 2010 | 10 | (11.6) | 11 | (12.8) | 2 | (2.3) | 48 | (55.8) | 112 | (83.0) | 23 | (17.0) |
| | 2011 | 3 | (5.0) | 16 | (26.7) | 0 | (0.0) | 32 | (53.3) | 112 | (76.2) | 35 | (23.8) |
| | 2012 | 8 | (14.3) | 6 | (10.7) | 0 | (0.0) | 35 | (62.5) | 110 | (76.9) | 33 | (23.1) |
| | 2013 | 9 | (16.4) | 11 | (20.0) | 2 | (3.6) | 24 | (43.6) | 115 | (73.2) | 42 | (26.8) |
| | 2014 | 2 | (3.8) | 13 | (25.0) | 2 | (3.8) | 30 | (57.7) | 146 | (80.7) | 35 | (19.3) |
| | 2015 | 5 | (8.2) | 11 | (18.0) | 1 | (1.6) | 30 | (49.2) | 148 | (78.7) | 40 | (21.3) |
| | 2016 | 5 | (10.0) | 12 | (24.0) | 2 | (4.0) | 24 | (48.0) | 127 | (68.0) | 59 | (32.0) |

[a] Trend positive and significant at $P < 0.05$

[b] Trend negative and significant at $P < 0.05$

Note 1: Trend tests are conducted on proportions (not counts).

Note 2: Exposures are not mutually exclusive. Counts of opioid type may not sum to case counts. Percentages may not sum to 100.

in those decisions. Thus, decreases in acetaminophen-containing combination product exposures leading to decreases in acetaminophen toxicity from these medications may account for a decrease in the number of calls to the WPC.

We observed declines in WPC calls regarding exposures to opioid/acetaminophen combinations. Changes in opioid prescribing practices among medical providers leading up to the designation of hydrocodone combination products as Schedule II drugs by the Drug Enforcement Agency (DEA) in 2014 may have promoted transition to alternatives.[13] Adherence to opioid prescribing guidelines also may be a contributing factor and may encourage providers to switch to tramadol.[14] Wisconsin PDMP data have shown an increase of 60.0% from 514,220 tramadol prescriptions in 2013 to 819,719 prescriptions in 2016.[12] This would be consistent with our observations that an increase in the number of calls to the WPC were due to tramadol over the study period. Although tramadol is considered to have an acceptable safety profile relative to morphine,[15] supra-therapeutic doses can result in serious side effects and death. Furthermore, tramadol has potential for abuse and dependence and can cause an atypical withdrawal syndrome due to its effects on serotonin and norepinephrine. The Food and Drug Administration (FDA) added a contraindication against the use of tramadol in patients < 12 years of age, and in 2015 tramadol was designated a schedule IV drug by the DEA. Any increased tramadol prescribing should be accompanied by appropriate adherence to FDA prescribing guidelines and education of patients on the safe storage of tramadol as for any other opioid.

Other studies have found increases in prescribing of buprenorphine.[3] We noted an increase in calls to the WPC regarding this substance for children 0–5 years old. Although the number of WPC calls remains relatively low, the upward trend is notable. National poison center data indicate that buprenorphine exposures have not declined in tandem with other opioids and are more likely to result in a hospital admission.[3] Changes in buprenorphine formulation and packaging have reduced ED visits for accidental ingestions in young children nationally,[16] but increased prescribing of buprenorphine for opioid use disorder and continued exposures among young children indicate a need for continued patient education.

Among adolescents, the rate of opioid-related hospital encounters increased significantly during 2002–2016. These rates were the highest among adolescents beginning in 2005. Similar trends have been observed in national hospitalization data.[4] Other studies of hospitalization, ED, and poison center data have shown misuse and self-harm to be the primary drivers behind opioid-related exposures in adolescents, as opposed to accidental overdose and therapeutic errors seen in young children.[4,17] The higher proportion of opioid-related encounters among adolescent females compared to males might be driven in part by self-inflicted injury; national ED data show that poisoning is the most common method of self-harm among females aged 10–24 years.[18] The upward trend in opioid-related hospital encounters is mirrored in national death data, with the poisoning death rate among adolescents aged 15–19 years nearly doubling during 2000–2009, in part due to an increase in prescription drug overdoses.[19]

The increasing proportion of hospital encounters related to heroin among adolescents is notable. Although heroin was responsible for fewer than 10.0% of encounters in 2002 in those aged 13–19 years, this increased more than 3-fold to 36.0% by 2016. This coincides with other statewide evidence suggesting increased heroin use in Wisconsin.[6,20] Nationally, hospitalizations due to heroin in adolescents increased 161% from 1997 to 2012,[4] a trend reflected in poisoning deaths of adolescents and young adults in national vital statistics. This presents a new challenge to health care providers and public health agencies as the opioid epidemic shifts toward increased use of heroin and other illicitly produced opioids.[21,22] Early identification of adolescents with substance use disorders and increased availability of medication-assisted treatment will be needed to address misuse of prescription opioids and reverse trends toward greater use of illicit opioids.[23,24]

## Limitations

Some limitations in our data and analysis should be considered. In WPC data, more than half of the poison center calls regarding opioid exposures pertained to children in the youngest age category (0–5 years), while hospitalization data showed that the majority of hospital encounters (76.1%) involved adolescents (13–19 years). Although the reason for this discrepancy is not fully understood, it may be related to increased hand and object-to-mouth contact among young children.[9] It also might be related to the severity of the exposure (eg, parents might be more likely to call WPC for minor exposures in younger children). Additionally, a recent national study showed that adolescents were more likely to experience an intentional poisoning and experience a serious medical complication, which may be associated with greater likelihood of hospitalization.[3,4] As such, hospitalization data may reflect cases with higher severity while WPC data reflect less severe exposures. WPC data support this hypothesis as the majority of cases (n = 1,899; 57.2%) were indicated as having a "minor effect" or "no effect" from exposure. Other types of encounters with the health care system (eg, urgent care and primary care office visits) are not reflected in our data. Future research may consider these additional sources.

This study treats the WPC and hospitalization data as separate but parallel indicators of trends in opioid exposure and poisoning. However, it should be noted that WPC staff members often refer individual callers to medical facilities for treatment. As such, we are unable to identify duplicate cases that are likely to appear in both datasets. It is also important to note that WPC data are based on calls from the public and health care providers. As such, many factors can affect whether or not a case gets called into the WPC, including medical expertise of clinicians, awareness of the poison center, and perception of what constitutes a poisoning. Finally,

the current study includes data from hospitalizations during the transition from ICD-9 to ICD-10 codes during the 4th quarter of 2015. While the numbers appear to be consistent with the previous years and trends, it is possible that differences in the number of opioid-involved poisonings in 2015 and 2016 could be due to this change in coding and may misestimate the observed increase in the number of hospitalizations.

## CONCLUSIONS

Our study provides important details regarding the substantial increases in opioid-related exposures in Wisconsin. Hospital encounters for opioid poisoning and calls to the WPC regarding opioid exposures at least doubled for young Wisconsinites in the 15-year period we considered. Moreover, specific substances were important to these trends. Among Wisconsin adolescents hospitalized for opioid poisoning, a growing proportion of cases were related to heroin. In WPC data, trends in exposure for both children and adolescents were driven by exposure to tramadol. As the US Food and Drug Administration (FDA) does not recommend prescribing tramadol to children under the age of 12,[25] it is likely that increase in exposures are related to children's access to others medications. It would be useful to repeat this analysis in several years to see if changes in prescribing practices have had an effect on the trends described here. Future research should also explore social determinants of health that are driving the high burden of overdoses among adolescents.

These findings suggest the need for parental education related to safe use, storage, and disposal of opioid medications and potential misuse of opioids among adolescents. Further, provider adoption of the Centers for Disease Control and Prevention or Wisconsin Medical Examining Board opioid prescribing guidelines is important in reducing the availability of prescription opioids.[26] These guidelines include recommendations for screening for conditions associated with higher risk for opioid misuse, including psychiatric conditions such as depression, which may be particularly important when adolescents receive opioid prescriptions.

**Funding/Support:** None declared.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Wisconsin Department of Health Services. Wisconsin Interactive Statistics on Health Query System. Opioid Overdose Deaths, Wisconsin 2000-2016. https://www.dhs.wisconsin.gov/wish/opioid/index.htm. Last Revised December 14, 2018. Accessed January 24, 2018.

**2.** National Center for Injury Prevention and Control. *Annual Surveillance Report of Drug-Related Risks and Outcomes -- United States, 2017*. Atlanta, GA: Centers for Disease Control and Prevention; 2017.

**3.** Allen JD, Casavant MJ, Spiller HA, Chounthirath T, Hodges NL, Smith GA. Prescription opioid exposures among children and adolescents in the United States: 2000-2015. *Pediatrics*. 2017;139(4):e20163382. doi:10.1542/peds.2016-3382

**4.** Gaither JR, Leventhal JM, Ryan SA, Camenga DR. National trends in hospitalizations for opioid poisonings among children and adolescents, 1997 to 2012. *JAMA Pediatr*. 2016;170(12):1195-1201. doi:10.1001/jamapediatrics.2016.2154

**5.** Vivolo-Kantor AM, Seth P, Gladden RM, et al. Vital signs: trends in emergency department visits for suspected opioid overdoses - United States, July 2016–September 2017. *MMWR*. 2018;67(9):279-285. doi:10.15585/mmwr.mm6709e1

**6.** Stein J. Wisconsin Senate OKs bills targeting opioid addiction. *Milwaukee Journal Sentinel*. May 2, 2017. https://www.jsonline.com/story/news/politics/2017/05/02/senate-vote-bills-targeting-heroin-regulations/101151382/. Accessed June 1, 2017.

**7.** American Association of Poison Control Centers. National Poison Data System (NPDS). http://www.aapcc.org/. Published 2017. Accessed June 1, 2017.

**8.** American Association of Poison Control Centers. NPDS Coding User Manual, Version 3.2. Updated February 2016.

**9.** Tulve NS, Scuggs JC, McCurdy T, Cohen Hubal EA, Moya J. Frequency of mouthing behavior in young children. *J Expo Anal Environ Epidemiol*. 2002;12(4):259-264. doi:10.1038/sj.jea.7500225

**10.** Lovegrove MC, Weidle NJ, Budnitz DS. Trends in emergency department visits for unsupervised pediatric medication exposures, 2004-2013. *Pediatrics*. 2015;136(4):e821-e829. doi:10.1542/peds.2015-2092

**11.** Centers for Disease Control and Prevention. U.S. opioid prescribing rate maps. https://www.cdc.gov/drugoverdose/maps/rxrate-maps.html. Page Last Reviewed October 2018. Accessed November 7, 2017.

**12.** Wisconsin Department of Safety and Professional Services. Wisconsin enhanced prescription drug monitoring program statistics dashboard. https://pdmp.wi.gov/statistics. Published 2017. Accessed September 25, 2017.

**13.** Jones CM, Lurie PG, Throckmorton DC. Effect of U.S. Drug Enforcement Administration's rescheduling of hydrocodone combination analgesic products on opioid analgesic prescribing. *JAMA Intern Med*. 2016;176(3):399-402. doi:10.1001/jamainternmed.2015.7799

**14.** Weiner SG, Baker O, Poon SJ, et al. The effect of opioid prescribing guidelines on prescriptions by emergency physicians in Ohio. *Ann Emerg Med*. 2017;70(6):799-808. doi:10.1016/j.annemergmed.2017.03.057

**15.** Expert Committee on Drug Dependence. *Tramadol: Update Review Report*. Geneva, Switzerland: World Health Organization; 2014.

**16.** Kim HK, Smiddy M, Hoffman RS, Nelson LS. Buprenorphine may not be as safe as you think: a pediatric fatality from unintentional exposure. *Pediatrics*. 2012;130(6):e1700-e1703. doi:10.1542/peds.2012-1342

**17.** Allareddy V, Rampa S, Allareddy V. Opioid abuse in children: an emerging public health crisis in the United States! *Pediatr Res*. 2017;82(4):562-563. doi:10.1038/pr.2017.166

**18.** Mercado MC, Holland K, Leemis RW, Stone DM, Wang J. Trends in emergency department visits for nonfatal self-inflicted injuries among youth aged 10 to 24 years in the United States, 2001-2015. *JAMA*. 2017;318(19):1931-1933. doi:10.1001/jama.2017.13317

**19.** Centers for Disease Control and Prevention. Vital signs: unintentional injury deaths among persons aged 0-19 years - United States, 2000-2009. *MMWR Morb Mortal Wkly Rep*. 2012;61:270-276.

**20.** Wisconsin State Council on Alcohol and Other Drug Abuse. *Wisconsin's Heroin Epidemic: Strategies and Solutions: Analysis and Recommendations for Reducing Heroin Abuse in Wisconsin*. Madison, WI: State Council on Alcohol and Other Drug Abuse; 2014.

**21.** Smith DE. Medicalizing the opioid epidemic in the U.S. in the era of health care reform. *J Psychoactive Drugs*. 2017;49(2):95-101. doi:10.1080/02791072.2017.1295334

**22.** Pergolizzi JV, LeQuang JA, Taylor R, Raffa RB, Group NR. Going beyond prescription pain relievers to understand the opioid epidemic: the role of illicit fentanyl, new psychoactive substances, and street heroin. *Postgrad Med*. 2018;130(1):1-8. doi:10.1080/00325481.2018.1407618

**23.** Harris BR. Talking about screening, brief intervention, and referral to treatment for adolescents: An upstream intervention to address the heroin and prescription opioid epidemic. *Prev Med*. 2016;91:397-399. doi:10.1016/j.ypmed.2016.08.022

**24.** Hadland SE, Wood E, Levy S. How the paediatric workforce can address the opioid crisis. *Lancet*. 2016;388(10051):1260-1261. doi:10.1016/S0140-6736(16)31573-2

**25.** FDA statement from Douglas Throckmorton, M.D., Deputy Center Director for Regulatory Programs, Center for Drug Evaluation and Research, on new warnings about the use of codeine and tramadol in children & nursing mothers [press announcement]. Silver Spring, MD: US Food and Drug Administration; April 20, 2017. https://www.fda.gov/newsevents/newsroom/pressannouncements/ucm553285.htm. Accessed November 7, 2017.

**26.** Wisconsin Medical Examining Board. Opioid Prescribing Guideline 2016. https://dsps.wi.gov/Documents/BoardCouncils/MED/20180321MEBGuidelinesv8.pdf. Updated March 21, 2019. Accessed August 18, 2017.

# Childhood Lead Poisoning in Wisconsin

Krista Christensen, PhD, MPH; Marjorie J. Coons, RN, MS; Reghan O. Walsh, BS; Jon Meiman, MD; Elizabeth Neary, MD, MS


## ABSTRACT

**Introduction:** In 2016, 4,353 Wisconsin children under 6 years of age were identified with elevated blood lead levels (≥ 5 µg/dL). There is no safe level of lead in the human body; extensive research shows that children with blood lead levels < 5 µg/dL may still be at risk for adverse health effects including developmental delays.

**Discussion:** Physicians should follow current guidelines and consider factors such as the child's age, socioeconomic status, and housing situation when determining need for testing. In addition to Wisconsin's screening recommendations, federal requirements exist for testing Medicaid-enrolled children. Under state statute, all blood lead test results and specified demographic information must be reported to the Wisconsin Childhood Lead Poisoning Prevention Program. To eliminate elevated blood lead levels, primary prevention is key. Physicians play an important role by educating parents, prospective parents, and caregivers about lead poisoning risks and prevention measures. Physicians are also vital in secondary prevention—mitigating the adverse effects in children already exposed to lead. Secondary prevention requires first identifying children with elevated blood lead levels through appropriate testing. Use of the Wisconsin Blood Lead Registry can alert providers about children with elevated blood lead levels and reduce duplicate testing. Recent surveillance data show current screening is inadequate; in 2015, only 32% of Medicaid-enrolled children received appropriate testing. Physicians should provide clinical management for children with elevated blood levels and their families.

**Conclusions:** Physicians are a vital partner in preventing, identifying, and mitigating the effects of elevated blood lead levels for Wisconsin's children.


• • •

**Author Affiliations:** Wisconsin Childhood Lead Poisoning Prevention Program, Wisconsin Department of Health Services, Division of Public Health, Bureau of Environmental and Occupational Health (Christensen, Coons, Walsh, Meiman); University of Wisconsin Hospital (Neary), Madison, Wis.

**Corresponding Author:** Jon Meiman, MD, Wisconsin Department of Health Services, 1 W Wilson St, Madison, WI 53703; email jonathan.meiman@dhs.wisconsin.gov.

## INTRODUCTION

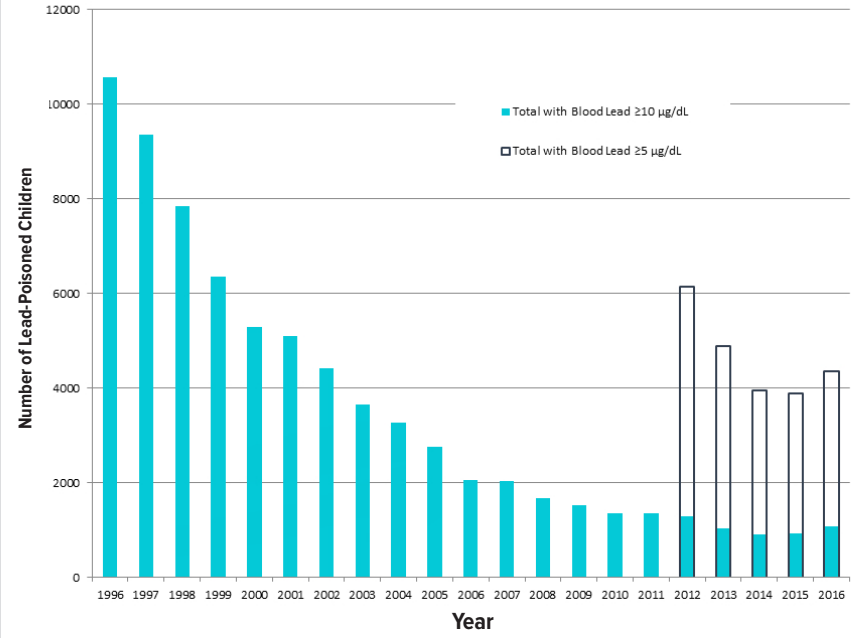
Elevated blood lead levels cause serious harm to the physical and mental health of children, with concomitant societal burdens of increased educational and health care costs, higher incarceration rates, and loss of productivity in the workforce. Children exposed to lead even at levels below the Centers for Disease Control and Prevention's (CDC) "reference value" of 5 µg/dL in blood may be at risk for developing an array of adverse, long-term health effects (reviewed in a recent National Toxicology Program report[1]) including neurological and developmental delays. Adverse outcomes of childhood lead exposure are also observed in adulthood.

In this review, we present data on elevated blood lead levels in Wisconsin children, with an emphasis on the most recently available data (2016), as well as information on the physician's role in screening, primary prevention, and secondary prevention of elevated blood lead levels. Use of the Wisconsin Blood Lead Registry and the role of public health in secondary prevention are reviewed.

In Wisconsin, there were 4,353 children under age 6 years identified with elevated blood lead levels (5 µg/dL or higher) in 2016 alone.[2] The sale of lead-based paint and varnish for household use was banned in the United States in 1978, but this paint is still present on the walls, windows, wood trim, doors, floors, and ceilings of many older homes. While lead in water has been prominent in the media due to the situation in Flint, Michigan, lead-based paint remains the primary source of lead exposure for

children in Wisconsin. Physicians and other health care providers play a crucial role in screening for and in the prevention of childhood lead exposures and their consequences.

**Figure.** Number of Children Under Age 6 Years Found to Have Elevated Blood Lead Levels, Wisconsin, 1996-2016




## Elevated Blood Lead Levels in Wisconsin Children

In 1994, the Wisconsin Department of Health Services Childhood Lead Poisoning Prevention Program (WCLPPP) began systematically collecting information on all blood lead tests conducted in Wisconsin. Under the requirements of Wis. Stat. § 254.13, laboratories—including clinics that perform lead testing on site—must report the results and specified demographic information associated with all blood lead tests. The WCLPPP maintains the blood lead testing data in a relational database, which forms the basis for analyses and surveillance activities conducted at the state level.

From 1996 through 2016, more than 200,000 Wisconsin children under age 6 years were identified with elevated blood lead levels using the current CDC reference value of 5 µg/dL, or about one-fifth of all children under age 6 who received a blood lead test during that time period. During 2016 alone, 87,443 children under age 6 years received a blood lead test, and 5% (n=4,353) were identified with elevated blood lead levels. As shown in the Figure, the number of children considered to have elevated blood lead levels had been declining steadily but increased dramatically in 2012 when the CDC changed its "level of concern" of 10 µg/dL to a "reference value" of 5 µg/dL.

Importantly, the number of children tested has decreased over the past 6 years, with 18,000 fewer children tested in 2016 compared with 2010. Further, the number of children tested in 2016 represents only about 22% of children under age 6 years in Wisconsin, and it is likely that some of the children not tested were at risk for lead exposure and elevated blood lead levels. Thus, the data presented here underestimate the true number of children with elevated blood lead.

With the data available, it is not possible to estimate the exact number of children at risk for elevated blood lead levels who should receive testing. However, there are some indicators of the extent of the problem. In 2016, there were an estimated 662,013 housing units built before 1950 in Wisconsin;[3] this older housing is the most likely to have lead based paint hazards present. According to the US Department of Housing and Urban Development survey of the prevalence of lead hazards in US housing, about one-third of housing units in the Midwest have lead hazards (compared to 25% for the United States as a whole), and further, older housing was more likely to be occupied by families with children.[4] With respect to income, the 2015 American Community Survey indicates that there were over 63,000 children aged under 5 years living in poverty in Wisconsin.[5] Among the 203,068 children aged under 6 years who were enrolled in Medicaid in 2015, over one-third (n=71,565; 35.2%) had never been tested for lead. These factors indicate that not all physicians are appropriately testing children who are at risk for lead exposure.

## Factors Affecting Risk for Elevated Blood Lead Levels and Recommendations for Lead Testing

A number of factors affect a child's risk for elevated blood lead levels and consequent recommendations for timing and frequency of lead testing. The most important of these are age of housing and the child's age. In conjunction with screening guidelines discussed below, these factors and others should be considered by physicians when recommending lead testing.

*Age of House*—Children living in older housing, where lead-based paint is more prevalent, are at greater risk for elevated blood lead levels than children who live in newer housing. In Wisconsin, 90% of children first identified with lead poisoning from 1996 to 2006 lived in homes that were built before 1950.[6] Consequently, while elevated blood lead levels are a risk statewide, significantly higher rates are seen in certain communities or parts of communities with higher prevalence of older housing and other risk factors for elevated blood lead levels. For example, of the Wisconsin cities with at least 100 children tested in 2015, the cities with the 10 highest prevalence rates of ele-

**Table.** Wisconsin Blood Lead Screening Recommendations

| Age | Screening Criteria | Testing Interval |
|---|---|---|
| **Children living in Milwaukee or Racine** | | |
| ≤24 months of age | All children | At ages 12, 18, and 24 months |
| 3-5 years of age | ≥1 risk factor [a] *or* no record of prior test | Annually at ages 3, 4, and 5 years |
| **Children living outside Milwaukee or Racine** | | |
| ≤24 months of age | ≥1 risk factor [a] | At ages 12 and 24 months |
| 3-5 years of age | ≥1 risk factor [a] *and* no record or prior test | Once between 36-72 months of age |

[a] Risk factors for lead poisoning:

- Enrolled in Medicaid or the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) (proxy for low socioeconomic status).
- Lives or spends time in housing unit built before 1950.
- Lives or spends time in housing unit built before 1978 with recent/ongoing renovations.
- Sibling or playmate with lead poisoning.

vated blood lead levels were Milwaukee (9.3%), Racine (8.2%), Beloit (8.1%), Sheboygan (7.1%), Hartford (6.9%), Two Rivers (6.5%), Watertown (6.5%), Beaver Dam (6.3%), New London (6.0%), and Janesville (5.5%). The prevalence rates of elevated blood lead levels in these cities are higher than the 2015 statewide rate of 4.6% and are calculated as the number of children with a blood lead level ≥ 5 µg/dL over the number of children tested.

***Age of Child***— One of the most important determinants of lead exposure is age. A child's blood lead level tends to be highest between 18 and 36 months of age because frequent hand-to-mouth behavior and increased mobility make lead-containing dust more accessible to the child. Additionally, for a given amount of lead exposure, younger children would generally experience a greater impact compared with older children or adults given their smaller size and higher rate of absorption. Although physicians should recommend at-risk children be tested around 1 year of age for early identification and intervention, it is also very important that children be tested again around 2 years of age or later, when they become more mobile and their risk of exposure to lead is greater. According to the American Academy of Pediatrics, a low blood lead concentration in a 1-year-old does not preclude elevation later.[7] While a normal blood lead test at 1 year of age is reassuring, children are still at risk for elevated blood lead levels as they age and should be retested.

***Socioeconomic Factors***— Another characteristic affecting lead testing and exposure is family income. Children from low-income families are at greater risk for elevated blood lead levels, largely because they have limited options for selecting housing. In Wisconsin, Medicaid-enrolled children are at a 3 times greater risk of lead poisoning than non-Medicaid-enrolled children.

## Wisconsin Blood Lead Screening Recommendations

Clearly, there are many factors that affect risk of lead poisoning for Wisconsin children. These factors have been used to develop the Wisconsin Blood Lead Screening Recommendations[8] (Table), which recommend targeted screening of children who are at greatest risk for lead poisoning. If the parent or caretaker is not sure about certain factors (such as age of home) it is better to err on the side of caution and test the child if he or she may be at risk for lead exposure. In addition to Wisconsin screening recommendations, federal requirements exist for children enrolled in Medicaid.

***Children Living in Milwaukee and Racine, Wisconsin***— The Wisconsin Blood Lead Screening Recommendations include universal testing of all children living in the cities of Milwaukee and Racine. Because the extremely high proportion of older housing in these communities creates an extremely high risk of elevated blood lead levels, each child should have a blood lead test 3 times before the age of 3 years: around 12 months, 18 months, and 24 months. Children aged 3 through 5 years should be tested annually if they meet one or more of the following risk criteria:

1. Enrolled in Medicaid, enrolled in the Women, Infants and Children Food and Nutrition Service (WIC), or is uninsured (proxy for low socioeconomic status).
2. Live in a housing unit built before 1950.
3. Live in a housing unit built before 1978 with recent or ongoing renovations.
4. Have a sibling or playmate with lead poisoning.
5. Have no record of a prior test.

***Children Living Outside Milwaukee and Racine***—When seeing children from areas outside the cities of Milwaukee and Racine, health care providers are encouraged to use the Four Easy Questions below to determine whether a child is at risk for elevated blood lead levels and, if there is no record of a previous test, whether the child should be tested at around 12 months and 24 months of age and between 36 and 72 months of age:

1. Is the child enrolled in Medicaid or WIC (proxy for low socioeconomic status)?
2. Does the child live in or visit a housing unit built before 1950 (including childcare facilities and homes of friends or relatives)?
3. Does the child live in or visit a housing unit or building built before 1978 with recent or ongoing renovations (including childcare facilities and homes of friends or relatives)?
4. Does the child have a sibling or playmate with elevated blood lead levels?

***Children Enrolled in Medicaid***— Children enrolled in Medicaid are required to receive blood lead testing as part of their Early and Periodic Screening, Diagnostic and Treatment (EPSDT), ie, HealthCheck services. More specifically, *"all children enrolled in Medicaid should receive a screening blood lead test at 12 and 24*

*months of age … Children over the age of 24 months, up to 72 months of age, for whom no record of a previous screening blood lead test exists, should also receive a screening blood lead test."*[9] The Wisconsin Medicaid Program collaborates with the WCLPPP in linking program data to determine blood lead testing and elevated blood lead levels among Medicaid-enrolled children. This data linkage has demonstrated that, despite the federal testing policy, many Wisconsin children enrolled in Medicaid are not tested at the appropriate ages; in 2015, only 32% of Medicaid-enrolled children received the appropriate testing at both 1 and 2 years of age. WIC programs in Wisconsin are strong partners in assuring that children who are at risk for lead poisoning receive the blood lead tests they need. In 2014, 52.1% of Medicaid-enrolled children under 6 years of age who received a blood lead test were tested by a WIC provider rather than their primary health care provider. Many WIC projects have voluntarily established successful testing programs and act as a safety net, testing children who might otherwise be missed. However, while all WIC participants do receive some standard services, not all are tested at WIC for lead. Health care providers maintain primary responsibility for testing children during well-child visits.

***Testing Using Point-of-Care Lead Testing Devices***— Many health care providers have begun to test children's blood lead levels using portable point-of-care lead testing devices, such as the LeadCare II. These devices offer increased ease and timeliness in collecting and analyzing blood samples and are a useful tool for increasing testing rates for providers and their patients. However, these blood lead test results are not automatically transmitted to the WCLPPP and must be reported by the clinic staff. WCLPPP staff has worked with the LeadCare manufacturer to maintain a list of clinics and laboratories that have purchased the devices and to inform these sites of the reporting requirements and procedures for Wisconsin. However, challenges remain in obtaining complete and timely reporting of results from these sites. As clinic staff turn over and newly hired staff are oriented to the device, reporting requirements may not be discussed. Clinics also may purchase LeadCare devices from a second party, and reporting requirements normally shared at time of purchase from the manufacturer are not conveyed to the new owner. All blood lead tests must be reported to the WCLPPP per statutory requirement, and physicians are a vitally important partner in ensuring that all lead test results are reported.

***Use of the Wisconsin Blood Lead Registry***—As children may be tested for lead outside of their medical home, preventing unnecessary duplicate screening by primary care providers is important. The State of Wisconsin provides physicians with access to all blood lead test results through the Wisconsin Blood Lead Registry (Lead Registry) via the Wisconsin Immunization Registry (WIR) portal. The Lead Registry is updated each week with new test results, including tests done at all locations, such as WIC sites, HeadStart, and physicians' offices. The Lead Registry also can help physicians to easily identify children who have not yet been tested or are due for another test. Information on how to access the Lead Registry is provided in Appendix A.

## Eliminating Childhood Lead Poisoning in Wisconsin

***Primary Prevention***— Because no level of lead is safe, primary prevention is the best way to eliminate childhood elevated blood lead levels. Primary prevention prevents exposure before it happens. Children can be exposed to lead-based paint in their homes, lead-contaminated soil in their yards, and potentially in their water supply if their housing unit has lead pipes or lead-containing solder. To a much lesser extent, other potential sources of exposure include lead in toys, candy, and other products, like imported spices and cosmetics. Physicians play a key role by educating parents and caregivers about elevated blood lead level risks and prevention measures so that they can take corrective action. Primary care physicians should initiate primary prevention as early as possible, ideally at a prenatal visit. If the family or caretakers live in older housing, clinicians should discuss ways to decrease exposure to lead and provide the family with written material to take home. (See Appendix B.)

***Special Considerations for Physicians Who Provide Prenatal Care and Services***— Primary prevention should begin even before a child is born. Not only is prenatal care an important time to educate future parents about lead exposure, mothers who are themselves exposed may pass this lead to their fetus during gestation and through breast milk. The fetal blood lead level approximates the maternal blood lead level. The CDC has published guidelines for care of pregnant and lactating women,[10] which include models of screening questionnaires to determine a woman's risk for lead exposure. In brief, the most important action is to identify and remove potential sources of lead exposure. In addition, women should be assessed for dietary adequacy and counseled about breastfeeding options at higher levels of exposure. Physicians should ask about occupation, hobbies, home remedies, folk medicine, pica, and imported candies and ceramics to identify potential environmental sources. However, even with no current exposure, lead stored in bone from childhood exposure may be mobilized along with calcium during pregnancy and lactation, leading to an increased blood lead level. It is critical to counsel pregnant and lactating women on recommended intake of calcium, iron, and Vitamin C, as proper nutrition can reduce the absorption of lead and the mobilization of lead stored in bone (from previous lead exposure). However, these nutritional efforts are meant to mitigate some of the harmful effects of lead and are *not* a substitute for primary prevention.

***Secondary Prevention***— Physicians also play a key role in secondary prevention, or mitigating the adverse effects in children already exposed to lead. The first step is identifying children with elevated blood lead levels through blood lead testing. Elevated blood lead

levels in young children are primarily asymptomatic, therefore testing is the only way to detect them. As described above, many children are never tested for lead, including those at high risk for lead exposure. Consequently, many children with elevated blood lead levels are never identified and do not receive interventions, increasing their risk for the myriad health, educational, and social problems associated with prolonged exposure to lead. Although the reasons for not receiving required testing have not been identified fully, they include a mistaken belief that the child is not at risk or has been tested elsewhere (eg, WIC), lack of awareness of the Medicaid testing requirements, a decision by parents/guardians not to have their child tested, and logistical barriers (eg, the child is referred to an outside lab for the blood draw or the child changes health care providers).

Physicians are a vital partner in ensuring that children receive appropriate blood lead testing and that children identified with elevated blood lead levels receive appropriate care. The American Academy of Pediatrics has published "Prevention of Childhood Lead Toxicity,"[7] which is one resource physicians may use to determine the course of follow-up, and other resources are listed in Appendix A. The CDC also has some specific advice for children with a blood lead level ≥ 5 μg/dL:[11]

- Confirm an elevated capillary blood lead test with a venous sample.
- Provide follow-up blood lead monitoring according to the CDC recommended schedule.
- Conduct a complete history and physical exam on the child.
- Conduct the appropriate laboratory tests to assess iron status.
- Assess the child's growth and development (including neurological development[12]) and continue to monitor as the child ages and enters school.
- Provide education to the family on the sources of lead and how to reduce any possible lead hazards.
- Abdominal x-ray (if particulate lead ingestion is suspected) with bowel decontamination if indicated.
- Environmental investigation conducted by local health department and lead hazard remediation conducted by certified lead professional.
- Oral chelation therapy for blood lead levels of > = 45 μg/dL or higher; consider hospitalization if lead-safe environment cannot be assured.

Public health plays a key role in secondary prevention. Local health departments provide nursing case management and environmental investigations for children with elevated blood lead levels. These services can identify and eliminate lead sources in the home and prevent future exposures to people living in the same residence. Providers can contact the local health department in their community for more information about available services and refer children with elevated blood lead levels for further assessment.

## CONCLUSIONS

Wisconsin is making significant progress in protecting children from the harmful lasting effects of elevated blood lead levels, but much work remains to eliminate childhood elevated blood lead levels forever. Health care providers maintain primary responsibility for testing children, thus physicians are a vital partner in preventing elevated blood lead levels, identifying children already affected by lead, and reducing the adverse effects of lead exposure throughout the lifespan and across generations.

**Funding/Support:** This research was funded by Cooperative Agreement Award Number 5NUE1EH001288-03-00, funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** National Toxicology Program. NTP monograph on health effects of low-level lead. https://ntp.niehs.nih.gov/pubhealth/hat/noms/lead/index.html. NIH Publication No. 12-5996. Published June 2012. Accessed March 19, 2019.

**2.** Christensen KY, Coons MJ, Walsh RO. 2016 report on childhood lead poisoning in Wisconsin. https://www.dhs.wisconsin.gov/publications/p01202-16.pdf. Wisconsin DHS Publication P-01202-16. Published October 2017. Accessed March 19, 2019.

**3.** United States Census Bureau. American Fact Finder. Table B25034: Year structure built. American Community Survey 1-Year Estimate for 2016. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_1YR_B25034&prodType=table. Published 2016. Accessed March 19, 2019.

**4.** Jacobs DE, Clickner RP, Zhou JY, et al. The prevalence of lead-based paint hazards in U.S. housing. *Environ Health Perspect*. 2002;110(10):A599-606. doi:10.1289/ehp.021100599

**5.** United States Census Bureau. American Fact Finder. Table B17010: Poverty status in the past 12 months of families by family type by presence of related children under 18 years by age of related children. American Community Survey 1-Year Estimates. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk. Published 2015. Accessed March 19, 2019.

**6.** Wisconsin Department of Health and Family Services, Division of Public Health, Bureau of Environmental and Occupational Health. *The Legacy of Lead: The Report on Childhood Lead Poisoning in Wisconsin.* Madison, WI: Wisconsin Department of Health and Family Services; 2008.

**7.** Council on Environmental Health. Prevention of childhood lead toxicity. *Pediatrics*. 2016;138(1):e20161493. doi:10.1542/peds.2016-1493

**8.** Wisconsin Department of Health Services. Wisconsin Childhood Lead Poisoning Prevention and Control Handbook. Wisconsin DHS Publication P-00660. https://www.dhs.wisconsin.gov/publications/p00660.pdf. Revised November 2014. Accessed March 19, 2019.

**9.** Department of Health and Human Services, Health Care Financing Administration. Letter to State Medicaid Directors on Lead Screening. http://www.medicaid.gov/Federal-Policy-Guidance/DOWNLOADS/SMD102299.PDF. Published 1999. Published Oct. 22, 1999. Accessed March 29, 2019.

**10.** Ettinger AS, Wengrovitz AG. *Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women.* Atlanta GA: US Department of Health and Human Services; 2010.

**11.** Advisory Committee on Childhood Lead Poisoning Prevention of the Centers for Disease Control and Prevention. Low level lead exposure harms children: a renewed call for primary prevention. http://www.cdc.gov/nceh/lead/acclpp/final_document_030712.pdf. Published January 4, 2012. Accessed March 19, 2019.

**12.** Educational Services for Children Affected by Lead Expert Panel. *Educational Interventions for Children Affected by Lead*. Atlanta: US Department of Health and Human Services; 2015.

# Carbon Monoxide Exposure and Poisoning Cases in Wisconsin, 2006–2016

Grace M. Christensen, MPH; Paul D. Creswell, PhD; Jon G. Meiman, MD


## ABSTRACT

**Introduction:** Carbon monoxide (CO) poisoning is responsible for over 450 deaths and 21,000 Emergency Department visits annually in the United States. In Wisconsin, multiple large-scale CO poisoning events have occurred in recent years. This analysis explores trends in CO exposure events in the state from 2006 through 2016.

**Methods:** Wisconsin Poison Center (WPC) CO exposure data from January 1, 2006 through December 31, 2016 was analyzed for trends over time. CO poisoning cases were classified using the Council of State and Territorial Epidemiologists case definition.

**Results:** During the study period, 3,703 persons were exposed to CO and 2,148 were poisoned. On average, 337 persons were exposed annually over this period, with an annual average of 195 suspected and probable poisoning cases per year, as reported to the WPC. Large-scale events (≥ 5 persons) accounted for 4.8% (n = 104) of all events. Using data extracted from WPC case notes for large-scale exposures, the most common source of exposure was furnaces or water heaters (20.2%; n = 21) followed by fire (8.7%; n = 9).

**Conclusions:** Despite public health efforts to reduce CO exposures, CO poisoning continues to affect Wisconsin residents. Efforts to prevent large scale CO poisonings should focus on awareness of CO exposure within the home, as well as the risk in public or occupational settings. Moreover, these efforts should focus on improving the use of CO detectors in all settings to prevent exposure. The WPC can be used as a resource for clinicians in cases of CO exposure and poisoning.


• • •

**Author Affiliations:** Wisconsin Department of Health Services, Bureau of Environmental and Occupational Health (Christensen, Creswell, Meiman); Applied Epidemiology Fellowship, Council of State and Territorial Epidemiologists, Centers for Disease Control and Prevention (Christensen); Department of Population Health Sciences, University of Wisconsin Madison, (Creswell), Madison, Wis.

**Corresponding Author:** Grace M. Christensen, MPH, Wisconsin Department of Health Services, 1 W Wilson St, Room 150, Madison, WI 53703; phone 608.267.3227; fax 608.257.4853; email grace.christensen@wi.gov.

## INTRODUCTION

Carbon monoxide (CO) is a colorless, odorless, and nonirritating gas that is often described as a silent killer because exposure may not be detected until the onset of severe symptoms. Symptoms of CO poisoning are nonspecific and include headache, nausea, vomiting, dizziness, confusion, chest pain, and loss of consciousness. Severe poisoning can result in myocardial injury, coma, and death.[1,2] CO exposure is especially dangerous for pregnant women, as poisoning can result in miscarriage of the fetus.[3,4] Sources of CO include internal combustion engines, fires, and gas-powered appliances such as furnaces and stoves.[3,4] CO poisoning occurs frequently and is a leading cause of non-drug poisoning mortality in the United States. The Centers for Disease Control and Prevention (CDC) estimate that unintentional, non-fire-related CO poisoning is responsible for 450 deaths and 21,000 Emergency Department (ED) visits annually in the United States.[3]

Large-scale CO poisoning events have been described in case studies and have occurred in settings such as churches, ice hockey arenas, schools, and occupational environments.[5-12] While these are described as "large-scale events" due to the large number of persons exposed, there is currently no definition of a large-scale CO poisoning event used in the literature. In the past decade, several high-profile, large-scale CO poisoning events have occurred in Wisconsin. For example, 74 people were poisoned at a youth hockey tournament in 2014 due to a poorly maintained ice resurfacer; 123 people

**Figure 1.** Carbon Monoxide Poisoning Cases and Exposure Events by Year in Wisconsin, 2006-2016

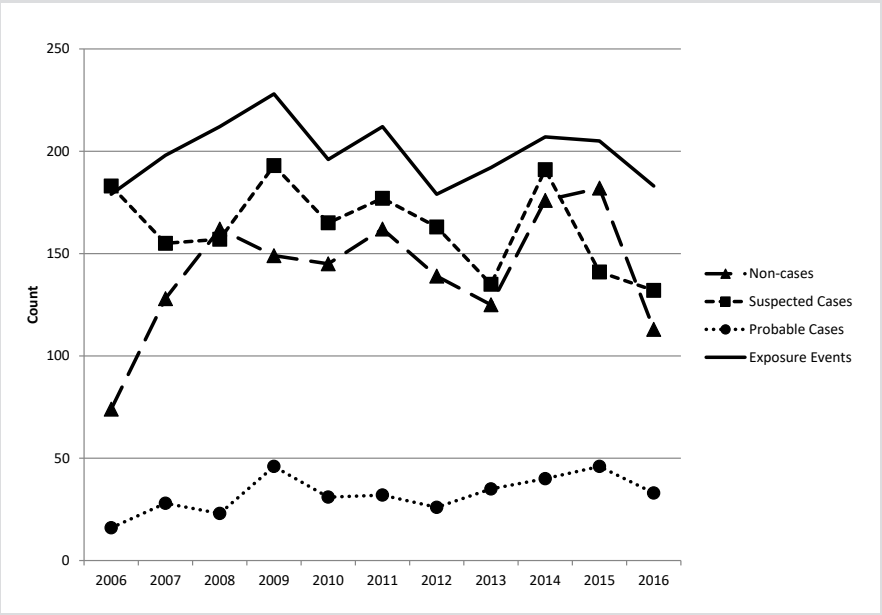
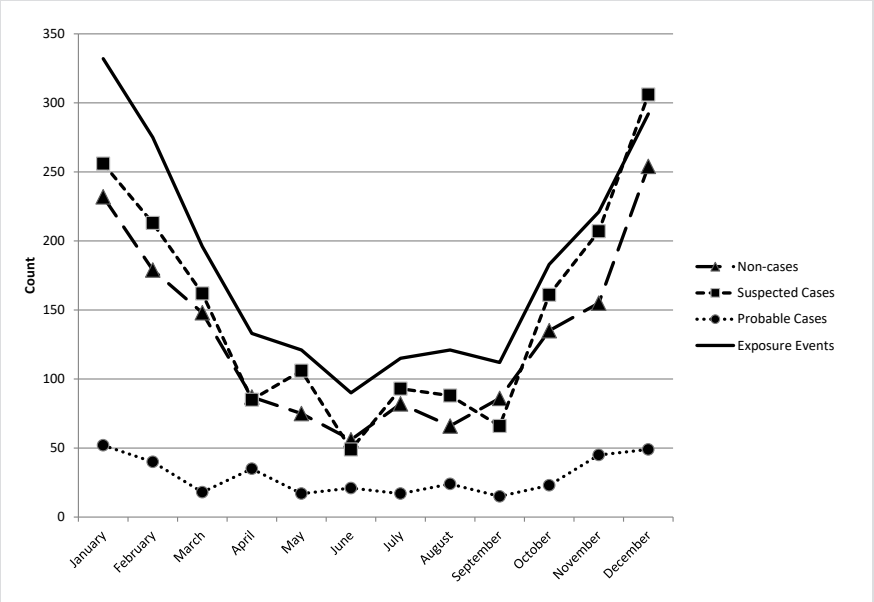



**Figure 2.** Carbon Monoxide Poisoning Cases and Exposure Events by Month in Wisconsin, 2006-2016




were exposed at a movie theater in 2015; and 31 workers were poisoned in 2017 following an occupational exposure at an appetizer manufacturing facility.[7,11,13] In the case of the hockey tournament, players and game attendees complained of nonspecific symptoms, such as headache and difficulty breathing, but CO exposure was not suspected until a player lost consciousness in the locker room.[7]

Despite case reports of large-scale CO poisonings, epidemiological studies that assess the frequency and severity of poisonings caused by large-scale CO exposure events are lacking. CO poisoning was not a reportable condition in Wisconsin until July 2018 (Wisconsin Statute § DHS 145.04) and surveillance data are limited. However, the Wisconsin Poison Center (WPC) serves as a passive surveillance system for chemical poisoning exposures and illnesses in the state. Although not all exposures are reported to the WPC, this database still constitutes the best available data source to assess trends in CO exposure events.

Using WPC data, this paper aims to describe CO exposure events in the state of Wisconsin from January 1, 2006 through December 31, 2016. Large-scale exposure events are described and evaluated for temporal trends.

## METHODS

### Carbon Monoxide Exposures

To identify individuals exposed to CO during the study period, data were collected from the WPC, a certified poison control center for the state of Wisconsin. Calls to the WPC are managed by Specialists in Poison Information (SPIs) who are physicians, nurses, or pharmacists trained in poison information. Calls are received from the public as well as health care professionals. The National Poison Data System (NPDS) houses WPC data and was queried for CO exposure calls that occurred during the 2006-2016 study period. Exposure calls with the substance "carbon monoxide" during the specified time period were included in this analysis. An exposure call is defined as a call about a concern relating to an exposure to a substance. In some instances, SPIs determine that an exposure initially believed to have occurred never actually occurred; these calls are labeled with medical outcome "Confirmed Non-Exposure" and were removed from the dataset prior to analysis. All exposures reported to the WPC are given a medical outcome using the American Association of Poison Control Centers (AAPCC) classifications. The AAPCC defines a minor effect as symptoms of the exposure that were minimal and resolved rapidly. Moderate effects are more prolonged than minor effects and usually require some form of medical treatment. Major effects are considered to be life-threatening or result in significant disability or disfigurement. More information on NPDS medical outcome definitions can be found in the NPDS annual report or coding manual.[14]

### CO Poisoning Cases

CO poisoning cases were identified and classified using the 2014 Council for State and Territorial Epidemiologists (CSTE) case definition.[15] CSTE defines a suspected case in poison control center data as record of an individual with "exposure" as the type of call where the substance was CO and a minor medical outcome was reported. Probable cases are defined as CO exposure records with a moderate or major medical outcome or where death was reported. Confirmed cases meet the suspected or probable definitions and have a positive environmental exposure consistent with CO poisoning as indicated in the case notes.[15]

**Table 1.** Demographic Characteristics of Carbon Monoxide Exposed Persons by Case Designation, Wisconsin, 2006-2016

| | Non-poisoning Cases | | Suspected Cases | | Probable Cases | | Total Events | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **N** | **%** [a] | **N** | **%** [a] | **N** | **%** [a] | **N** | **%** [b] | ***P*-value** [c] |
| **Total** | **1555** | **41.99** | **1792** | **48.39** | **356** | **9.61** | **3703** | **100** | - |
| Sex | | | | | | | | | |
| Male | 686 | 39.56 | 837 | 48.27 | 211 | 12.17 | 1734 | 46.83 | |
| Female | 842 | 43.74 | 941 | 48.88 | 142 | 7.38 | 1925 | 51.98 | <0.001 |
| Missing [d] | 27 | 61.36 | 14 | 31.82 | 3 | 6.82 | 44 | 1.19 | |
| Age Category | | | | | | | | | |
| ≤5 | 358 | 65.93 | 167 | 30.76 | 18 | 3.31 | 543 | 14.66 | |
| 6-12 | 96 | 36.09 | 149 | 56.02 | 21 | 7.89 | 266 | 8.43 | |
| 13-19 | 195 | 34.76 | 315 | 56.15 | 51 | 9.09 | 561 | 7.18 | |
| 20-29 | 181 | 34.28 | 301 | 57.01 | 46 | 8.71 | 528 | 15.15 | |
| 30-39 | 89 | 24.12 | 223 | 60.43 | 57 | 15.45 | 369 | 14.26 | |
| 40-49 | 93 | 27.68 | 172 | 51.19 | 71 | 21.13 | 336 | 9.96 | <0.001 |
| 50-59 | 151 | 48.40 | 147 | 47.12 | 14 | 4.49 | 312 | 9.07 | |
| 60-69 | 42 | 32.06 | 59 | 45.04 | 30 | 22.90 | 131 | 3.54 | |
| 70-79 | 30 | 41.67 | 32 | 44.44 | 10 | 13.89 | 72 | 1.94 | |
| 80+ | 12 | 30.77 | 14 | 35.90 | 13 | 33.33 | 39 | 1.05 | |
| Missing [d] | 308 | 56.41 | 213 | 39.01 | 25 | 4.58 | 546 | 14.74 | |
| Exposure Site | | | | | | | | | |
| Public Area | 52 | 27.66 | 108 | 57.45 | 28 | 14.89 | 188 | 5.08 | |
| Residence | 1390 | 46.15 | 1359 | 45.12 | 263 | 8.73 | 3012 | 81.34 | <0.001 |
| Unknown | 11 | 50.00 | 9 | 40.91 | 2 | 9.09 | 22 | 0.59 | |
| Workplace | 53 | 15.92 | 230 | 69.07 | 50 | 15.02 | 333 | 8.99 | |
| Other | 49 | 33.11 | 86 | 58.11 | 13 | 8.78 | 148 | 4.00 | |

[a] Calculated as a row percent.
[b] Calculated as a column percent.
[c] Chi-square test statistic.
[d] Missing categories were not included in the chi-square statistic.

### CO Exposure Events

In this analysis, CO exposures with a common carbon monoxide-emitting source were grouped and defined as 1 CO exposure event. An event may involve 1 or more people and, as such, may involve more than 1 call to the WPC. Exposure events were classified into 2 categories: poisoning events and nonpoisoning events. A poisoning event involved at least 1 case of CO poisoning, suspect or probable, as defined by the CSTE case definition. For the purposes of this analysis, we defined large-scale events as exposure events involving ≥5 persons. This threshold was chosen to describe large-scale events in order to select events large enough to be at the tail end of the distribution (ie, between 95$^{th}$ and 99$^{th}$ percentile), while simultaneously providing a sufficient sample of events to monitor across time. Sensitivity analyses using higher cut-points showed similar trends but were less stable with regards to rate fluctuations due to low sample sizes. Case notes for large-scale events were abstracted and reviewed for information involving source of exposure and mention of CO detectors. Case notes for non-large-scale events <5 persons were not reviewed and detailed exposure information was not available.

### Statistical Analysis

All data were analyzed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina). Counts of cases and individuals exposed by demographic, exposure site, and temporal characteristics were calculated. Counts of exposure events by event characteristics were also calculated. Two-by-two tables were used to obtain chi-square statistics. Trends in proportions of cases over time and large-scale events over time were calculated using the Cochran-Armitage trend test.

## RESULTS

### CO Exposures and Poisoning Cases

During the 2006–2016 study period, 3,703 individuals were exposed to CO, which resulted in 1,792 suspected and 356 probable cases of CO poisoning (Figure 1). On average, 337 persons were exposed annually over this period with an annual average of 195 suspected and probable poisoning cases per year. Men were more likely to be poisoned than women ($P<0.001$, chi-square) (Table 1).

Of the 2,148 suspected and probable CO poisoning cases, 1,640 (76.4%) were from acute exposure, 263 (12.2%) from chronic exposure, and 185 (8.6%) from acute-on-chronic exposure. The majority of poisoning cases (83.4%; n=1,792) had a minor medical outcome; 320 (14.9%) had a moderate outcome, 33 (1.5%) had a major outcome, and there were 3 deaths (0.1%). Eighty-seven (4.1%) cases received hyperbaric oxygen treatment.

There was not a significant trend in proportion of exposures that resulted in cases of CO poisoning over time ($P=0.12$, Cochran-Armitage Trend test). Chi-square tests showed there was a significant difference between the proportion of cases among residential and non-residential exposures, with those exposed in

**Table 2.** Carbon Monoxide Exposure Event Characteristics, Poisoning vs Nonpoisoning Events, Wisconsin, 2006-2016

| | Non-poisoning Cases | | Poisoning Events | | Total Events | | |
|---|---|---|---|---|---|---|---|
| **Variable** | **N** | **%[a]** | **N** | **%[a]** | **N** | **%[b]** | ***P*-value[c]** |
| **TOTAL** | **735** | **33.55** | **1456** | **66.45** | **2191** | **100** | -- |
| Caller Site | | | | | | | |
| Health Care Facility | 111 | 17.65 | 518 | 82.35 | 629 | 28.71 | |
| Public Area | 5 | 41.67 | 7 | 58.33 | 12 | 0.55 | <0.001 |
| Residence | 528 | 41.67 | 739 | 58.33 | 1267 | 57.83 | |
| Unknown | 2 | 66.67 | 1 | 33.33 | 3 | 0.14 | |
| Workplace | 20 | 27.78 | 52 | 72.22 | 72 | 3.29 | |
| Other | 69 | 33.17 | 139 | 66.83 | 208 | 9.49 | |
| Exposure Site | | | | | | | |
| Public Area | 13 | 21.31 | 48 | 78.69 | 61 | 2.78 | |
| Residence | 650 | 37.19 | 1098 | 62.81 | 1748 | 79.78 | <0.001 |
| Unknown | 9 | 45.00 | 11 | 55.00 | 20 | 0.91 | |
| Workplace | 40 | 15.44 | 219 | 84.56 | 259 | 11.82 | |
| Other | 23 | 22.33 | 80 | 77.67 | 103 | 4.70 | |
| Persons Exposed per Event | | | | | | | |
| 1 | 521 | 34.21 | 1002 | 65.79 | 1523 | 69.51 | |
| 2 | 102 | 32.59 | 211 | 67.41 | 313 | 14.29 | |
| 3 | 47 | 30.92 | 105 | 69.08 | 152 | 6.94 | 0.72 |
| 4 | 35 | 35.35 | 64 | 64.65 | 99 | 4.52 | |
| 5+ | 30 | 28.85 | 74 | 71.15 | 104 | 4.75 | |
| Reason | | | | | | | |
| Intentional - Other | 10 | 23.26 | 33 | 76.74 | 43 | 1.96 | |
| Intentional - Suspected suicide | 20 | 14.18 | 121 | 85.82 | 141 | 6.44 | |
| Unintentional - Environmental | 541 | 37.08 | 918 | 62.92 | 1459 | 66.59 | <0.001 |
| Unintentional - Occupational | 32 | 14.75 | 185 | 85.25 | 217 | 9.90 | |
| Unintentional - Other | 123 | 39.81 | 186 | 60.19 | 309 | 14.10 | |
| Unknown | 9 | 40.91 | 13 | 59.09 | 22 | 1.00 | |

[a] Calculated as a row percent.
[b] Calculated as a column percent.
[c] Chi-square test statistic.

residential settings more likely to be classified as non-cases than as cases ($P<0.001$, chi-square). Conversely, occupational exposures are more likely to result in case status than non-case status ($P<0.001$, chi-square), compared to nonoccupational exposures.

### CO Exposure Events

Over the study period, there were 2,191 CO exposure events, 1,456 (66.5%) of which resulted in at least 1 CO poisoning case. Trends were observed in month of exposure but not year. Winter months—November through February—accounted for 51.2% of exposure events. January had the highest number of events (15.15%; 332) and June had the fewest (4.11%; 90) over the 11-year period (Figures 1 and 2).

The majority of CO exposure events (79.8%; n = 1,748) occurred in residential settings followed by occupational settings (11.8%; n = 259). A total of 61 (2.8%) events occurred in public areas. Of residential exposure events, 1,098 (62.8%) resulted in at least 1 case of CO poisoning. Of the 259 workplace exposure events, 219 (84.6%) events resulted in at least 1 case of CO poisoning (Tables 1 and 2). Large-scale events (≥ 5 persons), either residential or in a public area, accounted for 4.8% (n = 104) of all events (Table 2).

Of 104 large-scale exposure events identified, 75 (72.1%) included at least 1 case of carbon monoxide poisoning. The median number of individuals exposed during large-scale events was 5 (range: 5–72); all but 1 event had 5 to 15 persons exposed; the outlier had 72 persons exposed. On average, 43.7% of those exposed (range 0%–100%) during large-scale events developed CO poisoning. The number of large-scale events each year was unstable ranging from a minimum of 3 in 2015 to a maximum of 15 in 2011 with an average of 9 per year. There was no significant trend in proportion of events that were considered large-scale events over time ($P=0.79$, Cochran-Armitage trend test). The vast majority (86.5%; n = 90) were in residential settings, followed by occupational settings (8.7%; n = 9) and public areas (4.8%; n = 5).

Using data abstracted from WPC case notes for large-scale exposures, the most common source of exposure was furnaces or water heaters (20.2%; n = 21) followed by fire (8.7%; n = 9) (Table 3). The presence or absence of CO detectors was mentioned in 53 (51.0%) of large-scale event case notes. Of the large-scale event case notes reviewed, 41 (39.4%) mentioned a CO detector present at the site of exposure. It was noted in 12 (11.5%) that a CO detector was not present.

## DISCUSSION AND CONCLUSIONS

Carbon monoxide poisoning continues to be a significant public health issue in Wisconsin and results in an average of 195 poisoning cases every year based upon poison center data. Despite public health efforts to reduce CO exposures, the number of poisonings reported to the WPC has remained relatively constant from year to year. Nationally, CO poisoning is responsible for over 21,000 ED visits annually.[3] Poisoning can result in long-term health effects like memory loss and other neurological impairments.[16] The economic burden of CO poisoning in the United States has been estimated at $1.3 billion annually as a result of direct health care costs and lost earnings.[17]

Analysis of WPC data revealed that CO exposures in Wisconsin peak in the winter months and decline in the summer. The seasonality of CO poisoning in northern states is well documented and is due to increased use of gas heating equipment in the winter months.[3,4,16] Residential exposure events were the most common

(79.8%; n = 1,748). The risk of CO exposure from gas-powered household appliances, such as furnaces, water heaters, stoves, generators, and vehicles, is well-documented and is reinforced by these findings.[3,4,16] Residential exposures were also the most common exposure site among large-scale events; 20.2% of large-scale event exposure sources were home furnaces or water heaters, indicating a departure from the literature that primarily provides case studies of large-scale CO poisonings in public areas.[5-12]

CO poisoning events described in the literature are very large and have involved 25 to 184 individuals poisoned.[5-10] In our sample, only 4.75% of events affected 5 or more people, and of those events, all but one affected fewer than 15 individuals. The outlier event was the poisoning at a youth hockey tournament in 2014, with 72 records.[7] This finding suggests that while there are CO poisoning events affecting dozens of persons in public areas, as documented in the literature, it is much more common that families are exposed to CO and poisoned in their homes. As such, efforts to prevent large-scale CO poisonings should focus on awareness of CO exposure within the home, in addition to public or occupational settings. Moreover, these efforts should focus on improving the use of CO detectors in all settings to prevent exposure.

Although poison control data can provide detailed event information, poison centers rely upon reports from the public and health providers and likely underestimate the true incidence of CO poisonings. A public health investigation of a large-scale exposure at a hockey tournament discovered that only 72 (48.0%) individuals exposed had records in WPC data. During this incident, over 150 people were exposed and 92 went to the ED.[7] An occupational exposure investigation found that of 41 workers that went to the ED, only 7 (17.0%) records were found in WPC data for this event. Additionally, it was discovered that only 2 of the 5 EDs visited by the workers called the WPC.[11] These investigations underscore the limitations of using poison control center data as a passive surveillance system and indicate that these data underrepresent the true number of CO exposure events as well as the number of people exposed during these events. Residential exposures are likely to be either reported in full or missed completely because family members are likely to present to the same ED; whereas larger public site or workplace exposures are likely to present to multiple EDs.

The findings presented here reinforce the need for improved prevention efforts and improved surveillance activities to better characterize the burden of CO poisoning. Use of CO detectors with audible alarms is effective in alerting potential victims of its presence, reducing symptoms from exposure.[18,19] Large-scale poisoning events in hockey rinks spurred enactment of a 2013 law requiring detectors at public venues in Minnesota (Minnesota Statute § 4620.4550). Wisconsin requires CO detectors in all homes and apartments that have gas-powered appliances, but does not require them in workplaces or public areas (Wisconsin Statute § 101.149). CO poisoning is a reportable condition in Wisconsin as of July 2018. By making the condition reportable to public health, there will be increased awareness of the condition among health care providers. Additionally, the Wisconsin Department of Health Services will gather improved exposure information to identify the true burden of CO exposure as well as information on which CO sources should be targeted through public health messaging.

**Table 3.** Sources of Carbon Monoxide Large-Scale Events as Described in Wisconsin Poison Center Case Notes

| | N | % |
|---|---|---|
| Ice resurfacer | 1 | 0.96 |
| Vehicle [a] | 7 | 6.73 |
| Fire | 9 | 8.65 |
| Fireplace or wood stove | 5 | 4.80 |
| Furnace or Water heater | 21 | 20.18 |
| Generators | 3 | 2.88 |
| Gas-powered stove or grill | 8 | 7.69 |
| Other gas-powered equipment [b] | 3 | 2.88 |
| Unspecified | 47 | 45.20 |

[a] Includes cars, recreational vehicles, forklifts, and pallet lifters.
[b] Includes gas-powered saw, laundry machine, and pool equipment.

Finally, clinicians should be maintaining a high index of suspicion for CO poisoning when patients present with nonspecific symptoms without obvious cause. Nonspecific symptoms such as headache and nausea contribute to underdiagnosis.[20] In 1 study of ED visits, 37 patients presenting with a headache were investigated for evidence of carbon monoxide exposure. Seven (19%) of these patients had carboxyhemoglobin levels >10%, and 6 of the 7 had a definite or probable toxic CO exposure. None of these patients were suspected of having CO poisoning until the clinician received the test results. Additionally, 3 of the 7 patients with CO poisoning had cohabitants with symptoms of CO poisoning.[21] Increased awareness of CO poisoning among health care providers is necessary for proper diagnosis and treatment of the condition. The WPC center can be used as a resource for clinicians.

**Acknowledgements:** This analysis was supported in part by an appointment to the Applied Epidemiology Fellowship Program administered by the Council of State and Territorial Epidemiologists (CSTE) and funded by the Centers for Disease Control and Prevention (CDC) Cooperative Agreement Number 1U38OT000143-05.

**Funding/Support:** Fellowship support from the Council of State and Territorial Epidemiologists (Christensen).

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Roderique JD, Joseph CJ, Feldman MJ, Speiss BD. A modern literature review of carbon monoxide poisoning theories, therapies, and potential targets for therapy advancement. *Toxicology.* 2015;334:45-58. doi:10.1016/j.tox.2015.05.004.

**2.** Satran D, Henry CR, Adkinson C, Nicholson CI, Bracha Y, Henry TD. Cardiovascular manifestation of moderate to severe carbon monoxide poisoning. *J Am Coll Card.* 2005;45(9):1513-1516. doi:10.1016/j.jacc.2005.01.044.

**3.** National Center for Environmental Health. Carbon monoxide poisoning. Centers for Disease Control and Prevention website. https://www.cdc.gov/co/. Updated September 16, 2018. Accessed March 28, 2019.

**4.** Agency for Toxic Substances and Disease Registry. Toxicological profile for carbon monoxide. https://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=1145&tid=253. Published June 2012. Accessed March 28, 2019.

**5.** Valerio A, Verze M, Marchiori F, et al. Managing a mass CO poisoning: critical issues and solutions from the field to the hyperbaric chamber. *Disaster Med Public Health Prep.* 2017;11(2):251-255. doi:10.1017/dmp.2016.112.

**6.** Paulozzi LJ, Satink F. Spengler RF. A carbon monoxide mass poisoning in an ice arena in Vermont. *Am J Public Health.* 1991;81(2):222.

**7.** Creswell PD, Meiman JG, Nehls-Lowe H, et al. Exposure to elevated carbon monoxide levels at an indoor ice arena - Wisconsin, 2014. *MMWR Morb Mortal Wkly Rep.* 2015;64(45):1267-1270. doi:10.15585/mmwr.mm6445a3.

**8.** McGuffie C, Wyatt JP, Kerr GW, Hislop WS. Mass carbon monoxide poisoning. *J Accid Emerg Med*. 2000;17(1):38-39.

**9.** Cummings C, Monti J, Kobayashi L, Potvin J, Williams K, Sullivan F. Ghost attack: the East Providence carbon monoxide mass casualty incident. *R I Med J.* 2018;101(1):26-27.

**10.** Ely EW, Moorehead B, Haponik EF. Warehouse workers' headache: emergency evaluation and management of 30 patients with carbon monoxide poisoning. *Am J Med.* 1995;98(2):145-155.

**11.** Wilson E, Tomassallo C, Meiman JG. Notes from the field: occupational carbon monoxide exposure in an industrial kitchen facility - Wisconsin, 2017. *MMWR Morb Mortal Wkly Rep.* 2018;67(28):786. doi:10.15585/mmwr.mm6728a5.

**12.** Klasner AE, Smith SR, Thompson MW, Scalzo AJ. Carbon monoxide mass exposure in a pediatric population. *Acad Emerg Med.* 1998;5(10):992-996.

**13.** Hansen AM. Carbon monoxide leak in Park Falls movie theater sends 30 people to hospital. APG Media of Wisconsin. February 3, 2015. https://www.apg-wi.com/news/local/carbon-monoxide-leak-in-park-falls-movie-theater-sends-people/article_ce84f996-e838-5b21-95e1-67c840270927.html. Accessed March 28, 2019.

**14.** Gummin DD, Mowry JB, Spyker DA, Brooks DE, Fraser MO, Banner W. 2016 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 34th *Annual Report. Clin Toxicol.* 2017;55(10):1072-1252. doi:10.1080/15563650.2017.1388087.

**15.** Centers for Disease Control and Prevention. Carbon monoxide poisoning 2014 case definition. National Notifiable Diseases Surveillance System. https://wwwn.cdc.gov/nndss/conditions/carbon-monoxide-poisoning/case-definition/2014/. Accessed March 28, 2019.

**16.** Raub JA, Mathieu-Nolf M, Hampson NB, Thom SR. Carbon monoxide poisoning -- a public health prospective. *Toxicology.* 2000;145(1):1-14.

**17.** Hampson NB. Cost of accidental carbon monoxide poisoning: a preventable expense. *Prev Med Rep.* 2015;3:21-24. doi:10.1016/j.pmedr.2015.11.010.

**18.** Krenzelok EP, Roth R, Full R. Carbon monoxide...the silent killer with an audible solution. Am J Emerg Med. 1996;14(5):484-486. doi:10.1016/S0735-6757(96)90159-X

**19.** Yoon SS, Macdonald SC, Parrish RG. Deaths from unintentional carbon monoxide poisoning and potential for prevention with carbon monoxide detectors. *JAMA*. 1998;279(9):685-687.

**20.** Hampson NB, Piantadosi CA, Thom SR, Weaver LK. Practice recommendations in the diagnosis, management, and prevention of carbon monoxide poisoning. *Am J Respir Crit Care Med*. 2012;186(11):1095-1101. doi:10.1164/rccm.201207-1284CI

**21.** Heckerling PS. Occult carbon monoxide poisoning: a cause of winter headache. *Am J Emerg Med.* 1987;5(3):201-204.

# A Unique Pattern on Memory Testing in Dementia Screening Predicts Obstructive Sleep Apnea

Donn D. Dexter, MD; Amber G. Ebert, PsyD


## ABSTRACT

**Objectives:** The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) is used to screen for dementia in many Wisconsin Alzheimer Institute memory care clinics. After observing a pattern of lower scores for immediate memory than for delayed memory (immediate memory < delayed memory) that seemed to predict obstructive sleep apnea in patients seen in our memory care clinic, we aimed to confirm the validity of this finding.

**Methods:** We retrospectively identified all patients seen in our memory care clinic from December 2011 through December 2014 who completed the RBANS. The frequency of obstructive sleep apnea was determined among those with the pattern of interest (immediate memory < delayed memory).

**Results:** Among 191 patients who met the inclusion criteria, 81 (42%) displayed the immediate memory < delayed memory pattern. Of these, 54 patients had been or were subsequently tested for obstructive sleep apnea; 35 (65%) were positive. In the positive group, the mean age was 74 years; 60% were women.

**Conclusions:** Obstructive sleep apnea is a known risk factor for cognitive dysfunction. It is a potentially treatable cause of memory loss that can be clinically silent. This study shows that a unique pattern (immediate memory < delayed memory) on the RBANS commonly used at memory care clinics can identify a group of patients who can be evaluated and treated for this common and remediable condition.


• • •

**Author Affiliations:** Mayo Clinic Health System, Department of Neurology, Eau Claire, Wis (Dexter); Coram Consulting, LLC, Rice Lake, Wis (Ebert).

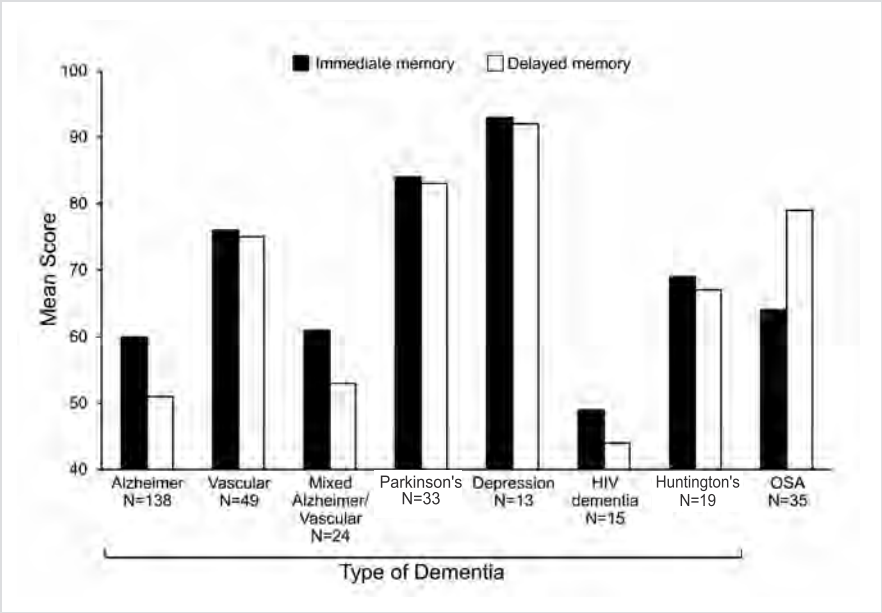
**Corresponding Author:** Donn D. Dexter, MD, Mayo Clinic Health System, Department of Neurology, 1400 Bellinger St, Eau Claire, WI 54703; phone 715.838.1911; fax 715.838.1934; email dexter.donn@mayo.edu.

## INTRODUCTION

Alzheimer disease and other dementias are common disorders with limited treatment options. One goal of memory care clinic evaluations is to identify and treat potentially reversible causes of dementia. Such identification relies on findings from patient history and examination. Neuropsychiatric testing can determine the severity of deficits and may be able to distinguish different forms of dementia, such as frontotemporal dementia or Alzheimer disease. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)[1] is a robust yet brief standardized screening tool used to evaluate patients for memory loss. It measures several cognitive domains, including immediate memory, delayed memory, visuospatial abilities, attention, and language, that can be affected by an underlying dementing process. The mean (SD) score on the RBANS is 100 (10), and the usual pattern in dementia is a decrease in scores across all domains. In every reported cognitive disorder, the *delayed memory* score (recall at 30 minutes) is considerably more affected (decreased) than the *immediate memory* score (recall at 5 minutes). In the memory care clinic setting, the test can be repeated as often as every 6 months, which allows for ongoing assessment of cognitive decline.

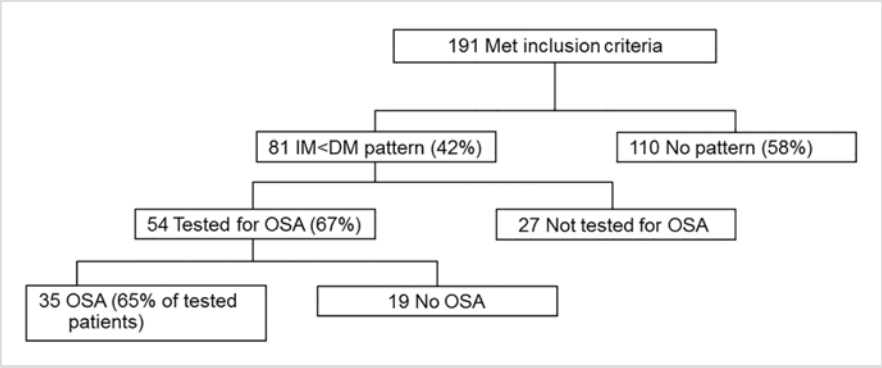
We noted a pattern of lower scores for immediate memory than for delayed memory (immediate memory < delayed memory) in patients with known or suspected obstructive sleep apnea. A

**Figure 1.** Typical RBANS Patterns for Various Dementias Compared With OSA Data From Current Study




Bars show mean scores for various cohorts. A mean (SD) score of 100 (10) indicates the 50th percentile. Abbreviations: OSA, obstructive sleep apnea; RBANS, Repeatable Battery for the Assessment of Neuropsychological Status. Data from Randolph.[1]

**Figure 2.** Patient Flow Chart




Abbreviations: IM<DM, immediate memory less than delayed memory; MCC, memory care clinic; OSA, obstructive sleep apnea.

review of 1 year of data in our clinic showed that this pattern seemed to predict obstructive sleep apnea. The patients often did not have typical sleep apnea symptoms and, as such, the diagnosis most likely would have been missed had we not investigated this pattern further.

The immediate memory < delayed memory pattern is opposite what typically is seen in dementias (Figure 1). In fact, in our clinic, patients with the usual pattern (immediate memory *greater than* delayed memory) rarely had diagnosed or suspected obstructive sleep apnea syndrome. In an earlier pilot study that we conducted, a screen of 43 patients who had the typical pattern of immediate memory > delayed memory showed a 14% rate of obstructive sleep apnea; in contrast, patients with the immediate memory < delayed memory pattern had a 35% rate of obstructive sleep apnea. Based on these findings, we expanded our study to encompass 3 years of patient data.

## METHODS

We conducted a retrospective chart review of all patients seen in our memory care clinic between December 2011 and December 2014 who met the inclusion criteria of age 20 to 89 years with documentation of RBANS evaluation. As part of the intake process, all patients had completed a routine screening questionnaire, which included questions regarding snoring, apnea episodes, and excessive sleepiness, as well as the Epworth Sleepiness Scale.

We identified patients who exhibited the pattern of interest (immediate memory < delayed memory), then evaluated those who were tested for sleep apnea to determine the percentage who had a diagnosis of obstructive sleep apnea based on standard criteria. The sleep evaluation was done using standard criteria polysomnography in an accredited sleep disorder center. In patients with the pattern of interest who were evaluated after the initial pilot study, we recommended overnight pulse oximetry for those who had not been formally tested for obstructive sleep apnea, whether or not they had a clinical indication for further testing. In patients without the pattern of interest, we did further testing only if clinical indicators for obstructive sleep apnea were present. We also evaluated body mass index (BMI) in all patients.

### Standard Protocol Approvals, Registrations, and Patient Consent

The Mayo Clinic Institutional Review Board reviewed and approved the study protocol. No informed consent was required due to the retrospective study design. Patients were identified using a query of electronic medical records.

## RESULTS

A total of 191 patients met inclusion criteria for the study period. Of this group, 81 patients (42%) exhibited the immediate memory < delayed memory pattern of interest and 54 (67%) had been or were subsequently tested for obstructive sleep apnea (Figure 2). In the group not tested (n = 27), many patients had declined or were unable to complete testing. Among the 54 patients tested

with polysomnography, 35 (65%) met criteria for obstructive sleep apnea (Figure 2). The mean age of the positive group was 74 years; 60% were women.

BMI was similar for patients with and without the pattern of interest (27.3 vs 26.6 kg/m²). A review of the intake questionnaires of patients seen in the memory care clinic demonstrated that many patients who were ultimately identified as having obstructive sleep apnea did not exhibit typical symptoms (eg, excessive daytime sleepiness, observed apneas, loud snoring, stop-breathing events) that would have suggested sleep apnea. Many patients with immediate memory < delayed memory also did not have the body habitus typically seen in obstructive sleep apnea.

## DISCUSSION

Sleep has an important role in memory function.[2,3] Obstructive sleep apnea has been shown to affect cognitive function, and treatment has shown variable effects.[4,5] Obstructive sleep apnea is present in 44% of men older than 65 years and 7% of women older than 65 years.[6] In our study, unexpected obstructive sleep apnea was found on the basis of RBANS testing with fairly high frequency. Since only two-thirds of the patients with the immediate memory < delayed memory pattern in our study group were tested with polysomnography, our results likely represent an underestimate of the frequency of obstructive sleep apnea in this patient population. We found no previous reports of using screening tests in a memory care clinic setting to predict obstructive sleep apnea, which makes our finding unique.

Memory loss in patients with obstructive sleep apnea may be due to the direct effect of low oxygen saturation on susceptible areas of the brain, including the hippocampus.[7] Disrupted sleep, which is common in patients with obstructive sleep apnea, also has been reported to decrease memory function. Among the causes that might explain this finding are effects on sleep architecture,[8] decreased clearance of metabolites in patients with sleep disruption,[9] and increased amyloid pathologic processes in patients with poor sleep.[10-12]

Different types of neurologic disorders, including Alzheimer disease and vascular dementia, show different patterns on the RBANS test, but the pattern in all reported disorders shows higher scores for immediate memory than delayed memory.

## CONCLUSION

Our study shows that a unique pattern noted on the RBANS can predict obstructive sleep apnea in a memory care clinic setting. This pattern (immediate memory < delayed memory) has not been reported in other forms of dementia (Figure 1). The finding of obstructive sleep apnea in our memory care clinic patients based on the unique pattern of immediate memory < delayed memory was common and often unexpected because patients did not have typical symptoms on standard obstructive sleep apnea screening criteria. The cause of this unique pattern in patients with obstructive sleep apnea is uncertain, and further investigation using a case-control study is planned.

Treatment of obstructive sleep apnea in memory care clinic patients can result in substantial improvement in cognitive function, especially if diagnosed early. Aggressive evaluation for obstructive sleep apnea in patients with the pattern of immediate memory < delayed memory is encouraged.

**Funding/Support:** None declared.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Randolph C. *Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) Manual.* San Antonio, TX: The Psychological Corporation; 1998.

**2.** Fulda S, Schulz H. Cognitive dysfunction in sleep disorders. *Sleep Med Rev.* 2001;5(6):423-445.

**3.** Bubu OM, Brannick M, Mortimer J, et al. Sleep, cognitive impairment, and Alzheimer's disease: A systematic review and meta-analysis. *Sleep.* 2017;40(1). doi:10.1093/sleep/zsw032.

**4.** Olaithe M, Bucks RS. Executive dysfunction in OSA before and after treatment: a meta-analysis. *Sleep.* 2013;36(9):1297-1305. doi:10.5665/sleep.2950.

**5.** Dalmases M, Sole-Padulles C, Torres M, et al. Effect of CPAP on cognition, brain function, and structure among elderly patients with OSA: a randomized pilot study. *Chest.* 2015;148(5):1214-1223. doi:10.1378/chest.15-0171.

**6.** Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. *JAMA.* 2004;291(16):2013-2016. doi:10.1001/jama.291.16.2013.

**7.** Gale SD, Hopkins RO. Effects of hypoxia on the brain: neuroimaging and neuropsychological findings following carbon monoxide poisoning and obstructive sleep apnea. *J Int Neuropsychol Soc.* 2004;10(1):60-71. doi:10.1017/S1355617704101082.

**8.** Pase MP, Himali JJ, Grima NA, et al. Sleep architecture and the risk of incident dementia in the community. *Neurology.* 2017;89(12):1244-1250. doi: 10.1212/WNL.0000000000004373.

**9.** Xie L, Kang H, Xu Q, et al. Sleep drives metabolite clearance from the adult brain. *Science.* 2013;342(6156):373-377. doi:10.1126/science.1241224.

**10.** Spira AP, Gamaldo AA, An Y, et al. Self-reported sleep and beta-amyloid deposition in community-dwelling older adults. *JAMA Neurol.* 2013;70(12):1537-1543. doi:10.1001/jamaneurol.2013.4258.

**11.** Sprecher KE, Koscik RL, Carlsson CM, et al. Poor sleep is associated with CSF biomarkers of amyloid pathology in cognitively normal adults. *Neurology.* 2017;89(5):445-453. doi:10.1212/WNL.0000000000004171.

**12.** Spira AP, Ju YS. Self-reported sleep and Alzheimer disease CSF biomarkers: a wake-up call. *Neurology.* 2017;89(5):419-420. doi: 10.1212/WNL.0000000000004189.

# Does Timing of Inferior Vena Cava Filter Retrieval Planning Impact Retrieval Rates? A Comparison of Planning Before or After Hospital Discharge

Benjamin Parsons, DO; Peter J. Polewski, MD; Angela L. Smith, MA; Andrew J. Borgert, PhD; Ezana Azene, MD; Kurt Ziegelbein, MD; Mason Fisher, MD; Andrew Horstman, PA-C; Shannon Brozak, PA-C; Paul J. Escher, BA

## ABSTRACT

**Introduction:** Indwelling inferior vena cava (IVC) filters are associated with complications, and the US Food and Drug Administration recommends their prompt removal when no longer indicated. Therefore, assessing strategies for increasing retrieval rates is warranted.

**Objective:** To analyze the variability of IVC filter retrieval rates within our institution based on 2 separate, pre-existing processes in which IVC retrieval is planned for before or after hospital discharge.

**Methods:** Retrospective chart review was completed for all IVC filters placed in adults between January 2005 and March 2015. Demographics and clinical data related to filter placement and retrieval were abstracted. Patients were classified into 2 groups: patients who had a trauma consultation trauma and nontrauma medical and surgical patients medical. The trauma group patients were subject to a 2-layer tracking process, in which retrieval planning was done before discharge, versus the medical group with a single-layer tracking process and retrieval planning done after discharge.

**Results:** Of the 588 filter placements analyzed, 236 were placed in trauma patients and 352 were placed for medical reasons. The retrieval rate of the entire cohort was 45% (262/588), with the rate among trauma patients more than double that of medical patients (155/236, 66% and 107/352, 30%; respectively, $P < 0.0001$).

**Conclusion:** IVC filter retrieval rate was increased when filter removal was included in discharge planning versus postdischarge tracking. A systematic, multidisciplinary strategic approach to IVC filter management has great potential to improve filter utilization, resource allocation, patient safety, and filter retrieval.

• • •

**Author Affiliations:** Gundersen Health System, La Crosse, Wis (Parsons, Polewski, Azene, Ziegelbein, Fisher, Horstman, Brozak); Gundersen Medical Foundation, La Crosse, Wis (Smith, Borgert, Escher).

**Corresponding Author:** Benjamin Parsons, DO, Mail Stop EB2-001, 1900 South Ave, La Crosse, WI 54601; phone 608.775.5768; email bmparson@gundersenhealth.org.

## INTRODUCTION

Venous thromboembolism events (VTE), which include deep vein thrombosis (DVT) and pulmonary embolism (PE), are a common problem affecting an estimated 422/100,000 people in the United States per year.[1] Anticoagulation is currently the standard of treatment to manage DVT and PE.[2] For those patients who have a contraindication to or proven failure of anticoagulation, placement of an inferior vena cava (IVC) filter is an effective mode of PE prevention.[3] Filter placement consensus guidelines have been published by the American College of Chest Physicians and the Society of Interventional Radiology, among others. Despite the implication of consensus, the differences that remain have led to varied practice patterns. Indications for placement are predominantly categorized as absolute, relative, or prophylactic.[3-5] However, over the last decade, the ease of use and retrievability of modern IVC filters has, in effect, lowered the threshold for device insertion in many clinical settings, rapidly expanding relative and prophylactic indications.[6]

Periprocedural complication rates are low with IVC filter placement, consisting mainly of insertion site DVT and, rarely, bleeding or vascular injury. However, increasing attention is being paid to long-term complications associated with indwelling filters. Filter fracture, embolization from IVC filter thrombi, IVC thrombosis, increase in subsequent DVTs, and migrations of the filter are among the reported complications.[7-17] These

complications and postmarketing reports prompted the US Food and Drug Administration (FDA) to release a statement in 2010 recommending filter removal as soon as PE protection is no longer warranted.[18]

Retrievable IVC filters should be removed from patients with a documented DVT/PE when tolerance of a therapeutic dose of anticoagulation has been reached, yet retrieval rates have been generally low. A single-center study review of retrieval rates between 2001 and 2006 found only 30.4% of patients had a documented plan for IVC filter removal. Of those without plans, 21.6% did not have contraindications to removal.[19] Ko and colleagues demonstrated that a specific institutional process that monitors insertion and removal of IVC filters significantly increased filter retrieval rates.[20] One member of their trauma service was tasked with compiling a database to coordinate timely removal of all filters placed. The database also was used to generate an email to the admitting provider of any patient who had a filter placed as a reminder to plan for retrieval. These results guided adoption of specific retrieval program protocols across the nation, leading to improved trends for retrieval.[21-23]

Institutional practices surrounding retrieval planning varies. At our institution, the interventional radiology (IR) department performs all IVC filter placement and removal procedures. The IR Department documents all IVC filter placements (medical and trauma patients) in a database that is reviewed quarterly to identify patients who need filter retrieval. Those patients identified are called to arrange for IVC filter removal. In addition, all patients with IVC filters placed by the trauma team are entered into a separate database maintained by the trauma team. This discrete trauma database is used to schedule retrieval prior to discharge. Thus, patients treated by the trauma service who require an IVC filter have an additional layer of retrieval planning prior to discharge. Because of this 2-layer tracking process, we sought to evaluate the variability of IVC filter retrieval rates within our institution.

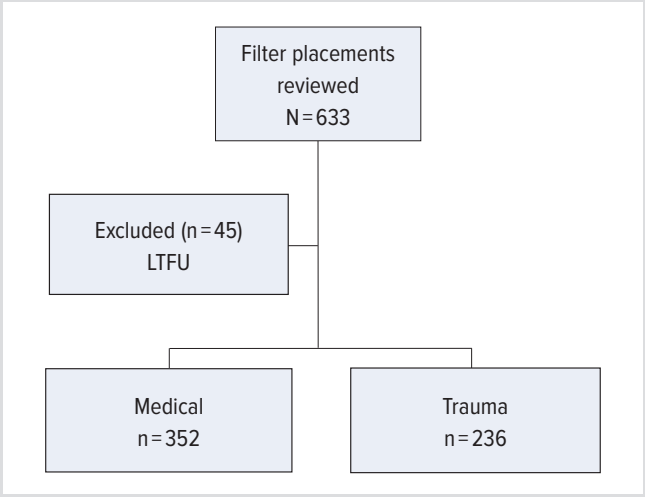
## METHODS

Our single-center cohort study consisted of patients with an IVC filter implanted between January 2005 and March 2015 who were 18 years or older at the time of placement. The study protocol was reviewed and approved by the institutional review board. No informed consent was required due to the retrospective study design. Patients were identified using a query of electronic medical records.

### Institution IVC Filter Placement Databases

The IR Department maintains a database, independent of the electronic medical record, of all implanted IVC filters. The database is populated using a radiology program that identifies all IVC filter placements over a specified time frame. Chart review is performed quarterly for patients in this database to determine if the filter has been removed, needs to be retrieved, or if the patient has died. If indicated, patients are contacted to arrange filter retrieval.

**Figure.** Study Population




Abbreviation: LTFU, Lost to follow-up.

To plan filter removal prior to discharge, our trauma service implemented a protocol of entering into a database patients who received a trauma consultation and had an IVC filter placed. Similar to the IR Department's, this trauma database also is separate from the electronic medical record. Most patients recorded in this database will have filter removal scheduled with IR prior to discharge. The independent process of chart review in the IR Department serves as an additional layer to capture those trauma patients who were either missed or were unable to keep the planned follow-up appointment, and phone calls are placed to schedule removal.

### Study Subjects and Measurements

Patients 18 years and older with an IVC filter were identified using a query of electronic medical records. Patients were divided into 2 groups: patients who had a trauma consultation trauma and nontrauma medical and surgical patients medical. Medical patients were defined as those requiring a filter for medical indications. The trauma group patients were subject to a 2-layer retrieval plan tracking process in which retrieval planning was done prior to discharge. Retrieval planning for the medical group was tracked by a single process in which retrieval is planned after hospital discharge. Patients with no medical record data subsequent to their filter placement were deemed lost to follow-up and excluded from analysis. See the Figure for a study population flow diagram.

Electronic medical records were reviewed and data were abstracted for predetermined variables, including patient characteristics (age, sex, body mass, smoking history), comorbid conditions, and filter placement and retrieval dates. To determine overall survival for patients included in analysis, the date of last contact and vital status also were abstracted.

**Table 1.** Patient Demographics and Clinical Characteristics

| Variable | Medical Group n = 352 | Trauma Group n = 236 | *P*-value |
|---|---|---|---|
| Age (years, median ± SD) | 65 ± 15.8 | 43 ± 19.7 | < 0.0001 |
| Gender | | | < 0.0001 |
| Male | 179 (51) | 172 (73) | |
| Female | 173 (49) | 64 (27) | |
| Body Mass Index* | | | 0.0003 |
| < 30 | 170 (49) | 141 (67) | |
| 30-34 | 85 (25) | 42 (20) | |
| 35-39 | 41 (12) | 18 (9) | |
| 40-49 | 30 (9) | 7 (3) | |
| ≥ 50 | 19 (5) | 3 (1) | |
| Smoking status | | | < 0.0001 |
| Current | 37 (11) | 62 (26) | |
| Former | 145 (41) | 50 (21) | |
| Never | 158 (45) | 94 (40) | |
| Never assessed | 12 (3) | 30 (13) | |
| Comorbidities | | | |
| Congestive Heart Failure | 47 (13) | 9 (4) | < 0.0001 |
| Nephrotic syndrome | 114 (32) | 13 (6) | < 0.0001 |
| Hypertension | 172 (49) | 52 (22) | < 0.0001 |
| Diabetes Mellitus | 85 (24) | 21 (9) | < 0.0001 |
| History of stroke | 36 (10) | 4 (2) | < 0.0001 |
| History of Myocardial Infarction | 24 (7) | 5 (2) | 0.0099 |
| Coronary Artery Disease | 52 (15) | 8 (3) | < 0.0001 |
| Chronic Lung Disease | 50 (14) | 14 (6) | 0.0016 |
| Venous Thromboembolism (at the time of filter placement) | 236 (67) | 13 (7) | < 0.0001 |

Note: Data are presented as frequency (%), unless indicated otherwise. Missing BMI data for 7 patients in the Medical Group, and 25 patients in the Trauma Group.

**Table 2.** Clinical Indications for Inferior Vena Cava Placement in the Medical Group

| Clinical Indication | n = 352 | (%) |
|---|---|---|
| Prep for surgery with a clot history | 84 | (24) |
| Pulmonary embolism with large clot burden | 56 | (16) |
| Bleeding on anticoagulation | 57 | (16) |
| Active or prior gastrointestinal bleed | 43 | (12) |
| Active bleed with deep vein thrombosis/ pulmonary embolism | 28 | (8) |
| Hemorrhagic cerebrovascular accident | 21 | (6) |
| Other | 18 | (5) |
| Malignancy | 12 | (3) |
| Failure of anticoagulation therapy | 11 | (3) |
| Inability to anticoagulate and surgery | 9 | (3) |
| Not an anticoagulation candidate | 9 | (3) |
| Severe cardiopulmonary disease | 3 | (1) |
| Fall risk | 1 | (0.3) |

Note: Data are presented as frequency (%).

### Statistical Analysis

Categorical variables were compared using the chi-square or Fisher's exact tests. Continuous variables were evaluated with Wilcoxon rank sum tests. To control for differences in demographic and clinical features between the trauma and medical groups, a multivariate logistic regression model of successful filter removal was developed via a stepwise variable selection process, with $P < 0.25$ required for initial inclusion of a candidate explanatory variable into the model, and $P$-value $< 0.10$ required for the candidate variable to remain in the model over subsequent model building steps. All statistical analysis was completed with SAS 9.3. A $P$-value of $< 0.05$ was defined as significant.

## RESULTS

There were 633 IVC filter placements at our institution during the 10-year study period; 45 patients were lost to follow-up, leaving a sample size of 588 for final analysis. Of those analyzed, 30 of the placed filters were deemed permanent at the time of placement, and 68 patients died within 30 days. Nearly all (n = 28) of the permanent filters were found in the medical group. We found that 60% of the filters placed during the study period were for medical indications, and the medical population had a higher percentage of comorbid conditions. The medical group was older, with a mean age of 65.4 years compared to 43.2 years in the trauma group ($P < 0.0001$). The medical group had a lower proportion of male subjects ($P < 0.0001$) and a higher percentage of comorbid conditions. See Table 1 for complete demographic and clinical characteristics.

The IR Department placed all of the filters included in our study. The most common type of filters inserted among both groups was Cook Medical® Celect™ (n = 381, 65%), followed by the G2® Bard® (n = 116, 20%), and Bard® Recovery™ (n = 51, 9%). Very few filters inserted were by Crux® or Günther-Tulip® (n = 26, 4%; and n = 13, 2%, respectively) and there was only 1 Bird's Nest® filter placed during our study period. Overall, 178 filters (30%) were placed for absolute indications and 72 (12%) for relative indications; 320 (54%) were placed with prophylactic indications and 18 (3%) for indications outside the Society of Interventional Radiology's guideline.[3] Some patients categorized in the trauma group (prophylactic indication) may have had absolute indications not noted in the data. The 3 most prevalent clinical indications for filter placement in the medical group were to prep for surgery with a clot history (n = 84, 24%), pulmonary embolism with large clot burden (n = 56, 16%), and bleeding on anticoagulation (n = 57, 16%). See Table 2 for a complete listing of clinical indications for filter placement.

Of the 588 filters implanted, the overall retrieval rate was 45% (262/588). The retrieval rate among trauma patients was more than double that of patients with an IVC filter placed for medical reasons (155/236, 66%, and 107/352, 30%; respectively, $P < 0.0001$), and the median time to removal was 63 days (range 8-820) for the trauma cohort versus 80.5 days (range 2-877) in the medical group ($P = 0.016$). Out of 285 attempts, there were 262 successful retrievals (92%). Of the 324 nonpermanent medical cases, 33% (n = 107) of IVC filters were removed, while 66% (155/234) of filters in the nonpermanent trauma cases were removed ($P < 0.0001$). The association between filter placement for trauma indications and successful retrieval remained significant after controlling for relevant demo-

graphic and clinical factors via multivariate logistic regression (Table 3). In this model, filter placement for trauma indications, body mass index > 35 kg/m$^2$, and temporary anticoagulation after filter placement (vs no anticoagulation after placement) were independently associated with increased probability of successful filter removal, while advanced age (> 75 years), an active cancer diagnosis, congestive heart failure, and hypertension were associated with a decreased probability of filter removal. We found that retrieval was not attempted for 66% (234/352) of the filters inserted in the medical cohort versus 29% (69/236) in the trauma group.

**Table 3.** Logistic regression

| Variable | Odds Ratio | Odds Ratio Confidence Interval | *P*-value |
|---|---|---|---|
| Trauma case | 2.74 | 1.69 - 4.46 | < 0.0001 |
| Age > 75 yrs | 0.25 | 0.14 - 0.45 | < 0.0001 |
| Body Mass Index > 35 | 1.66 | 1.02 - 2.71 | 0.042 |
| Active cancer | 0.35 | 0.20 - 0.63 | 0.0003 |
| Congestive Heart Failure | 0.31 | 0.13 - 0.70 | 0.005 |
| Hypertension | 0.65 | 0.42 - 1.01 | 0.05 |
| Lifelong Anticoagulation [a] | 1.23 | 0.64 - 2.24 | 0.53 |
| Temporary Anticoagulation [a] | 2.12 | 1.34 - 3.36 | 0.003 |

[a] Reference = Never Anticoagulation.

## DISCUSSION

Reported rates of IVC filter retrieval historically have been variable, ranging from 10% to 50%.[6] Adverse events, including caval perforation, strut fracture, IVC occlusion, and filter migration have been associated with long-dwelling retrievable filters.[7,10,12,16] In response to low retrieval rates and risks, the FDA issued a Safety Communication recommending that implanting physicians and clinicians be responsible for following up with patients with retrieval IVC filters and to remove them as soon as clinically indicated.[18]

The optimal strategy for IVC filter retrieval remains challenging and subject to individual institution processes. Our analysis of a 2-layer tracking system for trauma patients and a single-layer system for medical and surgical patients resulted in significantly greater retrieval rates for the 2-layer system. At our institution, the trauma service and IR Department have independent processes to track implanted IVC filters that need removal, with some overlap. The primary difference in the processes is the time when formal retrieval planning occurs–before or after discharge. The IR Department plans retrieval after discharge for all IVC filters placed (including trauma, medical, and surgical patients), whereas the trauma service plans for retrieval prior to discharge. Thus, trauma patients are afforded an additional layer of tracking to ensure a plan for retrieval. We found that filters placed in trauma patients (2-layer tracking system) are being removed 2 times (66%) more often than those placed for medical indications (30%).

The long-term complications associated with frequent lack of follow-up and failure to remove retrievable IVC filters has emerged as a major health issue. Several dedicated programs have been proposed to improve the rate of IVC filter retrievals. Databases and/or registries, dedicated filter retrieval clinics, and dedicated personnel to track and arrange retrieval all have been used as a means to retrieve filters in a timely manner.[23-26] Lynch tracked patients for follow-up through a database and yielded an improved retrieval rate from 24% to 59%, and a University of British Columbia study found that a hematology consult was a significant predictor of retrieval attempts.[24] By establishing a dedicated filter retrieval clinic, Minocha et al saw an increase in filter retrieval from 29% to 60%.[23] Leeper and colleagues demonstrated an approximately 40% greater retrieval rate within their trauma patients versus nontrauma patients with a single trauma nurse practitioner following filter patients and coordinating outpatient visits for retrieval prior to discharge.[27] The CIRSE Retrievable IVC Filter Registry has shown an increased trend to remove IVC filters in recent years, which could reflect institutional efforts at implementing programs focused on tracking and retrieving implanted filters; however, room for improvement remains.[25] Future efforts focusing on leveraging electronic medical records to improve IVC filter retrieval rates are warranted.

Given the retrospective nature of this study, a limitation is the inherent vulnerability of the data source and confounding variables. Our data collection was reliant upon the quality of documentation in the electronic medical record, and omissions, misclassification, and misreporting may have contributed to incomplete information. Given the retrospective nature of the study, we were not able to assess intent of filter permanence, patient preference for filter retrieval, reasons for failure to attempt filter retrieval, and other relevant data points that were not recoverable on chart review.

Despite these limitations, our results support the concept of planning for IVC filter retrieval before patients are discharged. Despite the challenges associated with varied health care system models, a systematic, multidisciplinary strategic approach to IVC filters has great potential to improve filter utilization, resource allocation and patient safety, and to increase filter retrieval rates. We encourage each institution to implement programs to assist in IVC filter retrieval. Based on the data we observed, our institution has now implemented a systemwide protocol of arranging IVC filter retrieval prior to discharge for all patients. We believe other institutions should give strong consideration to such a program.

**Funding/Support:** None declared.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Deitelzweig SB, Johnson BH, Lin J, Schulman KL. Prevalence of clinical venous thromboembolism in the USA: current trends and future projections. *Am J Hematol*. 2011;86(2):217-220. doi:10.1002/ajh.21917

**2.** Kearon C, Akl EA, Ornelas J, et al. Antithrombotic therapy for VTE disease: CHEST guideline and expert panel report. *Chest*. 2016;149(2):315-352. doi:10.1016/jchest.2015.11.026

**3.** Kaufman JA, Kinney TB, Streiff MB, et al. Guidelines for the use of retrievable and

convertible vena cava filters: report from the Society of Interventional Radiology Multidisciplinary Consensus Conference. *World J Surg*. 2007;31(2):251-264. doi:10.1007/s00268-006-0292-1

**4.** Baadh AS, Zikria JF, Rivoli S, Graham RE, Javit D, Ansell JE. Indications for inferior vena cava filter placement: do physicians comply with guidelines? *J Vasc Interv Radiol*. 2012;23(8):989-995. doi:10.1016/j.vir.2012.04.017

**5.** Hirsh J, Guyatt G, Albers GW, Harrington R, Schünemann HJ. Executive summary: American College of Chest Physicians evidence-based clinical practice guidelines (8th edition). *Chest*. 2008;133(6 Suppl):71S-109S. doi:10.1378/chest.08-0693

**6.** Angel LF, Tapson V, Galgon RE, Restrepo MI, Kaufman J. Systematic review of the use of retrievable inferior vena cava filters. *J Vasc Interv Radiol*. 2011;22(11):1522-1530. e3. doi:10.1016/j.jvir.2011.08.024

**7.** Blebea J, Wilson R, Waybill P, et al. Deep venous thrombosis after percutaneous insertion of vena caval filters. *J Vasc Surg*. 1999;30(5):821-829. doi:10.1016/S0741-5214(99)70006-6

**8.** Yan BP, Kiernan TJ, Gupta V, Ajani AE, Schainfeld RM. Combined pharmacomechanical thrombectomy for acute inferior vena cava filter thrombosis. *Cardiovasc Revasc Med*. 2008;9(1):36-40. doi:10.1016/j.carrev.2007.09.004

**9.** Kiguchi M, McDonald KA, Govindarajan S, Makaroun MS, Chaer RA. Pharmacomechanical thrombolysis for renal salvage after filter migration and renal vein thrombosis. *J Vasc Surg*. 2011;53(5):1391-1393. doi:10.1016/j.jvs.2010.10.126

**10.** Johnson MS. Vena cava filter fracture: unplanned obsolescence. *J Vasc Interv Radiol*. 2012;23(2):196-198. doi:10.1016/j.jvir.2011.12.004

**11.** Nicholson W, Nicolson WJ, Tolerico P, et al. Prevalence of fracture and fragment embolization of Bard retrievable vena cava filters and clinical implications including cardiac perforation and tamponade. *Arch Intern Med*. 2010;170(20):1827-1831. doi:10.1001/archinternmed.2010.316

**12.** Haddadian B, Shaikh F, Djelmami-Hani M, Shalev Y. Sudden cardiac death caused by migration of a TrapEase inferior vena cava filter: case report and review of the literature. *Clin Cardiol*. 2008;31(2):84-87. doi:10.1002/clc.20156

**13.** Roehm JO Jr. Bird's nest filter migration of the right atrium. *AJR Am J Roentgenol*. 2005;185(2):555-556. doi:10.2214/ajr.185.2.01850555a

**14.** Urena R, Greenwood L. Bird's nest filter migration to the right atrium. *AJR Am J Roentgenol*. 2004;183(4):1037-1039. doi:10.2214/ajr.183.4.1831037

**15.** Rasuli P, Mehran R, French G, Turek M, Lalonde KA, Cardinal P. Percutaneous retrieval of a vena cava filter from the right atrium: case report. *Can Assoc Radiol J*. 2000;51(1):30-35.

**16.** Joels CS, Sing RF, Heniford BT. Complications of inferior vena cava filters. *Am Surg*. 2003;69(8):654-659.

**17.** Grewal S, Chamarthy MR, Kalva SP. Complications of inferior vena cava filters. *Cardiovasc Diagn Ther*. 2016;6(6):632-641. doi:10.21037/cdt.2016.09.08

**18.** Removing retrievable inferior vena cava filters: initial communication. US Food and Drug Administration. https://2wt0853vtha23hf7qg2rwk3g-wpengine.netdna-ssl.com/wp-content/uploads/2017/12/Removing-Retrievable-Inferior-Vena-Cava-Filters.pdf. Last Updated November 20, 2012. Accessed October 5, 2016.

**19.** Athanasoulis CA, Kaufman JA, Halpern EF, Waltman AC, Geller SC, Fan CM. Inferior vena caval filters: review of a 26-year single-center clinical experience. *Radiology*. 2000;216(1):54-66. doi:10.1148/radiology.216.1.r00jl1254

**20.** Ko SH, Reynolds BR, Nicholas DH, et al. Institutional protocol improves retrievable inferior vena cava filter recovery rate. *Surgery*. 2009;146(4):809-816. doi:10.1016/j.surg.2009.06.022.

**21.** Mission JF, Kerlan RK Jr, Tan JH, Fang MC. Rates and predictors of plans for inferior vena cava filter retrieval in hospitalized patients. *J Gen Intern Med*. 2010;25(4):321-325. doi:10.1007/s11606-009-1227-y

**22.** Imerti D, Bianchi M, Farina A, Siragusa S, Silingardi M, Ageno W. Clinical experience with retrievable vena cava filters: results of a prospective observational multicenter study. *J Thromb Haemost*. 2005;3(7):1370-1375. doi:10.1111/j.1538-7836.2005.01448.x

**23.** Minocha J, Idakoji I, Riaz A, et al. Improving inferior vena cava filter retrieval rates: impact of a dedicated inferior vena cava filter clinic. *J Vasc Interv Radiol*. 2010;21(12):1847-1851. doi:10.1016/j.jvir.2010.09.003

**24.** Lynch FC. A method for following patients with retrievable inferior vena cava filters: results and lessons learned from the first 1,100 patients. *J Vasc Interv Radiol*. 2011;22(11):1507-1512. doi:10.1016/j.jvir.2011.07.019

**25.** Lee MJ, Valenti D, de Gregorio MA, Minocha J, Rimon U, Pellerin O. The CIRSE retrievable IVC filter registry: retrieval success rates in practice. *Cardiovasc Intervent Radiol*. 2015;38(6):1502-1507. doi:10.1007/s00270-015-1112-5

**26.** Kalina M, Bartley M, Cipolle M, Tinkoff G, Stevenson S, Fulda G. Improved removal rates for retrievable inferior vena cava filters with the use of a 'filter registry.' *Am Surg*. 2012;78(1):94-97.

**27.** Leeper WR, Murphy PB, Vogt KN, et al. Are retrievable vena cava filters placed in trauma patients really retrievable? *Eur J Trauma Emerg Surg*. 2016;42(4):459-464. doi:10.1007/s00068-015-0553-5

# Comparing Board Examination Scores Between Pediatric Residents in Continuity Clinics at Different Sites

Gary A. Cohen, MD, MS; James J. Nocton, MD; Robert Treat, PhD


## ABSTRACT

**Background:** Residency training programs are required to provide adequate continuity clinic experience for all residents.

**Objective:** Determine if there is a difference in medical knowledge between pediatric residents attending continuity clinic at a community-based center versus those attending an academic center, as measured by the American Board of Pediatrics In-Training Exam (in-training exam) and the American Board of Pediatrics Certification Exam (certification exam).

**Methods:** A retrospective evaluation of in-training and certification exam scores of pediatric residents enrolled at the Medical College of Wisconsin and Children's Hospital of Wisconsin was performed. Test scores of the group of residents participating in a community-based continuity clinic were compared to those residents attending an academic center continuity clinic.

**Results:** There were no statistically significant differences in mean test scores for each of the 3 years of residency training on the in-training exam or board certifying exam after graduation. In-training exam scores significantly predicted certification exam scores, and there were significant increases in the in-training exam scores throughout residency, irrespective of clinic location.

**Conclusion:** This study shows no difference between residents participating in a community-based continuity clinic and those participating in an academic center continuity clinic in objective outcomes as measured by scores on the American Board of Pediatrics In-Training Exam and the American Board of Pediatrics Certifying Exam.


• • •

**Author Affiliations:** Medical College of Wisconsin (MCW), Division of Neonatology, Children's Corporate Center, Wauwatosa, Wis (Cohen); MCW, Division of Rheumatology, Children's Corporate Center, Wauwatosa, Wis (Nocton); MCW, Milwaukee, Wis (Treat).

**Corresponding Author:** Gary A. Cohen, MD, MS, Associate Professor of Pediatrics, Division of Neonatology, Medical College of Wisconsin, Children's Corporate Center, 999 N 92nd St, Wauwatosa, WI 53226; phone 414.266.6820; fax 414.266.6979; email gcohen@mcw.edu.

## INTRODUCTION

Pediatric residency training programs should be designed to prepare residents for general pediatric practice in an ambulatory setting. To help accomplish this goal, the Residency Review Committee in Pediatrics of the Accreditation Council for Graduate Medical Education requires training programs to provide adequate continuity clinic experience for all residents.[1] This experience is expected to occur on a weekly basis throughout residency and to provide residents with the opportunity to see an appropriate number of patients and the same patients throughout their years in residency training.

In some training programs, residents are assigned to community-based practices for their continuity clinic experience. The pediatricians serving as preceptors in these practices are often volunteer faculty and not full-time faculty members within the affiliated medical school. Accordingly, these preceptors usually do not have access to faculty development resources, have received no specific training for the role of continuity clinic preceptor, and may not have the same academic and teaching experience as a full-time medical school faculty preceptor.

A previous study showed that over a 5-year period, there was no statistically significant difference in American Board of Pediatrics In-Training Exam (in-training exam) scores between residents who attend an academic center continuity clinic and those that attend a community-based continuity clinic. However, since the in-training exam is administered at the beginning of each year of training,

**Table 1.** Mean ABPCE and ABPITE Scores of Residents in Different Locations for Continuity Clinic, 2002-2011

| Exam | N | Location | Mean (SD) | Δ | *P*-value |
|---|---|---|---|---|---|
| PL-1 ABPITE | 98 | Academic | 159 (109) | 2 | .937 |
| | 75 | Community Based | 161 (106) | | |
| PL-2 ABPITE | 98 | Academic | 275 (116) | 14 | .412 |
| | 70 | Community Based | 289 (100) | | |
| PL-3 ABPITE | 89 | Academic | 341 (98) | -21 | .191 |
| | 71 | Community Based | 320 (104) | | |
| ABPCE | 104 | Academic | 508 (95) | 9 | .545 |
| | 81 | Community Based | 517 (94) | | |

Abbreviations: ABPCE, American Board of Pediatrics Certifying Examination; ABPITE, American Board of Pediatrics In-Training Examination; PL, pediatric level.

**Table 2.** Prediction of ABPCE Scores From ABPITE Scores From Multivariate Linear Regressions, 2002-2011

| Location | ABPITE | Individual Predictor | | Overall Regression Model Coefficients | |
|---|---|---|---|---|---|
| | | Beta | *P*-value | $R^2$ | *P*-value |
| Academic Center and Community-Based Combined | PL-2 | .496 | .001 | .51 | .001 |
| | PL-3 | .280 | .001 | | |
| Academic Center | PL-2 | .591 | .001 | .61 | .001 |
| | PL-1 | .239 | .021 | | |
| Community-Based | PL-3 | .407 | .004 | .39 | .001 |
| | PL-2 | .289 | .036 | | |

Abbreviations: ABPCE, American Board of Pediatrics Certifying Examination; ABPITE, American Board of Pediatrics In-Training Examination.

the study was not designed to evaluate differences in knowledge that might not be apparent until after the completion of training.[2] The objective of this study was to determine if there is a statistically significant difference in medical knowledge at the completion of training, as measured by the scores on the American Board of Pediatrics Certification Examination (certification exam) between residents participating in a community-based continuity clinic and residents participating in an academic center continuity clinic. Secondary objectives were to determine if there are differences in the in-training exam scores between these groups of residents, with analysis of data over an extensive time period to assess any longitudinal differences in the in-training exam mean scores, and how in-training exam scores predict the certification exam scores and measure potential increases in scores independent of location of the continuity clinic.

## METHODS

A retrospective study was conducted of pediatric residents enrolled at the Medical College of Wisconsin and Children's Hospital of Wisconsin from 2002 to 2011. Each resident was assigned to a weekly continuity clinic at a community-based practice or at an academic center practice (Downtown Health Center), based partly on individual resident preference at the start of residency. Residents who did not remain at the same clinic for their entire 3 years of training and those who did not take the certification exam were excluded from analysis. Resident scores were not evaluated after 2011 due to a change in the grading scale for the in-training and certification exams.

Researchers evaluated all eligible residents' test scores during the years 2002 to 2011 for the in-training exam, which is administered yearly for each of the 3 years of training, and the certification exam, which is administered once after completion of the residency program. Test scores of the group of residents participating in a community-based continuity clinic staffed by volunteer preceptors were compared to those residents attending an academic center continuity clinic staffed by full-time general pediatric faculty from the Medical College of Wisconsin using independent *t* tests. Comparison of in-training exam scores were made between the groups for each level of training, and certification exam scores were compared after graduating from residency. In addition, year by year comparisons of the certification exam scores were analyzed. A repeated measures analysis of variance (RM-ANOVA) was used to determine significant differences in mean scores of the in-training exam across the 3 training years for both groups of residents (separately and combined).

The relational strength and predictive strength of certification exam scores (outcome) from the 3 annual in-training exam scores (predictors) was determined with multivariate linear regression analysis.

This study received approval from the institutional review board. Data were obtained independently and stored securely on a protected hard drive by the pediatric residency coordinator. All data were deidentified before being analyzed by an independent analyst outside of the Department of Pediatrics. All statistical analysis was generated by IBM® SPSS® 23.0.

## RESULTS

A total of 189 out of a possible 193 (97.9%) resident test scores were evaluated. As reported in Table 1, there were no statistically significant differences in mean scores for the in-training exam from each of the 3 years of residency training or the certification exam when split by location of continuity clinic (academic center vs community-based). Figure 1 illustrates the certification exam scores across 2002 to 2011, split by location of continuity clinic.

As reported in Table 2, the in-training exam scores could significantly predict certification exam scores for both continuity clinic locations. The first-year (beta=.239) and second-year (beta=.591) in-training exam scores were significant predictors for the residents

at an academic center continuity clinic; the second-year (beta = .289) and third-year (beta = .407) in-training exam scores were significant predictors for the residents in a community-based continuity clinic.

There were statistically significant increases in pediatric resident in-training exam scores from Pediatric Level-1 (PL-1) to PL-2, PL-2 to PL-3 and PL-1 to PL-3 years as determined by RM-ANOVA reported in Table 3. These same patterns are observed when the data are split by location of continuity clinic. The largest mean differences were always between PL-1 and PL-3 residents, the second largest mean difference was between PL-1 and PL-2 residents, and the smallest difference was between PL-2 and PL-3 residents.

**Figure 1.** ABPCE Pediatric Board Scores Across Year Split by Practice Location


Abbreviation: ABPCE, American Board of Pediatrics Certifying Examination.

**Table 3.** Differences in Mean ABPITE Scores Related to Resident Year of Training

| Practice | N | Resident Year | Mean (SD) | Δ | Cohen's *d* | *P*-value |
|---|---|---|---|---|---|---|
| Academic Center and Community-Based Combined | 135 | PL-1<br>PL-2 | 159 (105)<br>282 (110) | 123 | 1.1 | .001 |
| | | PL-2<br>PL-3 | 282 (110)<br>332 (100) | 50 | 0.5 | .001 |
| | | PL-1<br>PL-3 | 159 (105)<br>332 (100) | 173 | 1.7 | .001 |
| Academic Center | 80 | PL-1<br>PL-2 | 158 (107)<br>275 (121) | 117 | 1.1 | .001 |
| | | PL-2<br>PL-3 | 275 (121)<br>339 (95) | 64 | 0.6 | .001 |
| | | PL-1<br>PL-3 | 158 (107)<br>339 (95) | 181 | 1.8 | .001 |
| Community-Based | 55 | PL-1<br>PL-2 | 161 (102)<br>293 (92) | 132 | 1.3 | .001 |
| | | PL-2<br>PL-3 | 293 (92)<br>322 (107) | 29 | 0.3 | .001 |
| | | PL-1<br>PL-3 | 161 (102)<br>322 (107) | 161 | 1.5 | .001 |

Abbreviation: ABPITE, American Board of Pediatrics In-Training Examination.

## DISCUSSION

Studies have compared the advantages and disadvantages of resident continuity clinics at different sites. Rice et al[3] in Houston, Texas found that residents in a private practice setting saw more patients, more acute care patients, observed their preceptor more, and had less continuity and less well-child care than residents in an academic clinic. Osborn et al[4] looked at the continuity experience at the University of Utah Health Sciences Center. Residents in a private community-based clinic saw more patients and more acute care, evaluated a broader range of patient problems, and were more likely to observe and be observed by their preceptor.

This study used objective measures—the American Board of Pediatrics In-Training Exam and the American Board of Pediatrics Certifying Exam—and determined there was not a significant difference in knowledge between residents attending an academic center continuity clinic and those attending a community-based continuity clinic. The data presented show that, independent of continuity clinic location, the in-training exam scores could predict certification exam scores, and independent of location, in-training exam scores improved year to year.

The data show that in-training exam scores from residents that are closer to graduation, the time of certifying exams, are more predictive of the certification exam for the community-based physicians. Conversely, in-training exam scores earlier in residency training are more predictive of the certifying exams for academic center physicians. We are not sure why this is the case and this was not a focus of the study.

There are several limitations to our study. First, in-training exams are administered at the beginning of the residency year and might bias the data against finding a difference in the PL-1 year. The lack of difference of scores in the PL-1 year does minimize potential selection bias by confirming that the baseline knowledge upon entry into the residency program was equivalent for the residents participating in continuity clinics at the 2 different locations. Second, this study design did not allow for the evaluation of responses to individual questions on either the in-training exam or the certification exam. Therefore, we could not evaluate potential specific differences in ambulatory pediatric knowledge, the knowledge that residents would be

expected to obtain through participation in continuity clinic. Third, the design of our study did not control for the differences in elective experiences of the residents throughout their 3 years of training and the possibility that ambulatory pediatric knowledge may have been acquired on other rotations, eliminating any differences in knowledge that potentially are present between residents participating in continuity clinics at the different locations. All residents in the current study participated in a core curriculum consisting of regularly scheduled educational conferences and discussions. All residents experienced month-long block rotations at the same academic center where some residents experienced their continuity clinic. Therefore, the considerable overlap in experience might also have mitigated potential differences in knowledge acquired through participation in continuity clinic. Fourth, this is a retrospective study at a single residency program. The results may not be generalizable to other institutions. Finally, the scoring/grading protocol changed after 2011. Our conclusions may be valid only for the time period of the study.

## CONCLUSION

Many pediatric residency training programs utilize community-based practices for continuity clinic sites with volunteer pediatricians as preceptors for residents at these sites. Studies in the past have shown subjective differences in the experience received in a private practice setting compared to the experience in an academic setting. This study shows that there appears to be no difference in objective outcomes as measured by scores on the American Board of Pediatrics In-Training Exam and the American Board of Pediatrics Certification Exam between residents participating in a community-based continuity clinic and those participating in an academic center continuity clinic. There does not appear to be a detrimental effect on residents participating in continuity clinics at different sites.

**Funding/Support:** None declared.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Accreditation Council for Graduate Medical Education. Program requirements for residency education in pediatrics. https://www.acgme.org/Portals/0/PFAssets/ProgramRequirements/320_pediatrics_2017-07-01.pdf. Revised July 1, 2017. Accessed February 15, 2019.

**2.** Cohen GA, Nocton JJ. Comparison of medical knowledge between pediatric residents who attend continuity clinic at different sites. *WMJ*. 2009;108(7):349-351.

**3.** Rice TD, Holmes SE, Drutz JE. Comparison of continuity experience by practice setting and postgraduate level. *Arch Pediatr Adolesc Med*. 1996;150(12):1299-1304.

**4.** Osborn LM, Sargent JR, Williams SD. Effects of time-in-clinic setting and faculty supervision on the continuity experience. *Pediatrics*. 1993:91(6):1089-1093.

# Student Leadership Development Initiative: A Pilot for a Sustainable, Replicable Model for Incorporating Leadership into Medical Education

John M. Idso, BS; Zachary M. Helmen, BBA; William J. Hueston, MD; John R. Meurer, MD, MBA


## ABSTRACT

**Introduction:** Today's medical students are tomorrow's leaders. As leadership training becomes incorporated into undergraduate medical education, there is a need for validated educational models that are both effective and replicable.

**Methods:** Between April 2017 and October 2017, groups of 15 to 20 medical students participated in sessions with an exemplary physician leader incorporating a guided interview format and discussion about her or his career. Prepared questions ensured leadership domains were covered. The program was evaluated using a post-session survey.

**Results:** One hundred percent of survey respondents (N = 58) reported that the session was a good use of time. Seventy-eight percent felt more prepared to lead a team; 93% learned specific ways to improve their leadership skills.

**Discussion:** This leadership program is a unique model to provide leadership education to medical students that is both effective and replicable.


## INTRODUCTION

Today's medical students are tomorrow's leaders. As leadership training becomes increasingly incorporated into undergraduate medical education, there is a need for validated educational models that are both effective and replicable.[1,2]

The call for leadership training in undergraduate medical education is not new. Nearly 20 years ago, the Committee on the Roles of Academic Health Centers in the 21st century recommended that academic health centers "…need to invest in programs and processes for identifying, preparing, and developing leaders who can generate and direct the innovations recommended…".[3] Solutions have been proposed, but leadership training needs to be more than a mere online module for students to complete or a short course grounded in business pedagogy, because these programs have not been shown to be effective.[4,5] Unfortunately, many health professionals do not receive leadership training until after they find themselves in a leadership role in residency or beyond.[6]

The Student Leadership Development Initiative was founded on the principle that leadership is best learned through unstructured, personal relationships with exemplary physician leaders.[7,8] This innovative model offers a novel format for these relationships to develop early in a student's training.

## METHODS

The Student Leadership Development Initiative brings students together with senior physician leaders from a broad cross-section of the health care industry and academic medicine. In each 60-minute session, a respected physician leader participates in a guided interview format and discusses his or her career with 15 to 20 students. These sessions occur in the evening over dinner to avoid schedule conflicts. Prepared questions are aligned with the Medical Leadership Competency Framework to standardize evaluation of outcomes.[2] (See Box 1.) This ensures important leadership domains are covered, such as team development, mentor identification, and work/life balance. Time is set aside at the end of each session for students to ask questions personalized to their interests. Students choose the physician leaders from academic medicine, private industry, and government. Student participants are recruited through their involvement in an educational pathway course at the medical school that focuses on health systems management and policy.

• • •

**Author Affiliations:** Medical College of Wisconsin, Milwaukee, Wis (Idso, Helmen, Hueston, Meurer).

**Corresponding Author:** John M. Idso, BS, Medical College of Wisconsin, 9020 W North Ave, Apt 6, Milwaukee, WI 53226; email john.milton.idso@gmail.com.

**Box 1.** Session Questions

Tell us the story of your career. How did you get to where you are today?
What has been a challenge in getting to where you are today? What has been a catalyst?
How have you balanced work and family?
Specifically, what opportunities should we seek out in medical school?
Residency? Early career?
How did you learn to successfully lead a team to achieve a goal?
What is some advice for successfully mentoring employees or students?
What is some advice for cultivating innovation within your team?
How did you learn to manage an institutional budget?
Can you speak to the importance of character and compassion in leadership?

**Box 2.** Focus Group Questions

What aspects of the program are done well?
What aspects of the program could be improved?
How has SLDI augmented your medical education?
Has SLDI been a valuable use of your time?
Would you recommend this program to your classmates? Why or why not?
Do you feel more prepared for leadership than if you hadn't participated in the program? How so?
How has SLDI affected your career plans?

Abbreviation: SLDI, Student Leadership Development Initiative.

The program was evaluated using Likert scale survey questions also guided by the Medical Leadership Competency Framework, as it has been suggested in prior research that a standardized model for assessment may lead to improved measurement of student competency and understanding of best practices.[2,9] One or more questions were designed to measure the program's alignment with each of the 5 Medical Leadership Competency Framework leadership domains: setting direction, demonstrating personal qualities, working with others, managing services, and improving services.

Additionally, a focus group of 10 regular attendees was organized in order to attain a big-picture understanding of the strengths and weaknesses of the program along with areas for improvement. See Box 2 for focus group questions.

The Medical College of Wisconsin Human Research Review Board approved the evaluation protocol with anonymous responses as exempt. The program meals were funded by a grant from the Office of Academic Affairs at Medical College of Wisconsin.

## RESULTS

Between April and October 2017, 4 physician leaders and 58 students participated in the leadership program. Fifty-eight student surveys were collected after the sessions. Of note, because the surveys were anonymous, it is likely that some individuals who attended multiple sessions filled out a survey at each session they attended. Forty-three (74%) respondents were men and 15 (26%) were women. Eighteen (31%), 22 (38%), and 18 (31%) respondents were first-, second-, and third-year medical students, respectively.

Survey results are shown in the Table. One hundred percent of respondents said the session was valuable. Ninety-six percent agreed the session addressed the importance of qualities such as character and compassion in leadership; 94% had specific ways in which they wanted to improve their leadership after the session; and over 75% indicated they felt more competent to lead a team. Nearly half reported (41%) that the session affected their career path, while 100% had a better understanding of the career paths of physician leaders from medical school to leadership positions. Ninety-six percent agreed that they had a better understanding of careers in leadership available for physicians, and nearly all participants (95%) agreed that they had a better understanding of the necessary strategy to achieve their career goals.

With regard to practical leadership skills, over 90% had a better understanding of how physicians build and motivate effective teams. Ninety-eight percent had better insight into how physicians cultivate innovation within their teams, as well as better understanding of how they effectively mentor employees and students. Finally, over half of all respondents (59%) had a better grasp of how physicians manage an institutional budget.

Comments from students included, "Leadership in medicine extends well beyond the walls of the clinic," "Find strong mentors and be a great follower," and "Understanding the different personalities you are leading is important to being a good leader."

The focus group of 10 students indicated that the "size [of the group] was one of its greatest benefits." They appreciated being able to directly ask questions of the leader and suggested more time to ask questions, but also thought the prepared questions were effective in guiding the conversation. They also indicated that the program could be improved by including more non-academic leaders and physician leaders early in their career. Students perceived that the program filled a mentorship gap present in medical education. One student said the program "set my sights higher." Students believed it ignited their ambitions to pursue more leadership opportunities in the future.

## DISCUSSION

For leadership education to become available for all medical students in Wisconsin and across the country, an effective, sustainable, and replicable model is needed. Though the need for leadership training for medical students is widely recognized, there exists a critical gap in the existing literature of leadership development in medical education.[1,3] This is the first US undergraduate medical education leadership program validated by a study that emphasizes replicability with effectiveness.

The hypothesis of the Student Leadership Development Initiative was that if a small group of students met for discussions with a physician leader, it would provide leadership training tailored to each student's needs and to each leader's experiences. One hundred percent of students surveyed thought the session was valuable. As medical school curricula become increasingly full, student perception of value is critical to the success of any program. The authors hypothesize that

this outcome may be due to the program's customizable design. Since the group of students gathered at each session was small and unique, the speaker could tailor advice based on the group. At the beginning of each session, each of the students stated their year in medical school and career interests so the speaker was familiar with the assembled group and was, therefore, able to provide leadership insight that was particularly relevant to the group. The fluid curricular structure allowed each of the leaders to teach directly based on their own specific experiences. In addition, the ability for students to ask questions personalized to their interests at the end of the session as an effective mode of education aligns well with previous studies.[8] After many of the sessions, students who were interested in the speaker's field personally connected with the speaker. For these students, their leadership development was continued beyond the session itself.

**Table.** Survey Results, N=58

| Survey Questions | n | % |
|---|---|---|
| This session was valuable. | 58 | 100% |
| This session displayed the importance of character in leadership. | 56 | 96% |
| This session displayed the importance of compassion in leadership. | 56 | 96% |
| After this session, I have specific ways in which I want to improve my leadership skills in medical school and residency. | 54 | 93% |
| After this session, I feel more competent to lead a team in the future. | 45 | 78% |
| This session affected my choice in career path. | 24 | 42% |
| This session gave me a better understanding of: | | |
| Career path/story of physician-leaders from medical school to their current position. | 58 | 100% |
| How physicians develop the skills to effectively mentor employees and students. | 57 | 98% |
| How physicians develop the skills to cultivate innovation within their teams. | 57 | 98% |
| Career in leadership available for physicians. | 56 | 97% |
| Strategy required to achieve my career goals. | 55 | 95% |
| How physicians motivate others and build effective teams. | 53 | 91% |
| How physicians develop the skills to manage an institutional budget. | 34 | 59% |

### Limitations

One limitation of this leadership program model is that the lack of a formalized curriculum meant that certain leadership topics were not necessarily covered. We attempted to alleviate this by including questions in the discussion guide that corresponded to each of the 5 Medical Leadership Competency Framework domains. The students who participated in the program were not randomly selected from the student population, which suggests the likelihood of volunteer bias. These self-selected students may have had more interest in developing leadership skills and, therefore, would find the sessions more beneficial than students who elected not to participate in the program. Consequently, expanding this program to all students might not generate the same degree of enthusiasm reported by these students.

A further limitation of this study is that the results are based on self-reported surveys, which can be biased by a subject's inability to accurately assess his or her own leadership development.

### Next Steps

The next step for this program is to scale up the pilot to allow room for all medical students at our institution to participate and monitor long-term outcomes of leadership effectiveness and positions. Our goal is for all medical students on campus to participate in at least 1 session during their undergraduate medical training and to facilitate students with particular interest to attend many sessions.

## CONCLUSION

The Student Leadership Development Initiative offers an effective model to provide leadership education to medical students that is both personalized and thorough. Its simplicity will allow it to be easily replicated by other medical schools interested in augmenting their students' leadership curriculum. The authors' hope is that other medical schools that currently lack a leadership program for their students due to a lack of human or financial resources will consider implementing this effective, sustainable, and replicable program.

**Funding/Support:** Funding for meals during the sessions was provided by a grant from the Office of Academic Affairs at the Medical College of Wisconsin.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Neeley S, Clyne B, Resnick-Ault D. The state of leadership education in US medical schools: results of a national survey. *Med Educ Online*. 2017;22(1):1301697. doi:10.1080/10872981.2017.1301697.

**2.** Webb A, Tsipis N, McClellan T, et al. A first step toward understanding best practices in leadership training in undergraduate medical education: a systematic review. *Acad Med.* 2014;89(11):1563-1570. doi:10.1097/ACM.0000000000000502.

**3.** Institute of Medicine. Academic health centers: leading change in the 21st century. *Acad Emerg Med.* 2004;11(7):802-806. doi:10.1197/j.aem.2004.02.0074.

**4.** Smart K, Cappel J. Students' perceptions of online learning: a comparative study. *J Inf Technol Educ.* 2006;5:201-219.

**5.** Cadieux D, Lingard L, Kwiatkowski D, Deven T, Bryant M, Tithecott G. Challenges in translation: lessons from using business pedagogy to teach leadership in undergraduate medicine. *Teach Learn Med.* 2017;29(2):207-215. doi:10.1080/10401334.2016.1237361.

**6.** Arroliga AC, Huber C, Myers JD, Dieckert JP, Wesson D. Leadership in health care for the 21st century: challenges and opportunities. *Am J Med*. 2014;127(3):246-249. doi:10.1016/j.amjmed.2013.11.004.7.

**7.** Arnold L, Cuddy P, Hathaway S, Quaintance J, Kanter S. Medical school factors that prepare students to become leaders in medicine. *Acad Med.* 2018;93(2):274-282. doi:10.1097/ACM.0000000000001937.

**8.** Till A, McKimm J, Swanwick T. Twelve tips for integrating leadership development into undergraduate medical education. *Med Teach*. 2017; Oct 26:1-7. Epub ahead of print. doi:10.1080/0142159X.2017.1392009.

**9.** NHS Institute for Innovation and Improvement and Academy of Medical Royal Colleges; 2010. Medical Leadership Competency Framework: Enhancing Engagement in Medical Leadership. 3rd ed. https://www.leadershipacademy.nhs.uk/wp-content/uploads/2012/11/NHSLeadership-Leadership-Framework-Medical-Leadership-Competency-Framework-3rd-ed.pdf. Published July 2010. Accessed March 27, 2019.

# Statewide Pediatric Quality Improvement Collaborative for HPV Vaccine Initiation

Mala Mathur, MD, MPH; Sarah Campbell, MD


## ABSTRACT

**Background:** Human papillomavirus (HPV) is the most commonly sexually transmitted pathogen and has been implicated in several types of cancers, yet immunization rates have remained low.

**Methods:** Wisconsin pediatricians participated in a 3-month health care collaborative from April through June 2016.

**Results:** HPV vaccination initiation increased overall among all participating practices from 56.4% at baseline to 71.2% after the 3-month time period. In addition, Tdap and meningococcal vaccine rates increased in these practices as well.

**Discussion/Conclusions:** A statewide pediatric health care collaborative can make significant improvements in HPV vaccination rates in a relatively short period of time and also can directly improve rates of other adolescent vaccines.


## BACKGROUND

Human papillomavirus (HPV) is the most common sexually transmitted pathogen, and it is estimated that 79 million Americans are infected with HPV at any one time.[1] Although the HPV infection may resolve on its own, some HPV infections can persist and lead to the development of cancer later in life, including cervical, anal, penile, vaginal, vulvar, and head and neck cancers.[2] HPV vaccines have been shown to be safe and effective through extensive safety testing done in clinical trials prior to their approval by the Food and Drug Administration. The 3-part vaccine series has been recommended for over 10 years in the United States, yet rates of vaccination continue to be low nationally and in Wisconsin. The 2015 Wisconsin vaccination rate for all adolescents (ages 13-18) was 44% for initiation of the HPV vaccine and 26% for completion of the HPV vaccine.[3] The purpose of the Wisconsin Chapter of the American Academy of Pediatrics (WIAAP) HPV project was to address ways to increase HPV vaccination initiation in adolescents ages 11 and 12 over a 3-month intervention period, utilizing quality improvement methodology with an emphasis on strong provider recommendation.

## METHODS

The WIAAP recruited pediatric practices to participate in this statewide initiative. Twenty-five pediatricians, most within 5 major clinic sites, participated in this quality improvement Maintenance of Certification (MOC) project supported by a grant from the Centers for Disease Control and Prevention through the American Academy of Pediatrics (AAP). During the four 1-hour webinars conducted during this project, US and Wisconsin HPV vaccination rates were reviewed and quality improvement methodology was presented. The webinars also highlighted evidence-based practice change ideas including information on how to communicate with parents

**Author Affiliations:** Department of Pediatrics, University of Wisconsin School of Medicine and Public Health, Madison, Wis (Mathur); Affinity Medical Group, St. Elizabeth Hospital, Appleton, Wis (Campbell).

**Corresponding Author:** Mala Mathur, MD, MPH, Department of Pediatrics, University of Wisconsin School of Medicine and Public Health, 600 Highland Ave, Madison, WI 53792-4108; phone 608.263.6421; fax 608.263.6547; email mmathur@wisc.edu.

regarding the HPV vaccine. The project lasted 3 months and involved 1 month of baseline data collection and 2 months of data collection after quality improvement interventions. For all 11- and 12-year-old patients who had an office visit during the data collection cycle, data was recorded on whether they received dose 1 of the HPV vaccination, the Tdap vaccine, and the meningococcal vaccine. We used chi-square analysis to determine whether the findings of our results were significant.

## RESULTS

During our 2-month intervention, the HPV vaccination initiation rates rose in participating practices from 56.4% to 71.2% (P<0.0001) (see Figure), which exceeds state and national averages for initiation of HPV vaccination rates. In addition, the Tdap initiation rates increased from 92.9% to 97.2%, and meningococcal vaccine rates increased from 89.7% to 92.8%. Although the primary focus of this project was on HPV initiation, we also tracked Tdap and meningococcal vaccines as these 3 vaccines form the platform of adolescent vaccinations.

## DISCUSSION

This project represents WIAAP's first statewide quality improvement project focusing on pediatric HPV immunization rates in Wisconsin. Several pediatricians working together within a practice may have contributed to the success of this project as it may have allowed for more robust practice changes. The increase in vaccination rates may have been due to the technical support in implementing evidence-based practices, such as making a strong provider recommendation, including the entire care team (nursing and rooming staff) in promoting the HPV vaccine, and vaccinating at all office visits, not just during the well-child check. In addition to increasing HPV vaccination rates, the rates of Meningococcal vaccine and Tdap also rose, possibly due to the increased provider emphasis on the adolescent vaccination platform.

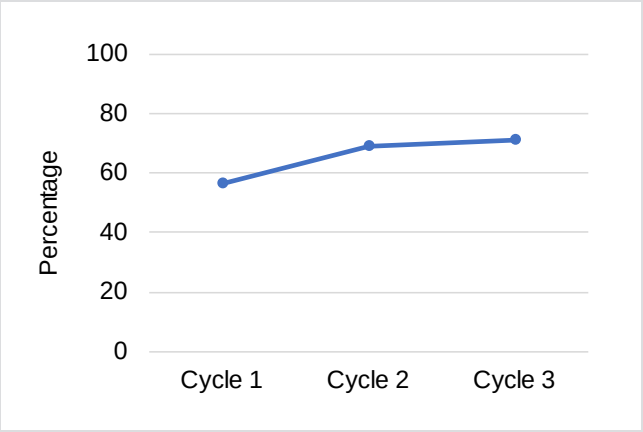
## CONCLUSION

A statewide learning collaborative can be a useful and productive way to improve the quality of care, and it is valued by the participants, particularly when maintenance of certification credit is awarded. It is a valuable opportunity to improve statewide vaccination rates and, in the future, could be expanded to include additional pediatric as well as family medicine practices throughout the state.

**Funding/Support:** This research was funded by the Grant or Cooperative Agreement Number, 5 NH23IP000952, funded by the Centers for Disease Control and Prevention and awarded to the Wisconsin Chapter of the American Academy of Pediatrics. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the CDC or the Department of Health and Human Services.

**Financial Disclosures: None declared.**

**Figure.** Human Papillomavirus Vaccine Initiation Rates




Percent initiation for the 3 cycles of data collection. Cycle 1 is baseline data (April 2016) and Cycles 2 and 3 reflect rates after quality improvement cycles (May and June 2016, respectively).

## REFERENCES

**1.** Markowitz L, Dunne E, Saraiya M, et al; Centers for Disease Control and Prevention. Human papillomavirus vaccination: recommendations of the Advisory Committee on Immunization Practices. *MMWR Recomm Rep.* 2014;63(RR-05):1-30.

**2.** Centers for Disease Control and Prevention. *Epidemiology and Prevention of Vaccine-Preventable Diseases.* Hamborsky J, Kroger A, Wolfe S, eds. 13th ed. Washington D.C. Public Health Foundation, 2015.

**3.** Reagan-Steiner S, Yankey D, Jeyarajah J, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13-17 years - United States, 2015. *MMWR Morb Mortal Wkly Rep.* 2016;65(33):850-858. doi:10.15585/mmwr.mm6533a4.

# Barriers to Enrollment for the Uninsured: A Single-Site Survey at an Urban Free Clinic in Milwaukee

Drumil Bhatt, BS; Ken Schellhase, MD, MPH


## ABSTRACT

**Background:** Wisconsin currently has a 6.4% uninsured rate. In Milwaukee, it is not known what proportion of the currently uninsured may be eligible for health insurance and why those eligible have not enrolled.

**Methods:** Anonymous surveys were distributed at a free/low-cost health clinic in Milwaukee to ask their attendees why they remain uninsured.

**Results:** Fifty-one percent of respondents cited insurance being "too expensive" as the primary reason for lacking health insurance. Additionally, 56% of respondents appeared to misunderstand their Medicaid eligibility, while 69% appeared to misunderstand their Affordable Care Act (ACA) Marketplace eligibility.

**Discussion:** A majority of respondents misunderstood their eligibility for ACA subsidies, indicating that additional efforts are needed to educate uninsured Milwaukee residents to maximize health insurance coverage.


## INTRODUCTION

In 2017, although the United States had one of the lowest rates of uninsured in over 50 years, there were still close to 29.3 million people who remained uninsured.[1,2] The Affordable Care Act (ACA) aimed to reduce the uninsured rate by expanding Medicaid eligibility and offering subsidies to make premiums and cost-sharing more affordable for commercial health insurance purchased through the ACA Marketplace. Wisconsin did not participate in the full Medicaid expansion under the ACA, but did expand Medicaid eligibility for individuals and families making up to 100% of the Federal Poverty Line (FPL) (up to $12,140 per year for an individual in 2018), while offering subsidized health plans through the Marketplace for people earning between 100% and 400% of FPL (between $12,140 and $48,560 per year for an individual in 2018).[3] Despite this, according to US census data, the uninsured rate in 2017 was 6.4% in Wisconsin and 13.2% in Milwaukee.[4]

To increase enrollment, Wisconsin allows individuals to apply for both Medicaid and Marketplace plans in person, by mail, over the phone, and online. Moreover, the US Department of Health and Human Services awarded close to $300,000 to federally qualified health centers in Milwaukee in 2014 to assist with outreach and enrollment under the ACA, and the Centers for Medicare & Medicaid Services awarded $1.3 million in grants to Navigator organizations during the 2015-2016 open enrollment period for Wisconsin.[5,6] While the uninsured rate has dropped from 9.1% in 2013 to 6.4% in 2017, it is not known why some individuals remain uninsured despite these efforts.

Thus, the goal of this project is to characterize this remaining uninsured population by understanding their eligibility status and reasons for being uninsured. Though this is a pilot study with a nonrepresentative sample of the uninsured, results from this study can provide an additional resource to shape local policy and outreach to the uninsured population, in addition to groundwork for future studies.

## METHODS

Surveys were conducted at the Outreach Community Health Center (OCHC) in Milwaukee, a community center that provides low-cost to no-cost primary care to the uninsured, in addi-

• • •

**Author Affiliations:** Medical College of Wisconsin (MCW), Milwaukee, Wis (Bhatt); MCW, Department of Family Medicine, Milwaukee, Wis (Schellhase).

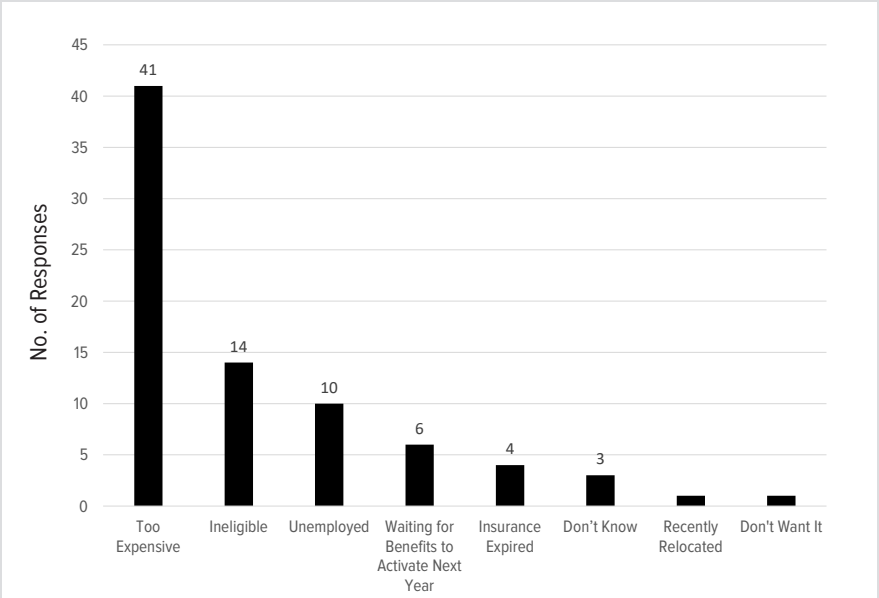
**Corresponding Author:** Drumil Bhatt, BS, Medical College of Wisconsin, 8701 W Watertown Plank Road, Milwaukee, WI 53226; phone 714.616.0506; email dbhatt@mcw.edu.

**Table.** Survey Respondent Demographics

| Demographic | Total | | | | | |
|---|---|---|---|---|---|---|
| **Age in years** | | **19-25** | **26-34** | **35-44** | **45-64** | |
| | 100 | 15 (15%) | 25 (25%) | 20 (20%) | 40 (40%) | |
| **Sex** | | **Male** | **Female** | | | |
| | 80 | 44 (55%) | 36 (45%) | | | |
| **Ethnicity** | | **Caucasian** | **African American** | **Hispanic** | **Asian** | **Other** |
| | 98 | 31 (32%) | 59 (60%) | 5 (5%) | 1 (1%) | 2 (2%) |
| **Family size** | | **1** | **2** | **3** | **4** | |
| | 90 | 71 (79%) | 9 (10%) | 5 (6%) | 5 (6%) | |
| **Eligibility*** | | **Medicaid Eligible** | **Marketplace Eligible** | | | |
| | 77 | 30 (39%) | 47 (61%) | | | |

*Medicaid and Marketplace eligibility were not self-reported by respondents but calculated by the authors based on self-reported income in comparison to the most recently defined poverty levels.

**Figure.** Reasons Identified for Being Uninsured, N=80




Free text responses to the question, "Please state in your own words why you are uninsured" were transcribed into displayed categorical responses by study staff.

tion to social services and case management. During these case management appointments, staff solicited interest from clients to participate in the study. Surveys were presented in paper form and English only. (Survey can be found at https://www.wisconsinmedicalsociety.org/_WMS/publications/wmj/pdf/118/1/Appendix-Bhatt.pdf). They were presented as voluntary and anonymous, and no incentives were offered. In case respondents had questions, the project purpose, details, and contact information were included in an informational letter that accompanied the survey. OCHC staff disseminated the surveys but were not part of the research team and did not record the number of surveys offered; therefore, no response rate was calculated. The questions consisted of a combination of free text and multiple choice. All responses were self-reported and each question was optional, thus, there is a different number of responses for each question. Data entry was performed by the primary author.

Institutional Review Board approval was obtained by the Medical College of Wisconsin Institutional Review Board #5 for study ID PRO00027333.

## RESULTS

### Demographics

Results were tabulated to include age, sex, ethnicity, family size, and eligibility (Table). Eligibility for Medicaid vs Marketplace plans was based on respondents' self-reported income and family size, which was compared to the eligibility charts on the ACA's official website. Of note, the majority (61%) of the respondents were above 100% of the FPL and would have some out-of-pocket expense to purchase plans through the Marketplace.

### Modes of Applying for Coverage

Respondents were asked if they planned to obtain health insurance and, if so, what modality they were going to use to apply for coverage. Most respondents (68%, n = 96) looked for coverage in 2017-2018 and the most popular mode of applying for coverage was online (34%).

### Employer-Sponsored Insurance

Sixty-seven percent of respondents said they were employed. Of these employed, 71% qualified for Marketplace plans while 29% qualified for Medicaid plans. Regarding access to employer-sponsored insurance, 50% of individuals were not offered insurance through their employer while 21% were offered insurance but said it was too expensive.

### Reasons for Being Uninsured

Respondents were asked, in a free text format, why they remain uninsured. Responses were then transcribed into displayed categorical responses by study staff (Figure). Most individuals (41/80 responses, 52%) cited insurance being "too expensive." Other answers included being unemployed or ineligible for insurance. There were also logistical reasons cited, such as having a waiting period before an employer could offer insurance or being recently uninsured due to expiration of benefits from relocating or having a new job.

### Knowledge of Eligibility

Respondents also were asked whether they know if they are eligible for Medicaid with response options of "Yes," "No," and "I don't know." Of the 72 individuals who self-reported an income and answered this question, 55.5% responded "I don't know" or answered incorrectly about their Medicaid eligibility. The same question was posed for respondents about Marketplace eligibility. Of the 73 individuals who self-reported an income and answered this question, 68.5% responded either "I don't know" or answered incorrectly about their Marketplace eligibility.

## DISCUSSION

In terms of knowledge of benefits and eligibility, the majority of respondents (55.5% for Medicaid, 68.5% for Marketplace) had some misunderstanding or misinformation about their eligibility. Thus, many respondents may not be taking full advantage of the benefits available to them. These findings are consistent with national surveys done by Kaiser of over 1,200 respondents that showed how many individuals had some misunderstanding of the ACA and its benefits and requirements.[7,8] Therefore, it appears that additional education and outreach must be part of efforts to improve uninsured rates.

While misinformation or misunderstanding may explain why some individuals do not sign up for insurance, it is important to note that most respondents (61%) appeared to be Marketplace eligible and would have some premium, copay, and/or deductible associated with their insurance plans. Thus, while an individual's premium varies based on numerous particulars, it is not surprising that many respondents cite insurance being too expensive as the primary reason they lack insurance. These individuals may be aware of benefits available to them but may have chosen to visit a free clinic instead.

Conversely, 39% of respondents qualify for Medicaid/Badgercare insurance, which involves minimal, if any, out-of-pocket expense. In addition to future research that explores why this cohort may remain uninsured despite financial assistance, more efforts need to be made to sign up this population for insurance.

This pilot study suggests that respondents may misunderstand the programs available to them and their costs and benefits, which is consistent with results from national surveys.[1,9] However, it is important to note that due to the limitations of this study, these findings may not be generalizable. Since this study was done at a single site with a voluntary, English-speaking population only, variables such as response rate, immigration status, and other barriers to enrollment, such as language, were not studied. Moreover, the respondent demographics are not generalizable to Milwaukee's entire uninsured population. Future studies must include sites at other locations to represent a different demographic and should include surveys transcribed in Spanish and Hmong to access significant portions of the non-English speaking population. Furthermore, studies could expand on the qualitative data shown in the Figure. For instance, surveys could explore the cost of a Marketplace premium in comparison to a sliding scale fee at a community health center. Respondents also could be surveyed before and after an educational session on Marketplace and Medicaid plans to assess the impact of these types of sessions on health care literacy.

## CONCLUSIONS

Cost appears to remain the biggest barrier to obtaining insurance, especially since a majority of survey respondents were Marketplace eligible and would have some out-of-pocket expense associated with their health care plans. However, it is unknown whether those eligible for Marketplace insurance have an accurate understanding of their actual out-of-pocket costs. Efforts need to be made to increase health care literacy, targeted at both Medicaid- and Marketplace-eligible individuals, to reduce uninsured rates and inform consumers about their eligibilities and benefits. Future studies can focus on the impact of education on health care literacy and how that education can help decrease uninsured rates.

**Funding/Support:** None declared.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Key facts about the uninsured population. Henry J. Kaiser Family Foundation. https://www.kff.org/uninsured/fact-sheet/key-facts-about-the-uninsured-population/. Published December 7, 2018. Accessed April 9, 2019.

**2.** Cohen RA, Zammitti EP, Martinez ME. Health insurance coverage: early release of estimates from the National Health Interview Survey, 2017. Center for Disease Control and Prevention. https://www.cdc.gov/nchs/data/nhis/earlyrelease/insur201805.pdf. Published May 2018. Accessed November 3, 2018.

**3.** QuickFacts: Milwaukee City, Wisconsin. United States Census Bureau website. https://www.census.gov/quickfacts/milwaukeecitywisconsin. Accessed March 6, 2018.

**4.** The Wisconsin health care landscape. Henry J. Kaiser Family Foundation. https://www.kff.org/health-reform/fact-sheet/the-wisconsin-health-care-landscape/. Published October 7, 2015. Accessed March 5, 2018.

**5.** Wisconsin: health center outreach and enrollment assistance. Health Resources and Services Administration website. https://www.hrsa.gov/about/news/2013-tables/outreach-and-enrollment/wi.html. Renewed April 2017. Accessed March 10, 2018.

**6.** Long M, Rae M, Claxton G, Damico A. Trends in employer-sponsored insurance offer and coverage rates, 1999-2014. Henry J. Kaiser Family Foundation. https://www.kff.org/private-insurance/issue-brief/trends-in-employer-sponsored-insurance-offer-and-coverage-rates-1999-2014/. Published March 21, 2016. Accessed March 18, 2018.

**7.** 2013 employer health benefits survey. Henry J. Kaiser Family Foundation. https://www.kff.org/private-insurance/report/2013-employer-health-benefits/. Published August 20, 2013. Accessed March 13, 2018.

**8.** DiJulio B, Firth J, Brodie M. Kaiser health tracking poll: December 2015. Henry J. Kaiser Family Foundation. https://www.kff.org/health-costs/poll-finding/kaiser-health-tracking-poll-december-2015/. Published December 17, 2015. Accessed March 18, 2018.

**9.** Garfield R, Orgera K, Damico A. The uninsured and the ACA: a primer – key facts about health insurance and the uninsured amidst changes to the Affordable Care Act. Henry J. Kaiser Family Foundation. https://www.kff.org/report-section/the-uninsured-and-the-aca-a-primer-key-facts-about-health-insurance-and-the-uninsured-amidst-changes-to-the-affordable-care-act-introduction/. Published January 25, 2019. Accessed April 9, 2019.

# Progressive Familial Intrahepatic Cholestasis Presenting With an Intracranial Bleed and Mimicking Abusive Head Trauma

Suzanne Haney, MD; James Harper, MD; Edward Truemper, MD


## ABSTRACT

**Introduction:** Abusive head trauma is a serious, often fatal condition; early identification is important to prevent repeat episodes and/or injuries to siblings. This case emphasizes the importance of a thorough workup in cases of suspected abusive head trauma.

**Case Presentation:** A 4-month-old infant was found to have a severe subdural hematoma requiring surgical evacuation. Initially, abusive head trauma was considered as a diagnosis. Testing revealed vitamin K deficiency bleeding (VKDB) despite prophylactic vitamin K administration at birth. The infant eventually was diagnosed with progressive familial lintrahepatic cholestasis type 2 (PFIC2).

**Discussion:** Although VKDB is a known cause of infantile intracranial hemorrhage, PFIC has not been previously reported to cause severe VKDB resulting in an intracranial hemorrhage.

**Conclusion:** Our case illustrates the importance of a comprehensive systematic approach to investigate causes other than abusive head injury when intracranial bleeding is a significant finding.


## CASE REPORT

A 4-month-old infant was admitted with concerns for altered mental status. Her parents related that 3 days prior to admission, they had been contacted at work by their in-home nanny. The nanny reported that the infant had vomited. The infant's mother contacted the primary physician and was given instructions on home care. The next day, the infant was seen by the primary physician for a sick visit and, at that time, it was noted that the patient had a bruise on her right chest and back. She was otherwise well and had a normal examination. She was sent home without intervention and did well that night. The next day, she was again in the care of her nanny, who reported more vomiting to the parents. The family tried oral rehydration solutions that night without significant improvement.

On the day of admission, the infant was taken to the primary physician and was noted to have a bulging fontanel. She was transferred to the Emergency Department where computed tomographic scan revealed a large left subdural hematoma with a significant left to right shift and early evidence of herniation. She was then transferred to the referral center where she had an emergent burr hole placed and evacuation of the subdural hematoma.Parents did not relate any history of falls, motor vehicle collisions, or other trauma. They had no history to account for the bruises or the subdural hematoma.

The patient was born at term in a hospital and received vitamin K after birth. She had been breastfed exclusively, and her mother reported that they had not been giving her multivitamin drops.

Family history initially was negative. A more detailed history later revealed that the infant's maternal uncle required vitamin K for treatment and that her father was a cystic fibrosis (CF) carrier. The mother was not a CF carrier.

Based on the patient's presentation with a large, surgical subdural hematoma and bruising without a historical explanation, nonaccidental trauma was considered in the differential diagnosis. A skeletal survey showed no fractures or bony abnormalities, and an ophthalmologic examination was normal without retinal hemorrhages. Law enforcement and child protective services were

• • •

**Author Affiliations:** Children's Hospital & Medical Center (Haney); University of Nebraska Medical Center (Haney, Harper, Truemper), Omaha, NE.

**Corresponding Author:** Suzanne Haney, MD, Children's Hospital & Medical Center, 8200 Dodge St, Omaha, NE 68114-4113; phone 402.955.6572; fax 402.955.4184; email shaney@ChildrensOmaha.org.

contacted because of the concern for nonaccidental trauma. They interviewed the family and the caregiver and found no further history to account for the injuries.

Coagulation studies performed in the operating room revealed a prothrombin test of >100, an international normalized ratio of >10, and a partial thromboplastin time of 74.7. Although this testing was performed as part of a routine evaluation for intracranial bleeding, the results were delayed due to multiple transfers of care and emergent neurosurgical intervention. Upon further testing, the patient also was found to have very low activity of all vitamin K dependent factors (II, Vii, IX, and X). Vitamin K levels were 0.04 ng/mL (normal 0.1-2.20) and protein induced by vitamin K absence-II (PIVKA-II) level was >36,20 ng/mL (normal < 6.3 ng/mL). She also was found to have mildly elevated total bilirubin of 2.4 mg/dL (normal <2.0 mg/dL) that remained elevated throughout her hospital stay. Her aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were initially normal, but her AST later ranged from 53 to 90 during the last days of her hospitalization (normal 15-41 U/L).

Based on her lab values, the patient was diagnosed with vitamin K deficiency bleeding (VKDB). Authorities were immediately informed as to her diagnosis and, given that there were no other concerns, they closed their investigations.

The patient was treated with intravenous vitamin K with improvement of her vitamin K level to 5.23 ng/mL. She recovered well from her surgery and appeared normal neurologically. She was discharged home after 8 days with oral vitamin K supplementation (2.5 mg of phytonadione/day) for 7 days. Eight days after stopping the oral vitamin K, her vitamin K level had dropped to 0.27 ng/mL. In addition, her AST and ALT were found to be mildly elevated at 108 U/L and 63 U/L, respectively (normal AST 15-41 U/L, ALT 14-54 U/L). This pattern prompted a more detailed workup of her cholestasis. Genetic testing revealed that she was heterozygous for a mutation in ABCB11, which is most associated with progressive familial intrahepatic cholestasis type 2 (PFIC2).

## DISCUSSION

Late onset VKDB is a well-known, albeit rare condition where children will frequently present with intracranial bleeding.[1,2] This condition has become more rare since the use of newborn intramuscular vitamin K. Most cases reported now are when an infant does not receive vitamin K at birth or as a result of a malabsorptive condition from cholestasis.[2]

Common causes of cholestasis in an infant include biliary atresia, CF, and alpha-1-antitrypsin deficiency.[3,4] These cases are more likely to present with VKDB when the mother is breastfeeding, and there have been multiple reports of these cases either presenting with or being complicated by intracranial bleeding from VKDB.

Progressive familial intrahepatic cholestasis is a rare autosomal recessive condition; its incidence varies from 1/50,000 to 1/100,000 births.[5] There are 3 types of PFIC, all which result in hepatocellular cholestasis. They typically present in infancy with jaundice, pruritus, and other symptoms of cholestasis. Children with PFIC2 will commonly progress to liver failure in the first few years of life. PFIC2 has not previously been reported to present with vitamin K deficiency and a subdural bleed.

In this case, the combination of strict breastfeeding without vitamin supplementation and cholestasis from PFIC2 most likely contributed to her presentation with late-onset VKDB. Nonaccidental trauma was clearly considered in the differential and is one of the most common causes of subdural bleeding and unexplained bruising in this age group.[6] A recent clinical prediction rule would have placed this child in the high risk category,[7] but there were other aspects in this case that pointed away from a diagnosis of abusive head trauma. Retinal hemorrhages were not present in this case; and while retinal hemorrhages are not diagnostic for abuse, they are highly associated with abusive injury. In addition, the hematoma was unilateral and there was no significant brain injury noted. Bilateral subdural hematomas with deep brain injury are more likely to be seen in abusive head trauma.

Late onset VKDB previously has been mistaken for child abuse, but this is a rare occurrence and the search for a medical condition should not supersede a workup for suspected abuse.[8] The American Academy of Pediatrics has clear recommendations on how a bleeding disorder can be evaluated in cases of suspected abuse, which were followed with this patient.[9] In this case, the family was briefly interviewed by authorities who, with appropriate communication from the medical team, quickly closed their case when it was determined that a medical condition caused this infant's presentation.

**Funding/Support:** None declared.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Ozdemir MA, Karakukcu M, Per H, Unal E, Gumus H, Patiroglu T. Late-type vitamin K deficiency bleeding: experience from 120 patients. *Childs Nerv Syst.* 2012;28(2):247-251. doi:10.1007/s00381-011-1575-x

**2.** Shearer MJ. Vitamin K deficiency bleeding (VKDB) in early infancy. *Blood Rev*. 2009;23(2):49-59. doi:10.1016/j.blre.2008.06.001

**3.** Akiyama H, Okamura Y, Nagashima T, Yokoi A, Muraji T, Uetani Y. Intracranial hemorrhage and vitamin K deficiency associated with biliary atresia: summary of 15 cases and review of the literature. *Pediatr Neurosurg*. 2006;42(6):362-367. doi:10.1159/000095566

**4.** Miyao M, Abiru H, Ozeki M, et al. Subdural hemorrhage: a unique case involving secondary vitamin K deficiency bleeding due to biliary atresia. *Forensic Sci Int*. 2012;221(1-3):e25-29. doi:10.1016/j.forsciint.2012.04.018

**5.** Jacquemin E. Progressive familial intrahepatic cholestasis. *Clin Res Hepatol Gastroenterol*. 2012;36(Suppl 1):S26-S35. doi:10.1016/S2210-7401(12)70018-9

**6.** Matschke J, Voss J, Obi N, et al. Nonaccidental head injury is the most common cause of subdural bleeding in infants <1 year of age. *Pediatrics*. 2009;124(6):1587-1594. doi:10.1542/peds.2008-3734

**7.** Hymel KP, Willson DF, Boos SC, et al; Pediatric Brain Injury Research Network (PediBIRN) Investigators. Derivation of a clinical prediction rule for pediatric abusive head trauma. *Pediatr Crit Care Med*. 2013;14(2):210-220. doi:10.1097/PCC.0b013e3182712b09

**8.** Brousseau TJ, Kissoon N, McIntosh B. Vitamin K deficiency mimicking child abuse. *J Emerg Med.* 2005;29(3):283-288. doi:10.1016/j.jemermed.2005.02.009

**9.** Anderst JD, Carpenter SL, Abshire TC; Section on Hematology/Oncology and Committee on Child Abuse and Neglect of the American Academy of Pediatrics. Evaluation for bleeding disorders in suspected child abuse. *Pediatrics*. 2013;131(4):e1314-1322. doi:10.1542/peds.2013-0195

# Renal Cell Carcinoma Presenting as Pleural Effusion

Abeer Arain, MD, MPH; Mahesh Swaminathan, MD; James Kumar, MD, MS, FACP


## ABSTRACT

Renal cell carcinoma is well-known for its propensity to present in unusual ways, and renal cell carcinoma presenting as pleural effusion is extremely rare. Pleural effusion secondary to renal cell carcinoma constitutes only about 1% to 2% of all malignant pleural effusions. We report the case of a 34-year-old man with no significant past medical or surgical history who presented in the Emergency Department with dyspnea. Chest x-ray demonstrated right-sided pleural effusion; computed tomography (CT) reported right-sided effusion in the pleura with suspicious mass in the upper border of left kidney. CT-guided pleural tap was performed and cytology was positive for vimentin and common acute lymphocytic leukemia antigen (CD10), leading to the diagnosis of primary renal cell carcinoma presenting as unilateral pleural effusion. While lungs are the common site of metastasis, the presentation of renal cell carcinoma as pleural effusion or pleural metastasis without lung involvement is rare.


## INTRODUCTION

There are several systemic and pulmonary disorders that can lead to pleural effusion. Pleural effusion can also develop secondary to underlying malignancy of solid organs such as breast and lung.[1] The involvement of pleura in renal cell carcinoma is not very common; it has been reported in about 12% of the autopsies of patients with metastatic renal cell carcinoma, even though the lung is one of the most common sites of metastasis.[1] However, the presentation of renal cell carcinoma as pleural effusion is uncommon and little is reported in the literature. Metastasis to the pleura, along with pleural effusion, is a late event in the course of malignancy.[1]

Renal cell carcinoma may spread by direct invasion, lymphogenous spread, or direct hematonegenous dissemination.[1] The exact mechanism of pleural metastases or the development of pleural effusion is not known; however, the mechanism is thought to be via lymphatics or through vertical plexus of veins.[1]

Expected 5-year survival of a person with renal cell carcinoma in Stage I is as high as 95%.[1] However, patients who develop metastatic disease have a 5-year survival rate of only 29% to 54%, if metastases are resectable.[1]

Renal cancers have been called "the internist's tumor" and are among the great mimics in medicine because they present with systemic symptoms unrelated to the kidney cancer, such as hypertension (secondary to elevated renin levels),[2] hypercalcemia (PTHrP), polycythemia (erythropoietin), eosinophilia, leukemoid reactions, Cushing's syndrome (ACTH), fever or wasting syndromes, and Stauffer's syndrome (reversible hepatic dysfunction after primary tumor removal).[2]

## CASE PRESENTATION

A 35-year-old man with recently diagnosed hypertension presented to our Emergency Department with the symptoms of fever, cough, chills, chest pain, and shortness of breath worsening with any position except when leaning forward. He was last observed to be asymptomatic 4 weeks prior. Hypertension was diagnosed

• • •

**Author Affiliations:** Department of Internal Medicine, University of Illinois Urbana-Champaign; Champaign, Ill (Arain, Swaminathan, Kumar).

**Corresponding Author:** Abeer Arain, MD, MPH, University of Illinois Urbana–Champaign, Department of Internal Medicine, 506 S Mathews Ave, Urbana, IL 61801; phone 217.979.5458; email aarain@illinois.edu.

about 3 months prior at the primary care clinic. He had no significant past medical, surgical, or family history. There was no history of cigarette smoking or use of alcohol or illicit drugs.

The patient described a 4-week history of progressively worsening right-sided chest discomfort, along with shortness of breath and some productive cough with yellowish sputum. He denied having any pulmonary symptoms, and did not complain of any headache, dizziness, lightheadedness, chest or abdominal pain, bowel or bladder symptoms, loss of consciousness, or recent trauma.

On physical examination, he was febrile and toxic looking, with low grade fever of 99.2º F and tachycardia. Chest examination revealed dullness of right-sided chest wall upon percussion and reduced breath sounds at the right lung base on auscultation, negative for rales or wheezing. Complete blood count, comprehensive metabolic panel, and prothrombin time/international normalized ratio were all unremarkable. Chest X-ray reported subpulmonic pleural effusion with mild atelectasis of the right lung and elevation of right hemidiaphragm. At this point, several differentials were taken into consideration, including infectious etiology (parapneumonic effusion, empyema), trauma (chylothorax), and possible underlying malignancy (lymphoma, bronchogenic carcinoma).

Computed tomographic (CT) scan of the chest showed right-sided pleural effusion with generalized thickening of right pleural reflections, along with atelectasis of the right middle lobe and right lower lobe. Interestingly, a complex cystic mass on the upper pole of left kidney was found on the last slice of chest CT, measuring 7.9 x 7.0 cm in size (Figure 1).

The patient's initial clinical presentation was highly suspicious of an underlying infection, and he was admitted to the hospital. Initial management was started with empirical intravenous antibiotics. However, the chest CT reporting large pleural effusion and suspicious cystic renal mass guided attention towards malignancy (Figure 2). The patient underwent diagnostic thoracentesis, and about 2,800 ml of serosanguinous fluid was removed. Pleural fluid pathology reported reactive-appearing mesothelial cells. These atypical cells were checked for multiple tumor markers and were found positive for Vimentin and CD10, raising the suspicion of renal cell carcinoma. CT abdomen and pelvis showed a separate mass on the upper pole of left kidney with negative lymph nodes, leading to the diagnosis of stage IV renal cell carcinoma (T2a, N0, M1). The patient's recently diagnosed hypertension may also have been related to the underlying renal cell carcinoma not picked up earlier.

Cancer management was started with surgical removal of the tumor, leading to left-sided nephrectomy with negative margins. Most patients with advanced renal cell carcinoma (metastatic) are treated with molecular targeted therapies, including agents directed at the molecular target of rapamycin (mTOR) pathway (temsirolimus) or vascular endothelial growth factor receptor inhibitors (sunitinib, bevacizumab).[3]

**Figure 1.** Complex Cystic Mass on the Upper Pole of Left Kidney, Measuring 7.9 x 7.0 cm

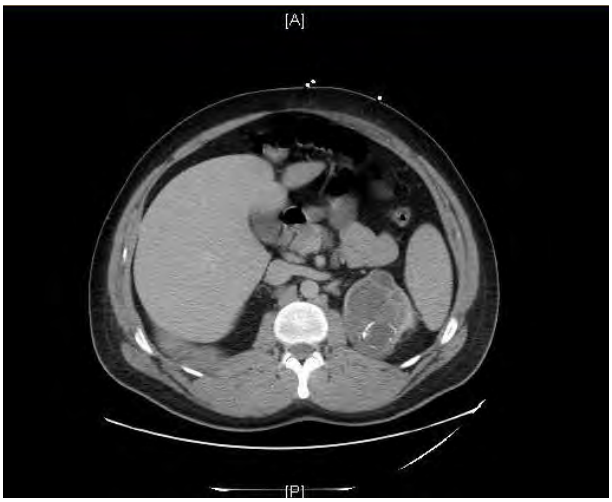
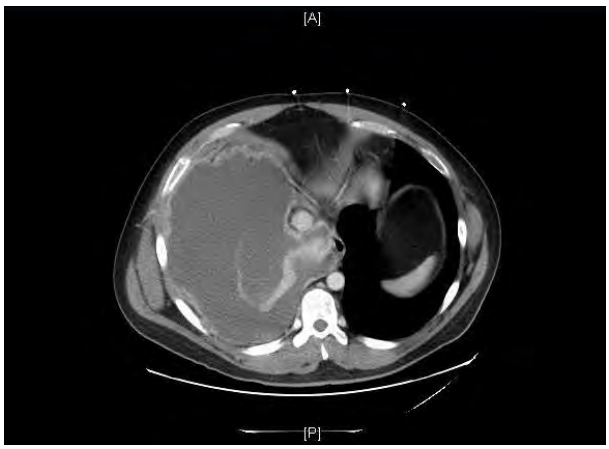



**Figure 2.** Computed Tomographic Scan of Chest Showing Right-Side Pleural Effusion Along With Generalized Thickening of Right Pleural Reflections




After the surgical treatment, chemotherapy options were discussed with the patient. He refused high-dose interleukin-2 therapy due to side-effect profile but agreed on temsirolimus. He showed minimum response to the treatment regimen and continued to develop recurrent right-sided pleural effusions managed by right thoracoscopy. Pleural biopsy proved parietal pleura neoplasm consistent with renal cell carcinoma. Chemical pleurodesis was later done for the recurrent pleural effusions. High-dose interleukin-2 therapy was started, but the tumor showed increased growth after 2 rounds of interleukin-2 therapy. Axitinib, a tyrosine kinase inhibitor, was started. The tumor advanced rapidly, and CT chest reported extensive intrathoracic neoplasm, with massive extrathoracic tumor extending around the posterior thorax. Radiation therapy was given to the chest wall. Unfortunately, the patient's health deteriorated and he expired few days later.

## DISCUSSION

While lung is the most common metastatic site for renal cell carcinoma, metastasis solely to the pleura without the involvement of lung parenchyma is very rare.[2] There are only few (about 4-5) case reports published to date that document the pleural metastasis as initial presentation of renal cell carcinoma. Most of these cases have been reported from Europe and Japan. A study by Ohnishi et al, documents a case of a 66-year-old man who presented with dyspnea and was found to have multiple mesothelioma-like pleural masses along with effusion in the left pleural space.[4] There were no pulmonary lesions.[4] Tumor markers from pleural effusion came back positive for cytokeratinin-19. Abdominal CT reported renal cell carcinoma mass in right kidney. The patient was treated with pleurodesis and right-sided nephrectomy. Pleural lesions showed dramatic improvement after nephrectomy.[4] Our case, however, differs in terms of resolution of the pleural tumors. Although our patient remained adherent to the treatment course and tolerated his treatment well, he did not show any response to chemotherapy, immunotherapy, or pleurodesis. Other case reports by Taylor et al,[5] Kataoka et al,[6] and Chow and Eckhardt,[7] have reported the case of metastatic renal cell carcinoma with similar presentation, that of worsening dyspnea and fatigue.

Renal cell carcinoma accounts for 90% to 95% of malignant neoplasms arising from the kidney.[2] The classic triad of hematuria, abdominal pain, and a palpable mass is present in ≤10% of cases.[2,4,8] While the lungs are the most common sites of metastasis, the presentation of renal cell carcinoma as pleural effusion is very rare. Pleural effusion secondary to renal cell carcinoma constitutes only 1% to 2% of all the malignant pleural effusions.[6] In most of the cases, pleural effusion is found in the diagnosed cases of renal cell carcinoma.[5] Our case, however, is unique because pleural effusion was the initial presentation of the renal cell carcinoma. Other uncommon presentations include cutaneous metastases in the form of scalp skin nodules, demyelinating neuropathy, numb-chin syndrome, and panhypopituitarism.[9]

Renal cell carcinoma often metastasizes to lung parenchyma. Pleural metastases have been described but are commonly secondary to underlying pulmonary metastases. One study reported about 12% of 1,451 patients with renal carcinoma had pleural metastases at autopsy, but no single patient had isolated pleural metastasis.[6,10]

## CONCLUSIONS

The presentation of renal cell carcinoma as pleural effusion and isolated pleural metastasis without the involvement of lung parenchyma is very rare. It is important to keep the differentials broad in patients with unilateral pleural effusion. Newly diagnosed hypertension in younger patients also requires closer follow-up and thorough workup to elucidate the cause of elevated blood pressure.

**Acknowledgements: Ethical** approval for this case report was obtained from the institutional review board. The patient is deceased and family was not reachable.

**Funding/Support: None** declared.

**Financial Disclosures:** None declared.

## REFERENCES

**1.** Hofmann HS, Neef H, Krohe K, Andreev P, Silber RE. Prognostic factors and survival after pulmonary resection of metastatic renal cell carcinoma. *Eur Urol.* 2005;48(1):77-81. doi:10.1016/j.eururo.2005.03.004

**2.** Kiely JM. Hypernephroma – the internist's tumor. *Med Clin North Am.* 1966;50(4):1067-1083.

**3.** Agarwal A, Sahni S, Iftikhar A, Talwar A. Pulmonary manifestations of renal cell carcinoma. *Respir Med.* 2015;109(12):1505-1508. doi:10.1016/j.rmed.2015.10.002

**4.** Ohnishi H, Abe M, Hamada H, et al. Metastatic renal cell carcinoma presenting as multiple plural tumours. *Respirology.* 2005;10(1):128-131. doi:10.1111/j.1440-1843.2005.00652.x

**5.** Taylor DR, Page W, Hughes D, Varghese G. Metastatic renal cell carcinoma mimicking pleural mesothelioma. *Thorax.* 1987;42(11):901-902.

**6.** Kataoka M, Yata Y, Nose S, Yasuda K, Ohara T. Solitary pleural metastasis from renal cell carcinoma: a case of successful resection. *Surg Case Rep.* 2015;1(1):36. doi:10.1186/s40792-015-0039-z

**7.** Chow L, Eckhardt S. Sunitinib: from rational design to clinical efficacy. *J Clin Oncol.* 2007;25(7):884–896.

**8.** Renshaw AA, Richie JP. Subtypes of renal cell carcinoma. Different onset and sites of metastatic disease. *Am J Clin Pathol.* 1999;111(4):539-543.

**9.** Gharabaghi MA. Clinical Spectrum of Patients with Renal Cell Carcinoma. In: Amato RJ, ed. Emerging Research and Treatments in Renal Cell Carcinoma. Iran: InTechOpen; 2012:229-244. https://www.intechopen.com/books/emerging-research-and-treatments-in-renal-cell-carcinoma/clinical-spectrum-of-patients-with-renal-cell-carcinoma. Accessed October 23, 2018.

**10.** Saitoh H. Distant metastasis of renal adenocarcinoma. *Cancer.* 1981;48(6):1487-1491.

## Index to Advertisers



**Advertise in *WMJ*—**

Call Kelly Slack, Slack Attack Communications, 5113 Monona Dr, PO Box 6096, Madison, WI 53716; phone 608.222.7630; fax 608.222.0262; e-mail kelly@slackattack.com.

# Insurance Services for Medical Professionals

## by WisMed Assure

WisMed Assure is the only Wisconsin-based insurance firm exclusively serving the medical community. With more than 30 years of dedicated service, our sole mission is meeting the insurance needs of physicians, hospitals, clinics, related health care professionals, their employees and families. We have offices in Madison, Milwaukee and Appleton.

### Why Us

WisMed Assure focuses on working with health care professionals to better serve their specific needs. We recently developed an association health plan and a new group disability plan to alleviate premium costs and allow smaller practices some of the benefits that larger employers enjoy. It is our goal to provide innovative and customized products with outstanding customer service to professionals who care for the health of others.

### Our Mission

Profits generated by WisMed Assure benefit the Wisconsin Medical Society to further its mission: Improve the health of the people of Wisconsin by supporting and strengthening physicians' ability to practice high-quality patient care in a changing environment.

### Contact Us

Wisconsin Medical Society
WisMed Assure
866.442.3810 or insurance@wismed.org.

### Insurance Product Lines Offered

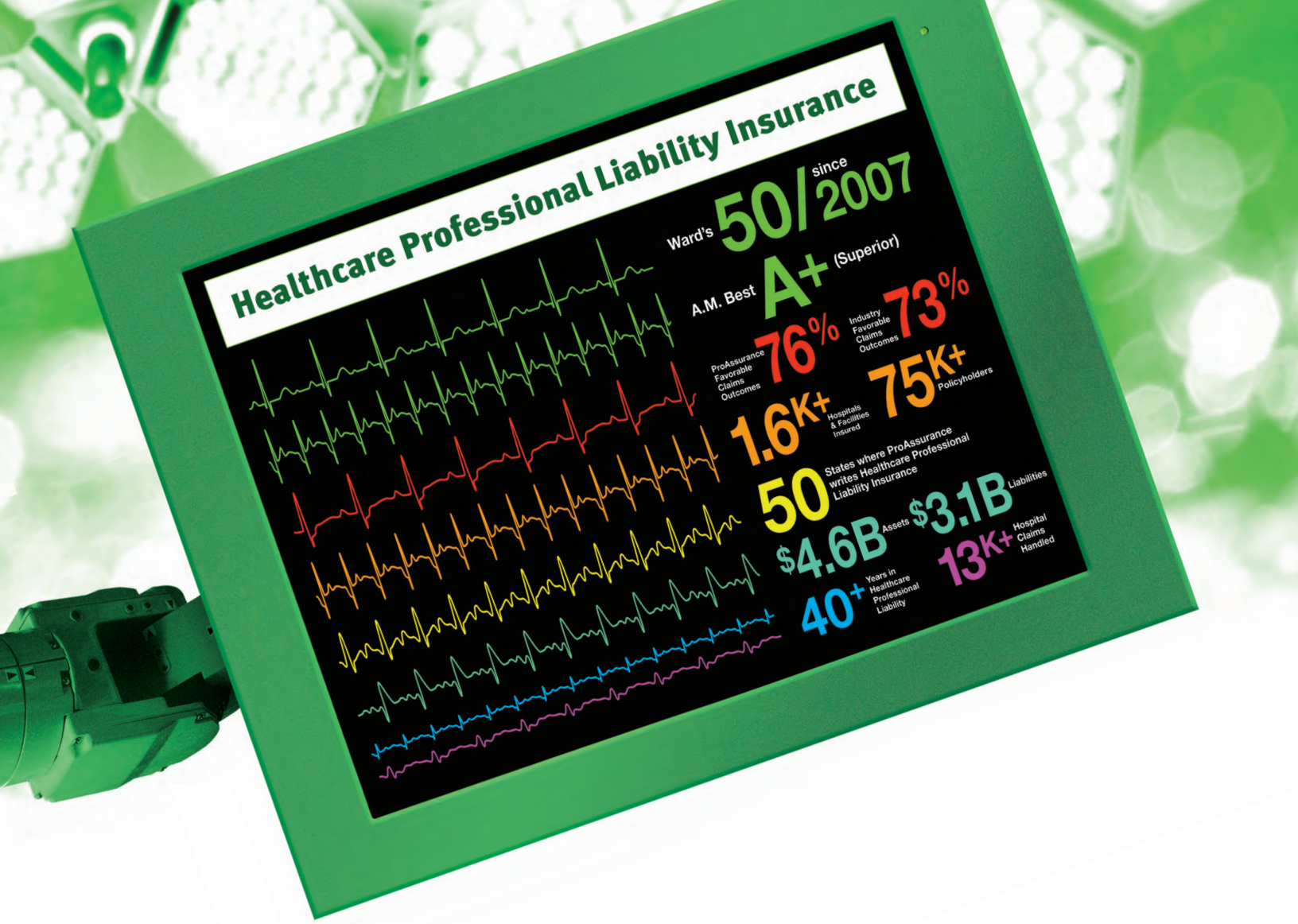
- Professional Liability
- Business
- Long-Term Care
- Association Health Plan
- Group and Individual
    - Health
    - Life
    - Disability
    - Dental
- HR 360 Subscription for Group Benefit Clients

Wisconsin Medical Society

WISMED ASSURE

wismedassure.org

02192019




# healthy vitals

ProAssurance has been monitoring risk and protecting healthcare industry professionals for more than 40 years, with key specialists on duty to diagnose complex risk exposures.

Work with a team that understands the importance of delivering flexible healthcare professional liability solutions.

*Proudly Endorsed by*

WISMED ASSURE

PROASSURANCE®
Treated Fairly

**Healthcare Professional Liability Insurance & Risk Resource Services**

**800.282.6242 • ProAssurance.com/Wisconsin**

**When you are treated fairly you are confident in your coverage.**