Centers for Disease Control and Prevention
MMWR
Morbidity and Mortality Weekly Report
Weekly / Vol. 66 / No. 42
October 27, 2017

Timeliness of Receipt of Early Childhood Vaccinations Among Children of Immigrants — Minnesota, 2016

Maureen Leeds, MPH[1]; Miriam Halstead Muscoplat, MPH[1]

Receiving recommended childhood vaccinations on schedule is the best way to prevent the occurrence and spread of vaccine-preventable diseases (*1*). Vaccination coverage among children aged 19–35 months in the United States exceeds 90% for most recommended vaccines in the early childhood series (*2*); however, previous studies have found that few children receive all recommended vaccine doses on time (*3*). The Minnesota Department of Health (MDH), using information from the Minnesota Immunization Information Connection (MIIC) and the MDH Office of Vital Records, examined early childhood immunization rates and found that children with at least one foreign-born parent were less likely to be up-to-date on recommended immunizations at ages 2, 6, 18, and 36 months than were children with two U.S.-born parents. Vaccination coverage at age 36 months varied by mother's region of origin, ranging from 77.5% among children born to mothers from Central and South America and the Caribbean to 44.2% among children born to mothers from Somalia. Low vaccination coverage in these communities puts susceptible children and adults at risk for outbreaks of vaccine-preventable diseases, as evidenced by the recent measles outbreak in Minnesota (*4*). Increased outreach to immigrant, migrant, and refugee populations and other populations with low up-to-date vaccination rates might improve timely vaccination in these communities.

A retrospective cohort study was conducted using existing birth certificate data from the Office of Vital Records and vaccination records from MIIC. The Office of Vital Records maintains electronic records for all births occurring in Minnesota. MIIC is a statewide immunization information system that includes vaccination records for children and adults residing in Minnesota. Most health care providers in Minnesota routinely submit data to MIIC; 92% of Minnesota children aged 24–35 months have at least two noninfluenza vaccination records in the system.*

Birth records for children born in Minnesota during 2011–2012 were obtained from the Office of Vital Records and matched to immunization records by MIIC personnel in November 2016 using birth certificate numbers. All records were for children aged ≥36 months. The information of primary interest was foreign birth of one or both parents, stratified by mother's region of origin. This information was

Continuing Education examination available at https://www.cdc.gov/mmwr/cme/conted_info.html#weekly.

* http://www.health.state.mn.us/miic.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

ascertained from birth records collected by the Office of Vital Records shortly after birth. The primary outcome of interest was the receipt of recommended vaccines at ages 2, 6, 18, and 36 months,[†] following the current recommendations of the Advisory Committee on Immunization Practices.[§,¶] Parental demographic characteristics were obtained from birth records maintained by the Office of Vital Records, including race, age, education, country of birth, maternal state of residence, and whether the mother participated in the Women, Infants, and Children (WIC) program during pregnancy. The study protocol was reviewed by the University of Minnesota Institutional Review Board, and deemed exempt from requirement for human subjects research approval.

Children were categorized into the following regional groups, based on their mother's birth country: United States, Asia, Eastern Europe, Western Europe and Canada, Africa (excluding Somalia), Central and South America and the Caribbean, and Oceania/Other. Somalia and Mexico, the two largest groups of foreign-born mothers of children in the sample, were considered separately. All analyses were performed using statistical software. Statistical significance was set at $p<0.05$, using two-sided tests. Multivariate logistic regression models were adjusted for the following variables: maternal age, race, and educational attainment. These were then used to estimate unadjusted and adjusted odds ratios for up-to-date vaccinations recommended at ages 2, 6, 18, and 36 months, comparing children with at least one foreign-born parent with children with two U.S.-born parents.

Vaccination records and parental characteristic information were obtained for 135,389 children. Removed from the merged data set were 36,998 records with missing or unknown data on parental countries of birth, maternal state of residence, WIC participation status during pregnancy, parental age, education, or race; children whose status was "not living" or "unknown" at time of birth record filing (150 children); and children born before 24 weeks' or after 42 weeks' gestation or whose gestational age was unknown (356), leaving a final sample of 97,885 (72.3%). Overall, 22% of children had at least one foreign-born parent, 30% of mothers participated in WIC during pregnancy, 80% of mothers were aged 20–34 years, nearly 80% were white, and 75% had attended at least some college (Table 1).

Birth of one or both parents outside the United States was significantly associated with a child's not being up-to-date on vaccinations at ages 2, 6, and 18 months, and not being caught up by age 36 months (Figure). There were differences in children's up-to-date status by mother's region of birth. The

[†] Age in months automatically calculated by the Minnesota Immunization Information Connection. For example, the 2 months category includes 2 months and zero days through to the day before the child reaches 3 months of age.

[§] https://www.cdc.gov/vaccines/schedules/downloads/child/0-18yrs-child-combined-schedule.pdf.

[¶] Up-to-date includes receipt of age-appropriate doses of hepatitis B vaccine, diphtheria and tetanus toxoids and acellular pertussis vaccine (DTaP), *Haemophilus influenzae* type b (Hib) vaccine, pneumococcal conjugate vaccine, polio vaccine, measles-mumps-rubella (MMR) vaccine, and varicella vaccine; and takes into account the number of doses recommended by the Advisory Committee on Immunization Practices as well as the minimum age and interval requirements.

The *MMWR* series of publications is published by the Center for Surveillance, Epidemiology, and Laboratory Services, Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services, Atlanta, GA 30329-4027.

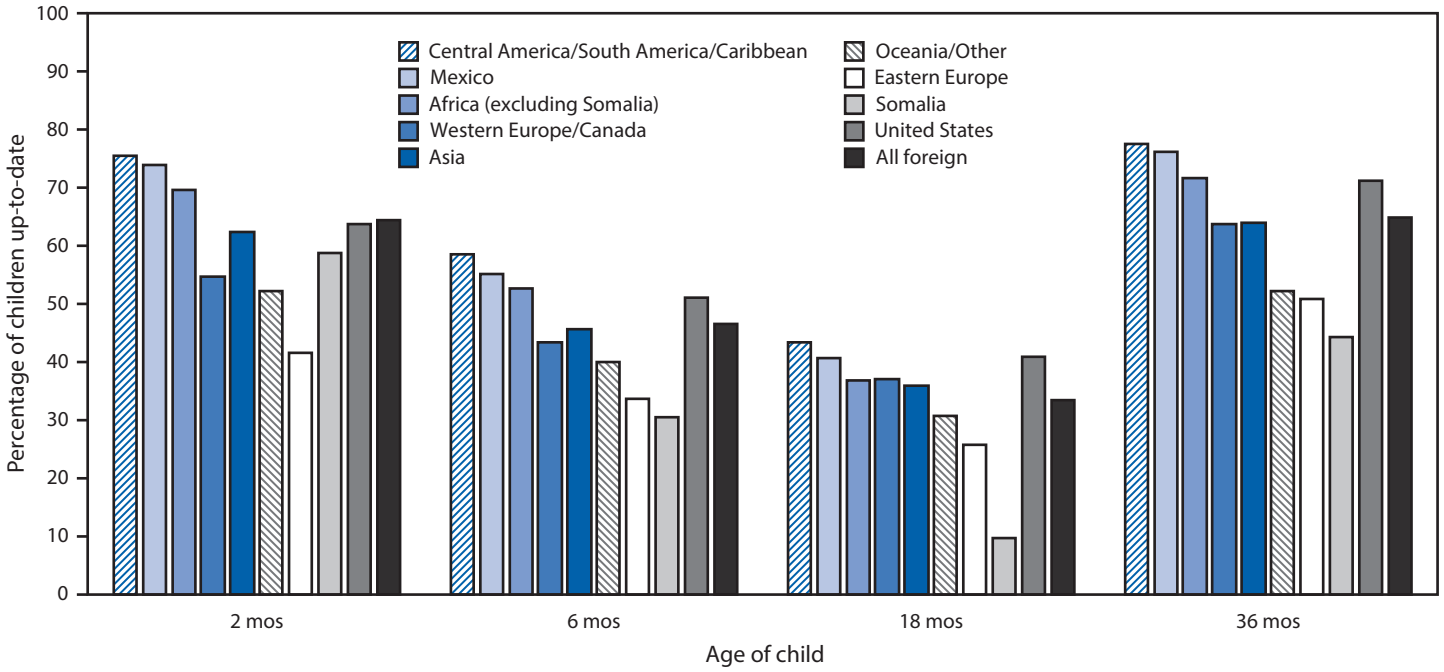
Suggested citation: [Author names; first three, then et al., if more than six.] [Report title]. MMWR Morb Mortal Wkly Rep 2017;66:[inclusive page numbers].

TABLE 1. Percentage of children born during 2011–2012 who were up-to-date with recommended vaccinations at ages 2, 6, 18, and 36 months, by selected maternal characteristics* — Minnesota, 2016

		Age vaccinations were up-to date			
	Total	2 mos	6 mos	18 mos	36 mos
Characteristic	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
At least one parent foreign-born	**21,579 (22.1)**	13,768 (63.8)	9,973 (46.2)	7,239 (33.6)	14,112 (65.4)
Both parents U.S.-born	**76,306 (77.9)**	48,767 (63.9)	39,219 (51.4)	31,594 (41.4)	54,400 (71.3)
Mother participated in WIC program during pregnancy					
Yes	**29,495 (30.1)**	20,594 (69.8)	14,514 (49.2)	9,753 (33.1)	20,735 (70.3)
No	**68,390 (69.9)**	41,941 (61.3)	34,678 (50.7)	29,080 (42.5)	47,777 (69.9)
Mother's age (yrs)					
≤19	**2,943 (3.0)**	2,117 (71.9)	1,441 (49.0)	908 (30.9)	2,134 (72.5)
20–34	**79,494 (81.2)**	51,551 (64.9)	40,665 (51.2)	32,068 (40.3)	55,950 (70.4)
≥35	**15,448 (15.8)**	8,867 (57.4)	7,086 (45.9)	5,857 (37.9)	10,428 (67.5)
Maternal race					
White	**77,203 (78.9)**	49,052 (63.5)	39,932 (51.7)	32,210 (41.7)	54,743 (70.9)
Black	**6,928 (7.1)**	4,477 (64.6)	2,837 (41.0)	1,735 (25.0)	4,241 (61.2)
Other	**13,754 (14.0)**	9,006 (65.5)	6,423 (46.7)	4,888 (35.5)	9,528 (69.3)
Mother's education attainment					
≤12th grade, no diploma	**8,179 (8.4)**	5,505 (67.3)	3,600 (44.0)	2,319 (28.4)	5,403 (66.1)
High school diploma or GED	**14,447 (14.8)**	9,711 (67.2)	6,870 (47.6)	4,615 (31.9)	9,800 (67.8)
Associate degree/College credit	**32,160 (32.9)**	21,355 (66.4)	16,608 (51.6)	12,156 (37.8)	22,722 (70.7)
Bachelor's degree or higher	**43,099 (44.0)**	25,964 (60.2)	22,114 (51.3)	19,743 (45.8)	30,587 (71.0)
Total	**97,885 (100)**	**62,535 (63.9)**	**49,192 (50.3)**	**38,833 (39.7)**	**68,512 (70.0)**

Abbreviations: GED = General Educational Development; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
* Information from the Minnesota Department of Health Office of Vital Records..

FIGURE. Percentage of children born during 2011–2012 who were up-to-date on recommended vaccinations at ages 2, 6, 18, and 36 months, by mother's birth region — Minnesota, 2016*



* Total number of children born in Minnesota during 2011–2012, by mother's birth region: United States, 80,664; all foreign, 17,221; Africa (excluding Somalia), 2,521; Asia, 6,463; Central America/South America/Caribbean, 1,445; Eastern Europe, 802; Mexico, 2,712; Oceania/Other, 65; Somalia, 2,321; Western Europe/Canada, 892.

percentage of children up-to-date at all ages was higher among those whose mothers were born in Central and South America and the Caribbean, Mexico, and Africa (excluding Somalia) than the percentage among children of U.S.-born mothers. In every maternal regional category the percentage of children up-to-date declined from age 2 months to age 6 months and from

age 6 months to age 18 months; however, except for children of Somali-born mothers, the percentage of children up-to-date at age 36 months was as high or higher than that at age 2 months. The lowest percentage of children up-to-date at ages 2, 6, and 18 months were those with mothers born in Eastern Europe; just over half of children whose mothers were born in Eastern Europe were up to date at age 36 months. Fewer than 10% of children whose mothers were born in Somalia were up-to-date at 18 months, although by 36 months, 44.2% had caught up.

Overall, children with at least one foreign-born parent were 25% less likely to be current on their vaccinations at 36 months than were children born to two U.S.-born parents, after adjusting for maternal race, age, and educational attainment (Table 2). Participation in WIC during pregnancy was significantly associated with being up-to-date at 2, 6, and 36 months. Children born to mothers from Africa (excluding Somalia), Central and South America and the Caribbean, and Mexico were significantly more likely to be up-to-date at ages 2, 6, 18, and 36 months compared with children with U.S.-born mothers. Children born to mothers from all other regions (Western Europe and Canada, Eastern Europe, Asia, and Somalia) were significantly less likely to be up-to-date at all ages than were children with U.S.-born mothers. Children with mothers from Somalia and Eastern Europe were least likely to be up-to-date at all ages.

Discussion

This study found wide variation in up-to-date vaccination status at different ages among Minnesota children with U.S.-born parents and those with at least one foreign-born parent. Up-to-date status varied by the mother's country of origin, with children of mothers born in Eastern Europe, Western Europe and Canada, and Somalia being less likely than children with U.S.-born mothers to be up-to-date at all ages, and those with mothers born in African countries (excluding Somalia), Central and South America and the Caribbean, and Mexico being more likely than children with U.S.-born mothers to be up-to-date at all ages. Inadequate parental understanding of vaccination and weaker public health education programs in some regions might account for some of these findings, as well as economic and social factors influencing emigration, including fleeing war, religious persecution, or poverty (*5*). Somali parents in Minnesota have been reported to be more likely than non-Somali parents to have concerns about the safety of measles-mumps-rubella (MMR) vaccine, which has led to a decline in coverage with MMR and possibly other childhood vaccines (*6*). From April to August 2017, Minnesota experienced a measles outbreak, ending with 79 confirmed cases, including 65 in children of Somali descent (*4*).

The findings in this report are subject to at least three limitations. First, health care provider participation in MIIC is voluntary, and MIIC might not account for children who receive immunizations in bordering states (excluding Wisconsin and North Dakota, which do exchange immunization data). Second, because of the nature of the data used, information on the health status of children in the study after birth was not available; therefore, it was not possible to determine whether any child had a medical contraindication to vaccination. Finally, the information gathered by the Office of Vital Records on parental countries of origin is self-reported and did not include information on when the parent arrived in the United States.

TABLE 2. Unadjusted and adjusted* odds ratios (ORs) for up-to-date recommended vaccination status at ages 2, 6, 18, and 36 months among children born during 2011–2012, comparing children with at least one foreign-born parent with children with two U.S.-born parents — Minnesota, 2016

	Age vaccinations were up-to date			
	2 mos	6 mos	18 mos	36 mos
Characteristic	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Foreign born parent(s)				
Unadjusted	0.99 (0.96–1.03)†	0.81 (0.79–0.84)	0.71 (0.69–0.74)	0.76 (0.74–0.79)
Adjusted	0.93 (0.90–0.96)	0.87 (0.84–0.90)	0.82 (0.79–0.85)	0.75 (0.72–0.78)
WIC during pregnancy				
Unadjusted	1.46 (1.42–1.50)	0.94 (0.92–0.97)	0.67 (0.65–0.69)	1.02 (0.99–1.05)†
Adjusted	1.37 (1.32–1.42)	1.04 (1.01–1.08)	0.87 (0.84–0.90)	1.15 (1.11–1.19)
Foreign-born mothers birth region (adjusted OR [95% CI])				
Central and South America/Caribbean	1.65 (1.45–1.87)	1.70 (1.53–1.90)	1.71 (1.53–1.91)	1.61 (1.41–1.83)
Mexico	1.45 (1.31–1.60)	1.63 (1.49–1.78)	1.84 (1.68–2.02)	1.58 (1.42–1.75)
Africa (excluding Somalia)	1.27 (1.17–1.40)	1.61 (1.07–1.26)	1.03 (0.95–1.12)	1.12 (1.02–1.22)
Western Europe and Canada	0.74 (0.65–0.85)	0.75 (0.66–0.86)	0.80 (0.70–0.92)	0.72 (0.63–0.83)
Asia	0.97 (0.91–1.03)†	0.93 (0.88–0.99)	0.94 (0.88–0.99)	0.74 (0.70–0.79)
Eastern Europe	0.41 (0.36–0.47)	0.49 (0.42–0.57)	0.49 (0.42–0.57)	0.43 (0.37–0.49)
Somalia	0.70 (0.64–0.76)	0.49 (0.45–0.54)	0.25 (0.21–0.28)	0.38 (0.25–0.41)

Abbreviations: CI = confidence interval; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
* Adjusted for maternal race, age, and education.
† OR is not statistically significant (p≥0.05).

Summary

What is already known about this topic?

Receiving the recommended childhood vaccinations on schedule is the best way to prevent vaccine-preventable diseases. Vaccination coverage in the United States for children aged 19–35 months exceeds 90% for most recommended childhood vaccines. Previous studies have found that few children receive all their vaccinations on time; however, few studies have examined whether a mother's country of birth affects her child's up-to-date vaccination status at various ages.

What is added by this report?

Fewer than half of children born in Minnesota in 2011–2012 were up-to-date on their immunizations at 18 months, and only 70% were caught up by 36 months. Up-to-date vaccination status was lower among children with at least one foreign-born parent compared with that of children with two U.S.-born parents, and rates varied by mother's country of origin. Children with mothers born in Somalia and Eastern Europe had the lowest rates of up-to-date vaccination.

What are the implications for public health practice?

Refugees and immigrants to the United States from certain regions might have greater difficulties getting their children vaccinated in a timely manner, compared with U.S.-born parents and parents from some other countries. Increased outreach to Eastern European and Somali immigrant, migrant, and refugee populations might benefit children in these communities by improving on-time receipt of recommended vaccinations.

Participation in WIC was associated with an increased likelihood of up-to-date vaccination status, and engaging eligible foreign-born families in programs such as WIC might provide an opportunity to increase on-time vaccination (*7*). Focus groups, meetings, and conversations with the Somali community have been employed in an effort to understand the underlying reasons for low vaccination rates; similar work could be done with the Eastern European immigrant community and other populations with low immunization coverage or late vaccination. Possible strategies include outreach to community leaders, parents, interpreters, and spiritual leaders to provide information on vaccines and vaccine preventable diseases. Encouraging medical providers to use interpreters, take time to build trust, and assess vaccination status at every visit might improve vaccination coverage in these populations (*8*).

Acknowledgments

Kristen Ehresmann, MPH; Carlota Medus, PhD; Margaret Roddy, MPH; Lynn Bahta; Sudha Setty, MPH; and Jonathan Safir, MD, PhD.

Conflict of Interest

No conflicts of interest were reported.

[1]Minnesota Department of Health, Infectious Disease Epidemiology, Prevention and Control.

Corresponding author: Maureen Leeds, Maureen.leeds@state.mn.us, 651-201-4027.

References

1. CDC. White paper on studying the safety of the childhood immunization schedule. Atlanta, GA: US Department of Health and Human Services, CDC; 2014. https://www.cdc.gov/vaccinesafety/pdf/WhitePaperSafety_web.pdf
2. Hill HA, Elam-Evans LD, Yankey D, Singleton JA, Kolasa M. National, state, and selected local vaccination coverage among children aged 19–35 months—United States, 2014. MMWR Morb Mortal Wkly Rep 2015;64:889–96. https://doi.org/10.15585/mmwr.mm6433a1
3. Luman ET, McCauley MM, Stokley S, Chu SY, Pickering LK. Timeliness of childhood immunizations. Pediatrics 2002;110:935–9. https://doi.org/10.1542/peds.110.5.935
4. Hall V, Banerjee E, Kenyon C, et al. Measles outbreak—Minnesota, April–May, 2017. MMWR Morb Mortal Wkly Rep 2017;66:713–7. https://doi.org/10.15585/mmwr.mm6627a1
5. Burnett A, Peel M. Health needs of asylum seekers and refugees. BMJ 2001;322:544–7. https://doi.org/10.1136/bmj.322.7285.544
6. Wolff ER, Madlon-Kay DJ. Childhood vaccine beliefs reported by Somali and non-Somali parents. J Am Board Fam Med 2014;27:458–64. https://doi.org/10.3122/jabfm.2014.04.130275
7. Brenner RA, Simons-Morton BG, Bhaskar B, Das A, Clemens JD; NIH-D.C. Initiative Immunization Working Group. Prevalence and predictors of immunization among inner-city infants: a birth cohort study. Pediatrics 2001;108:661–70. https://doi.org/10.1542/peds.108.3.661
8. Bahta L, Ashkir A. Addressing MMR vaccine resistance in Minnesota's Somali community. Minn Med 2015;98:33–6.

Tobacco Use Among Working Adults — United States, 2014–2016

Girija Syamlal, MBBS[1]; Brian A. King, PhD[2]; Jacek M. Mazurek, MD[1]

Cigarette smoking has declined considerably among U.S. adults over several decades (*1*); however, increases have occurred in the use of noncigarette tobacco products in recent years, and the use of multiple tobacco products has become common among current users of noncigarette tobacco products (*2*,*3*). Differences in tobacco use have also been observed across population subgroups, including among working adults (*2*,*4*). CDC analyzed National Health Interview Survey (NHIS) data for 2014–2016 to describe the most recent prevalence estimates of current (every day or some days) tobacco product use among working U.S. adults by industry and occupation. Among working adults, 22.1% (32.7 million) currently used any form of tobacco; 15.4% used cigarettes, 5.8% used other combustible tobacco (cigars, pipes, water pipes or hookahs, very small cigars, and bidis), 3.0% used smokeless tobacco, and 3.6% used electronic cigarettes (e-cigarettes); 4.6% (6.9 million) reported current use of two or more tobacco products. By industry, any tobacco use ranged from 11.0% among education services to 34.3% among construction workers; current use of two or more tobacco products was highest among construction workers (7.1%). By occupation, any tobacco use ranged from 9.3% among life, physical, and social science workers to 37.2% among installation, maintenance, and repair workers; current use of two or more tobacco products was highest among installation, maintenance, and repair workers (10.1%). Proven interventions to prevent and reduce tobacco product use, including current use of multiple products, among working adults are important (*5*,*6*). Workplace tobacco-control interventions have been especially effective in reducing cigarette smoking prevalence (*7*).

NHIS data* are collected annually from a nationally representative sample of the noninstitutionalized U.S. population through a personal interview. Basic health and demographic information is collected for all family members. One adult aged ≥18 years per family is randomly selected to participate in the NHIS Sample Adult component of the survey, which contains questions on employment status and tobacco use. To improve the precision and reliability of estimates, NHIS data collected during 2014–2016 were combined. The NHIS Sample Adult component included 36,697 respondents in 2014, 33,672 respondents in 2015, and 33,028 respondents in 2016; response rates for those years were 60.8%, 55.2%, and 54.3%, respectively. The analysis was restricted to working adults (59,690; 57.7%). Respondents were considered to be currently working if, when asked about their employment status during the week before their interview, they reported that they were "working at a job or business," "with a job or business but not at work," or "working, but not for pay, at a family-owned job or business." Information on participants' current industry and occupation was coded by trained coders and grouped into 21 industry groups and 23 occupation groups.†

Current cigarette smokers were defined as respondents who reported having smoked ≥100 cigarettes during their lifetime and who reported now smoking "every day" or "some days." Current other combustible tobacco smokers were those who reported smoking tobacco products other than cigarettes (including cigars, pipes, water pipes or hookahs, very small cigars, and bidis) at least once during their lifetime and currently smoking "every day" or "some days." Current smokeless tobacco users were those who reported using smokeless tobacco products (including chewing tobacco, snuff, dip, snus, or dissolvable tobacco) at least once during their lifetime and who currently use "every day" or "some days." Current e-cigarette users were those who reported using e-cigarettes at least once during their lifetime and current use "every day" or "some days." Any current tobacco users were those who reported using one or more tobacco products (cigarettes, other combustible tobacco products, smokeless tobacco, or e-cigarettes). Multiple tobacco users were those who reported current use of two or more tobacco products.

Data were adjusted for nonresponse and weighted to be nationally representative. Prevalence estimates and corresponding 95% confidence intervals were calculated overall and by sociodemographic characteristics, industry, and occupation. Estimates with a relative standard error >30% are not reported. Two-sided t-tests§ were used to determine statistically significant ($p<0.05$) differences between point estimates.

During 2014–2016, among the annual estimated 242 million adults aged ≥18 years, 148 million (61.2%) were employed during the week before the interview. Among currently employed adults, 22.1% currently used any form of tobacco, including 15.4% who used cigarettes, 5.8% who used other

* https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/srvydesc.pdf.

† Additional information about industry and occupation groups and codes is available at ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/samadult_layout.pdf on pages 378–384.

§ https://www.cdc.gov/nchs/data/series/sr_10/sr10_256.pdf.

combustible tobacco, 3.0% who used smokeless tobacco, and 3.6% who used e-cigarettes; 4.6% reported using two or more tobacco products.

Any current tobacco use was highest among men (27.4%), non-Hispanic whites (whites) (24.8%), persons aged 18–34 years (24.9%), those with high school education or less (30.1%), those with no health insurance (33.9%), those living below the federal poverty level[¶] (28.5%), and those living in the Midwest (25.8%). Multiple tobacco product use was highest among men (6.5%), whites (5.5%), persons aged 18–34 years (6.0%), persons with a high school education or less (6.2%), and persons with no health insurance (7.7%) (Table 1).

Current tobacco use varied by industry (Table 2) and occupation (Table 3). Workers in the construction industry (34.3%) and installation, maintenance, and repair occupations (37.2%) had the highest reported use of any tobacco. Multiple tobacco product use was highest among workers in the construction industry (7.1%) and installation, maintenance, and repair occupations (10.1%). Cigarette smoking was highest among workers in the accommodation and food services industry (24.0%) and construction and extraction occupations (25.8%). Other combustible tobacco product use was highest among workers in the utilities industry (9.0%) and protective services occupations (10.2%). Smokeless tobacco use was highest among workers in the mining industry (14.3%) and installation, maintenance and repair occupations (9.6%). E-cigarette use was highest among workers in the accommodation and food services industry (5.8%) and installation, maintenance, and repair occupations (7.9%).

Summary

What is already known about this topic?

Differences exist in tobacco use by industry and occupation among U.S. working adults. Workplace tobacco-control interventions have been effective in reducing cigarette smoking prevalence and exposure to secondhand smoke.

What is added by this report?

Analysis of National Health Interview Survey data for 2014–2016 found that among working adults, 22.1% currently (every day or some days) used any form of tobacco product; 15.4% currently used cigarettes, 5.8% used other combustible tobacco products, 3.0% used smokeless tobacco, and 3.6% used electronic cigarettes; overall, 4.6% used two or more tobacco products. By industry, any tobacco product use ranged from 11.0% among education services to 34.3% among construction workers; use of two or more tobacco products was highest among construction industry workers. By occupation, any tobacco use ranged from 9.3% among life, physical, and social science workers to 37.2% among installation, maintenance, and repair workers; use of two or more tobacco products was highest among installation, maintenance, and repair workers.

What are the implications for public health action?

These findings underscore the importance of continued implementation of proven strategies to prevent and reduce tobacco product use, including current use of multiple products among working adults. To maximize the health of workers, employers could also consider integrating comprehensive and effective tobacco cessation programs into health promotion programs in the workplace.

Discussion

During 2014–2016, an estimated one in five working U.S. adults (32.7 million; 22.1%) currently used some form of tobacco, and cigarettes were the most commonly used tobacco product. Overall, a decline in cigarette smoking, smokeless tobacco, and e-cigarette use was observed among U.S. workers (*2*,*4*). However, tobacco use varied by product type, sociodemographic characteristics, and industry and occupation, with a higher prevalence of any tobacco use among workers in the construction industries and installation, maintenance, and repair occupations. These findings underscore the importance of implementation of evidence-based interventions, in coordination with continued surveillance of all forms of tobacco products use, to reduce tobacco-related disease and death[**] among U.S. working adults, particularly industry and occupation groups with higher tobacco use prevalences (*1*).

Among working adult tobacco users, an estimated 6.9 million adults used two or more tobacco products. Use of multiple tobacco products is associated with increased risk for nicotine addiction, dependence, and adverse health effects (*3*,*8*). These health effects can lead to increased risks for tobacco-related morbidity and mortality (*3*). In addition, variations in multiple tobacco product use were observed across population groups, which is consistent with previous findings of higher prevalences of combustible and smokeless tobacco use among workers in certain industries and occupations (*2*). These findings underscore the importance of opportunities for targeted efforts to reduce tobacco use among populations with the greatest prevalence of tobacco use, including multiple tobacco product users.

[¶] Poverty status is based on family income and family size using the U.S. Census Bureau's poverty thresholds for the previous calendar year. In the National Health Interview Survey, "'poor" persons are defined as having incomes less than the poverty threshold, "near poor"' are defined as having incomes of 100% to less than 200% of the poverty threshold, and "not poor" are defined as having incomes that are 200% of the poverty threshold or greater. ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/samadult_layout.pdf.

[**] Task Force on Community Preventive Services. https://www.thecommunityguide.org/tobacco/tobacco.pdf.

TABLE 1. Estimated prevalence of current tobacco use among working* adults, by product type and selected characteristics — National Health Interview Survey, United States, 2014–2016

Characteristic	No. currently employed adults† (x 1000)	% (95%CI)					
		Cigarette smokers§	Other combustible tobacco products¶	Smokeless tobacco products**	E-cigarettes††	Any tobacco product§§	≥2 Tobacco products¶¶
Total (100%)	**148,481**	**15.4 (15.0–15.8)**	**5.8 (5.5–6.1)**	**3.0 (2.8–3.3)**	**3.6 (3.3–3.8)**	**22.1 (21.6–22.6)**	**4.6 (4.4–4.9)**
Age group (yrs)							
≥18–34	51,289	16.3 (15.5–17.1)	7.9 (7.4–8.5)	3.6 (3.3–4.0)	4.8 (4.4–5.2)	24.8 (23.9–25.8)***	6.0 (5.6–6.5)***
≥35–54	64,600	16.2 (15.6–16.8)	5.0 (4.6–5.5)	3.2 (2.9–3.5)	3.5 (3.1–3.8)	22.6(21.9–22.3)	4.4 (4.1–4.8)
≥55	32,592	12.4 (11.7–13.1)	3.9 (3.4–4.3)	1.7 (1.4–2.0)	1.9 (1.6–2.2)	16.6 (15.8–17.4)	2.8 (2.4–3.1)
Sex							
Men	78,858	16.9 (16.3–17.5)	9.0 (8.6–9.5)	5.5 (5.1–5.9)	4.3 (3.9–4.6)	27.4 (26.7–28.2)***	6.5 (6.0–6.9)***
Women	69,623	13.7 (13.2–14.3)	2.1 (1.9–2.3)	0.2 (0.1–0.3)	2.8 (2.6–3.1)	16.0 (15.4–16.5)	2.6 (2.3–2.8)
Race/Ethnicity							
Hispanic	24,331	11.2 (10.3–12.1)	3.8 (3.3–4.4)	0.7 (0.5–0.9)	2.1 (1.7–2.5)	15.0 (14.0–16.0)	2.3 (1.9–2.7)
White, non-Hispanic	96,908	16.9 (16.4–17.5)	6.3 (6.0–6.7)	4.2 (3.9–4.5)	4.2 (3.9–4.6)	24.8 (24.1–25.4)***	5.5 (5.2–5.9)***
Black, non-Hispanic	17,131	14.9 (13.8–16.0)	7.0 (6.2–7.8)	0.8 (0.6–1.0)	2.2 (1.8–2.7)	20.6 (19.3–21.9)	3.7 (3.1–4.2)
Other	10,111	11.8 (10.6–13.1)	3.0 (2.3–3.6)	1.2 (0.7–1.7)	3.4 (2.6–4.3)	15.7 (14.3–17.1)	3.1 (2.4–4.2)
Education							
≤High school, GED	45,932	23.6 (22.8–24.4)	5.4 (4.9–5.8)	4.3 (3.8–4.7)	4.6 (4.1–5.0)	30.1 (29.2–31.0)***	6.2 (5.7–6.7)***
>High school	101,999	11.7 (11.2–12.2)	6.0 (5.6–6.4)	2.5 (2.2–2.7)	3.2 (2.9–3.4)	18.4 (17.8–19.0)	3.9 (3.6–4.2)
Unknown	550	—†††	—†††	—†††	—†††	—†††	—†††
Poverty index§§§							
Poor	11,313	22.9 (21.4–24.4)	6.3 (5.4–7.2)	2.3 (1.7–2.9)	4.4 (3.7–5.1)	28.5 (26.9–30.2)***	6.1 (5.3–6.9)***
Near poor	21,065	22.9 (21.7–24.0)	5.2 (4.6–5.9)	2.6 (2.1–3.0)	5.1 (4.4–5.8)	28.1 (26.8–29.4)***	6.2 (5.5–6.9)***
Not poor	107,453	13.4 (12.9–13.9)	6.0 (5.6–6.4)	3.2 (3.0–3.6)	3.3 (3.0–3.6)	20.6 (19.9–21.2)	4.3 (4.0–4.6)
Unknown	8,650	12.1 (10.6–13.7)	3.6 (2.7–4.6)	2.2 (1.5–2.9)	2.9 (2.0–3.7)	17.1 (15.2–19.0)	2.8 (2.1–3.5)
Health insurance							
Not insured	17,095	27.5 (26.1–28.9)	7.0 (6.2–7.8)	3.4 (2.8–4.0)	5.5 (4.7–6.3)	33.9 (32.3–35.5)***	7.7 (6.9–8.5)***
Insured	130,460	13.8 (13.4–14.2)	5.6 (5.3–5.9)	3.0 (2.7–3.2)	3.3 (3.1–3.5)	20.5 (20.0–21.0)	4.2 (3.9–4.5)
Unknown	926	—†††	—†††	—†††	—†††	—†††	—†††
U.S. Census region¶¶¶							
Northeast	25,712	14.1 (13.2–15.1)	5.6 (4.8–6.4)	1.4 (1.1–1.8)	2.5 (2.0–3.0)	19.9 (18.7–21.1)	3.3 (2.7–3.8)
Midwest	34,657	18.8 (17.9–19.8)	5.9 (5.4–6.5)	4.1 (3.6–4.7)	3.9 (3.4–4.4)	25.8 (24.8–26.9)***	5.5 (5.0–6.0)
South	53,050	16.0 (15.3–16.7)	5.8 (5.3–6.3)	3.6 (3.2–4.0)	3.8 (3.3–4.2)	22.9 (22.0–23.8)	4.9 (4.5–5.4)
West	35,062	12.1 (11.4–12.8)	5.8 (5.2–6.4	2.3 (2.0–2.7)	3.9 (3.4–4.3)	18.7 (17.8–19.6)	4.3 (3.7–4.8)

Abbreviations: CI = confidence interval; GED = General Educational Development certificate or diploma.

* Adults who reported "working at a job or business"; "with a job or business but not at work"; or "working, but not for pay, at a family-owned job or business" during the week before the interview.

† Weighted to provide national annual average estimates for current employment.

§ Cigarette smokers were defined as persons who reported smoking ≥100 cigarettes during their lifetime and who currently smoke every day or some days (estimated n = 22.8 million).

¶ Other combustible tobacco product users were defined as persons who reported smoking cigars, cigarillos, or little filtered cigars or smoking tobacco in a regular pipe, water pipe, or hookah at least once during their lifetime and who currently use every day or some days (estimated n = 8.4 million).

** Smokeless tobacco product users were defined as persons who reported using chewing tobacco, snuff, dip, snus, or dissolvable tobacco at least once during their lifetime and who currently use every day or some days (estimated n = 4.4 million).

†† E-cigarette users were defined as persons reported who reported using electronic cigarettes at least once during their lifetime and who currently use every day or some days (n = 5.2 million).

§§ Any tobacco product users were defined as persons who reported current use of cigarettes or other combustible tobacco or smokeless tobacco or e-cigarettes every day or some days (estimated n = 32.7 million).

¶¶ Persons who reported current use of two or more individual tobacco products (estimated n = 6.9 million).

*** Statistically significant differences (p<0.05).

††† Estimate suppressed (relative standard error >30%).

§§§ Poverty status is based on family income and family size using the U.S. Census Bureau's poverty thresholds for the previous calendar year. In National Health Interview Survey, "poor" persons are defined as having incomes below the poverty threshold, "near poor" are defined as having incomes of 100% to less than 200% of the poverty threshold, and "not poor" are defined as having incomes that are 200% of the poverty threshold or greater. Additional information available at ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/srvydesc.pdf.

¶¶¶ https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf.

TABLE 2. Estimated prevalence of current tobacco use among working* adults, by tobacco product type and industry — National Health Interview Survey, United States, 2014–2016

Industry group	No. currently employed adults† (x 1000)	% (95% CI) Cigarette smokers§	Other combustible tobacco products¶	Smokeless tobacco products**	E-cigarettes††	Any tobacco product§§	≥2 Tobacco products¶¶
Accommodation and Food Services	9,907	24.0 (22.2–25.7)	6.9 (5.6–8.1)	2.1 (1.4–2.8)	5.8 (4.7–6.8)	29.9 (28.0–31.9)	7.0 (5.9–8.1)
Construction	9,346	23.4 (21.6–25.3)	7.9 (6.7–9.1)	7.8 (6.5–9.0)	4.2 (3.3–5.1)	34.3 (32.3–36.3)	7.1 (6.0–8.3)
Administrative and Support and Waste Management and Remediation Services	6,641	22.4 (20.3–24.5)	6.9 (5.5–8.3)	3.8 (2.7–5.0)	5.2 (3.9–6.4)	30.0 (27.8–32.3)	6.9 (5.4–8.4)
Transportation and Warehousing	6,052	20.3 (18.2–22.3)	7.4 (5.9–8.9)	5.3 (4.0–6.5)	5.2 (3.6–6.7)	30.2 (27.6–32.8)	6.5 (5.1–7.9)
Manufacturing	14,940	19.6 (18.2–20.9)	6.6 (5.4–7.8)	4.9 (4.2–5.6)	3.9 (2.8–5.1)	27.3 (25.7–28.9)	5.9 (4.9–7.0)
Retail Trade	14,968	17.8 (16.5–19.1)	6.1 (5.3–6.9)	2.3 (1.8–2.9)	4.8 (4.1–5.6)	24.3 (22.9–25.8)	5.5 (4.7–6.4)
Mining	859	17.5 (10.6–24.4)	5.2 (2.7–7.7)	14.3 (6.7–21.8)	—***	30.4 (23.3–37.5)	—***
Other Services (except Public Administration)	7,346	16.1 (14.3–17.9)	5.6 (4.3–6.8)	2.1 (1.5–2.8)	4.2 (3.1–5.2)	21.2 (19.1–23.2)	5.5 (4.3–6.7)
Wholesale Trade	3,810	16.0 (13.4–18.7)	6.5 (4.7–8.4)	4.0 (2.6–5.4)	3.6 (2.4–4.8)	24.2 (21.2–27.2)	4.9 (3.5–6.4)
Real Estate and Rental and Leasing	2,932	14.9 (12.3–17.5)	5.5 (3.8–7.2)	2.8 (1.5–4.1)	3.6 (2.2–5.0)	21.9 (18.8–25.0)	4.2 (2.7–5.6)
Agriculture, Forestry, Fishing, and Hunting	2,105	14.3 (11.5–17.2)	3.9 (2.5–5.3)	7.3 (5.2–9.5)	—***	21.4 (18.0–24.8)	5.0 (3.3–6.8)
Utilities	1,350	13.4 (9.4–17.4)	9.0 (5.7–12.4)	8.8 (4.5–13.1)	—***	25.3 (19.6–31.1)	5.4 (3.1–7.8)
Health Care and Social Assistance	19,755	13.0 (11.9–14.1)	3.3 (2.8–3.9)	1.2 (0.8–1.5)	2.4 (1.9–2.8)	16.4 (15.1–17.7)	2.7 (2.3–3.2)
Information	3,071	11.7 (9.3–14.0)	6.6 (4.8–8.5)	1.9 (0.9–2.9)	3.2 (1.8–4.5)	19.3 (16.4–22.2)	3.2 (2.0–4.5)
Finance and Insurance	6,775	11.2 (9.5–12.8)	5.6 (4.2–6.9)	1.7 (0.8–2.6)	3.2 (2.2–4.1)	17.6 (15.6–19.7)	3.2 (2.2–4.3)
Arts, Entertainment, and Recreation	3,059	11.1 (9.1–13.0)	6.4 (4.5–8.3)	2.3 (1.0–3.5)	3.6 (2.2–4.9)	17.4 (14.9–19.9)	5.1 (3.5–6.8)
Public Administration	7,358	10.9 (9.5–12.3)	6.4 (5.1–7.7)	3.8 (2.9–4.8)	2.1 (1.5–2.7)	19.0 (17.1–20.9)	3.6 (2.7–4.4)
Professional, Scientific, and Technical Services	11,286	9.6 (8.4–10.8)	7.1 (6.1–8.2)	1.5 (1.1–1.9)	3.9 (3.1–4.7)	17.7 (16.2–19.2)	3.4 (2.7–4.1)
Education services	14,135	7.2 (6.3–8.0)	3.3 (2.7–4.0)	1.2 (0.8–1.6)	1.4 (1.1–1.8)	11.0 (10.0–12.1)	1.7 (1.3–2.1)
Armed Forces	224	—***	—***	—***	—***	—***	—***
Management of Companies and Enterprises	83	—***	—***	—***	—***	—***	—***

Abbreviation: CI = confidence interval.

* Adults who reported "working at a job or business"; "with a job or business but not at work"; or "working, but not for pay, at a family-owned job or business" during the week before the interview.

† Weighted to provide national annual average estimates for current employment.

§ Cigarette smokers were defined as persons who reported smoking ≥100 cigarettes during their lifetime and who currently smoke every day or some days (estimated n = 22.8 million).

¶ Other combustible tobacco product users were defined as persons who reported smoking cigars, cigarillos, or little filtered cigars or smoking tobacco in a regular pipe, water pipe, or hookah at least once during their lifetime and who currently use every day or some days (estimated n = 8.4 million).

** Smokeless tobacco product users were defined as persons who reported using chewing tobacco, snuff, dip, snus, or dissolvable tobacco at least once during their lifetime and who currently use every day or some days (estimated n = 4.4 million).

†† E-cigarette users were defined as persons who reported using electronic cigarettes at least once during their lifetime and who currently use every day or some days (n = 5.2 million).

§§ Any tobacco product users were defined as persons who reported current use of cigarettes or other combustible tobacco or smokeless tobacco or e-cigarettes every day or some days (estimated n = 32.7 million).

¶¶ Persons who reported current use of two or more individual tobacco products (estimated n = 6.9 million).

*** Estimate suppressed (relative standard error >30%).

The findings in this report are subject to at least three limitations. First, the collected employment information applied only to the week before the interview. Some workers might have changed jobs, and thus, might have been in a different occupation or industry at the time of the survey interview. However, supplemental analyses examining the longest held job yielded similar results. Second, the extent of under- or overreporting of tobacco use could not be determined because tobacco use information was self-reported, and thus, was not validated by biochemical tests. However, comparison of self-reported smoking status with measured serum cotinine levels suggests generally high levels of correlation (*9*). Finally, estimates for some groups (e.g., management of companies and enterprises industry workers) and tobacco product use were unreliable and suppressed because of small sample sizes.

TABLE 3. Estimated prevalence of current tobacco use among working* adults, by tobacco product type and occupation — National Health Interview Survey, United States, 2014–2016

Occupation group	No. currently employed adults† (x 1000)	% (95% CI)					
		Cigarette smokers§	Other combustible tobacco products¶	Smokeless tobacco products**	E-cigarettes††	Any tobacco product§§	≥2 Tobacco products¶¶
Construction and Extraction	7,175	25.8 (23.7–28.0)	7.3 (5.9–8.7)	9.0 (7.5–10.4)	3.9 (3.0–4.8)	36.5 (34.1–38.9)	7.5 (6.2–8.9)
Food Preparation and Serving Related	7,501	25.1 (22.9–27.3)	6.5 (5.1–7.8)	1.7 (1.1–2.4)	5.3 (4.2–6.4)	29.8 (27.5–32.1)	6.8 (5.6–8.0)
Production	8,563	23.7 (21.8–25.6)	6.7 (5.6–7.8)	5.8 (4.8–6.7)	4.2 (3.3–5.1)	31.1 (29.0–33.3)	7.4 (6.3–8.5)
Installation, Maintenance, and Repair	5,043	23.1 (19.6–26.5)	10.1 (7.2–12.9)	9.6 (7.5–11.7)	7.9 (5.2–10.7)	37.2 (33.0–41.3)	10.1 (6.7–13.4)
Transportation and Material Moving	8,410	22.5 (20.6–24.4)	7.7 (6.4–8.9)	5.2 (4.4–6.1)	5.1 (4.0–6.2)	31.8 (29.7–33.9)	7.0 (5.8–8.2)
Building and Grounds Cleaning and Maintenance	5,896	22.0 (19.7–24.3)	4.8 (3.5–6.0)	2.9 (1.9–3.9)	3.3 (2.4–4.2)	26.5 (24.0–29.0)	5.3 (4.0–6.5)
Healthcare Support	3,298	18.6 (15.7–21.5)	2.4 (1.4–3.5)	1.3 (0.6–2.0)	3.4 (2.3–4.6)	21.8 (18.7–24.8)	3.3 (2.2–4.5)
Personal Care and Service	5,281	17.6 (14.2–21.0)	4.9 (3.6–6.2)	—***	4.0 (2.9–5.2)	21.4 (17.9–24.9)	5.2 (3.9–6.5)
Office and Administrative Support	17,481	16.3 (15.2–17.4)	3.8 (3.2–4.4)	1.2 (0.9–1.6)	4.1 (3.4–4.9)	21.1 (19.8–22.3)	3.9 (3.3–4.4)
Protective Service	3,067	15.8 (12.8–18.7)	10.2 (7.7–12.6)	8.3 (6.1–10.6)	3.5 (2.0–5.0)	29.1 (25.5–32.7)	6.8 (4.4–9.1)
Farming, Fishing, and Forestry	1,128	15.6 (11.7–19.5)	4.2 (2.4–6.1)	8.9 (5.8–12.1)	—***	23.8 (19.3–28.3)	5.6 (3.2–8.0)
Sales and Related	14,639	15.2 (13.9–16.5)	6.9 (6.0–7.9)	2.7 (2.0–3.4)	4.2 (3.5–4.9)	22.7 (21.2–24.2)	5.0 (4.2–5.8)
Management	14,856	12.0 (10.9–13.1)	6.9 (6.0–7.7)	3.0 (2.4–3.6)	3.0 (2.4–3.6)	19.8 (18.4–21.2)	4.0 (3.3–4.6)
Computer and Mathematical	5,218	9.6 (7.9–11.2)	5.8 (4.7–7.0)	1.3 (0.7–2.0)	2.8 (1.9–3.7)	16.5 (14.4–18.5)	2.6 (1.8–3.3)
Business and Financial Operations	7,664	9.2 (7.9–10.5)	5.3 (4.2–6.4)	1.9 (1.1–2.7)	2.5 (1.8–3.2)	15.0 (13.4–16.7)	3.1 (2.3–3.9)
Community and Social Services	2,756	8.9 (6.8–11.0)	5.3 (3.3–7.2)	—***	2.2 (1.3–3.1)	13.5 (11.0–16.1)	2.7 (1.3–4.0)
Architecture and Engineering	3,295	8.8 (6.7–10.8)	7.8 (5.6–10.0)	2.9 (1.7–4.2)	3.0 (1.7–4.4)	18.3 (15.2–21.3)	3.7 (2.3–5.1)
Arts, Design, Entertainment, Sports, and Media	3,083	8.7 (6.9–10.6)	7.2 (5.4–9.1)	1.8 (0.9–2.8)	2.9 (1.5–4.2)	16.7 (14.1–19.2)	3.2 (1.9–4.5)
Healthcare Practitioners and Technical	8,642	8.1 (6.9–9.3)	2.8 (2.1–3.6)	0.9 (0.4–1.3)	2.2 (1.5–2.8)	11.7 (10.4–13.1)	2.0 (1.3–2.6)
Legal	1,766	7.3 (5.0–9.5)	5.7 (3.5–8.0)	—***	2.4 (1.0–3.7)	14.1 (11.1–17.1)	—***
Education, Training, and Library	9,474	5.7 (4.7–6.6)	3.3 (2.5–4.1)	1.2 (0.6–1.7)	1.3 (0.9–1.8)	9.5 (8.3–10.8)	1.5 (1.0–2.0)
Life, Physical, and Social Science	1,535	5.6 (3.5–7.7)	3.9 (2.1–5.7)	—***	—***	9.3 (6.8–11.8)	—***
Military	234	—***	—***	—***	—***	—***	—***

Abbreviation: CI = confidence interval.

* Adults who reported "working at a job or business"; "with a job or business but not at work"; or "working, but not for pay, at a family-owned job or business" during the week before the interview.

† Weighted to provide national annual average estimates for current employment.

§ Cigarette smokers were defined as persons who reported smoking ≥100 cigarettes during their lifetimes and who currently smoke every day or some days (estimated n = 22.8 million).

¶ Other combustible tobacco product users were defined as persons who reported smoking cigars, cigarillos, or little filtered cigars or smoking tobacco in a regular pipe, water pipe, or hookah at least once during their lifetime and who currently use every day or some days (estimated n = 8.4 million).

** Smokeless tobacco product users were defined as persons who reported using chewing tobacco, snuff, dip, snus, or dissolvable tobacco at least once during their lifetime and who currently use every day or some days (estimated n = 4.4 million).

†† E-cigarettes users were defined as persons who reported using electronic cigarettes at least once during their lifetime and who currently use every day or some days (n = 5.2 million).

§§ Any tobacco product users were defined as persons who reported current use of cigarettes or other combustible tobacco or smokeless tobacco or e-cigarettes every day or some days (estimated n = 32.7 million).

¶¶ Persons who reported current use of two or more individual tobacco products (estimated n = 6.9 million).

*** Estimate suppressed (relative standard error >30%).

Continued implementation of proven strategies to address tobacco use among U.S. adults is important (*6*,*8*,*10*). Proven strategies include anti-tobacco messages; comprehensive tobacco-free laws covering public places and worksites; providing comprehensive coverage for tobacco cessation treatments for employees; increased tobacco prices; and tailored interventions that help prevent initiation and encourage cessation among workers. Workplace tobacco-control interventions have been especially effective in reducing cigarette smoking prevalence (*7*). Previous research has indicated that workers at worksites that adopted or maintained smoke-free policies were twice as likely to quit smoking than those whose worksites did not implement such policies (*7*). To maximize the health of workers, employers can also consider integrating

comprehensive and effective tobacco cessation programs into workplace health promotion programs (*7*,*10*).

Acknowledgments

Ahmed Jamal, Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion, CDC; Charlotte A. Schoenborn, Division of Health Interview Statistics, National Center for Health Statistics, CDC.

Conflict of Interest

No conflicts of interest were reported.

[1]Respiratory Health Division, National Institute for Occupational Safety and Health, CDC; [2]Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion, CDC.

Corresponding author: Girija Syamlal, gsyamlal@cdc.gov, 304-285-5827.

References

1. US Department of Health and Human Services. The health consequences of smoking—50 years of progress: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, CDC; 2014. http://www.surgeongeneral.gov/library/reports/50-years-of-progress/full-report.pdf
2. Syamlal G, Jamal A, Mazurek JM. Combustible tobacco and smokeless tobacco use among working adults—United States, 2012 to 2014. J Occup Environ Med 2016;58:1185–9. https://doi.org/10.1097/JOM.0000000000000898
3. Sung HY, Wang Y, Yao T, Lightwood J, Max W. Polytobacco use of cigarettes, cigars, chewing tobacco, and snuff among US adults. Nicotine Tob Res 2016;18:817–26. https://doi.org/10.1093/ntr/ntv147
4. Syamlal G, Jamal A, King BA, Mazurek JM. Electronic cigarette use among working adults—United States, 2014. MMWR Morb Mortal Wkly Rep 2016;65:557–61. https://doi.org/10.15585/mmwr.mm6522a1
5. Cahill K, Moher M, Lancaster T. Workplace interventions for smoking cessation. Cochrane Database Syst Rev 2008;(4):CD003440.
6. CDC. Best practices for comprehensive tobacco control programs—2014. Atlanta, GA: US Department of Health and Human Services, CDC; 2014. https://www.cdc.gov/tobacco/stateandcommunity/best_practices/pdfs/2014/comprehensive.pdf
7. Castellan RM, Chosewood LC, Trout D, et al. Current intelligence bulletin 67: promoting health and preventing disease and injury through workplace tobacco policies. Morgantown, WV: US Department of Health and Human Services, CDC, National Institute for Occupational Safety and Health; 2015. https://www.cdc.gov/niosh/docs/2015-113
8. Bombard JM, Pederson LL, Nelson DE, Malarcher AM. Are smokers only using cigarettes? Exploring current polytobacco use among an adult population. Addict Behav 2007;32:2411–9. https://doi.org/10.1016/j.addbeh.2007.04.001
9. Caraballo RS, Giovino GA, Pechacek TF, Mowery PD. Factors associated with discrepancies between self-reports on cigarette smoking and measured serum cotinine levels among persons aged 17 years or older: Third National Health and Nutrition Examination Survey, 1988–1994. Am J Epidemiol 2001;153:807–14. https://doi.org/10.1093/aje/153.8.807
10. Bauer JE, Hyland A, Li Q, Steger C, Cummings KM. A longitudinal assessment of the impact of smoke-free worksite policies on tobacco use. Am J Public Health 2005;95:1024–9. https://doi.org/10.2105/AJPH.2004.048678

Increased Risk for Mother-to-Infant Transmission of Hepatitis C Virus Among Medicaid Recipients — Wisconsin, 2011–2015

Theresa Watts, MPH[1]; Lauren Stockman, MPH[2]; Justin Martin, MPA[2]; Sheila Guilfoyle[2]; James M. Vergeront, MD[2]

State surveillance during the last 10 years reveals a nationwide increase in hepatitis C virus (HCV) infection among young adults (*1*). The proportion of infants born to HCV-infected women is also increasing nationally (*2*). To estimate the proportion of infants born to HCV-infected women and the frequency of confirmed HCV infection in their infants, maternal name and date of birth from HCV reports in the Wisconsin Electronic Disease Surveillance System (WEDSS) were linked to Wisconsin Medicaid data for 2011–2015 births. During this period, in the Wisconsin Medicaid population, the proportion of women who had evidence of HCV infection during pregnancy increased 93%, from 1 in 368 pregnancies to 1 in 192. Among 183 infants born to women with evidence of HCV viremia during pregnancy, 34% received recommended HCV testing (*3*). Mother-to-infant (vertical) transmission was documented in 4% of infants. Improvements in HCV screening practices among pregnant women and infants could enhance identification of infants at risk for vertical transmission of HCV.

Fueled by the increase in injection drug use ensuing from the opioid epidemic, the proportion of infants born to HCV-infected women is increasing nationwide (*1*,*2*). Vertical transmission is the most common mechanism of HCV infection for children, reported to occur in approximately 6% of infants born to women with HCV infection and approximately twice as often in women who are coinfected with HCV and human immunodeficiency virus (HIV) (*4*,*5*). Another risk factor that might increase the likelihood of vertical HCV transmission is presence of maternal HCV viremia (HCV RNA positivity) (*5*). Unlike other bloodborne infectious diseases that have a risk for vertical transmission, such as hepatitis B virus or HIV, for HCV there is no perinatal intervention available that has been shown to reduce vertical HCV transmission (*4*–*6*). Clinical signs of pediatric HCV infection often manifest slowly and can range in severity from being asymptomatic to fatal; liver transplantation is sometimes required (*7*,*8*).

During 2011–2015, the reported rate of HCV among persons aged 15–44 years in Wisconsin increased 81%, from 45.7 to 82.6 per 100,000 population; 3,013 (43%) reported cases in this age group were in women (Wisconsin Division of Public Health, unpublished data, 2016). Increases in the number of women of childbearing age with HCV in Wisconsin predict an increase in the number of infants at risk for vertical transmission. The aim of this study was to estimate the proportion of women enrolled in Wisconsin Medicaid with HCV infection during pregnancy and estimate the frequency of HCV testing and infection in infants born to HCV-infected women.

Since 2000, all HCV-positive laboratory tests in Wisconsin have been reportable to the Wisconsin Department of Health Services through WEDSS. To identify maternal HCV infection, Wisconsin Medicaid encounter data for pregnant women who delivered one or more infants during 2011–2015 were extracted and linked by maternal name and maternal date of birth to WEDSS. For women who matched to both data sources, WEDSS HCV surveillance data were reviewed for evidence of HCV infection (positive laboratory reports for anti-HCV antibody or RNA). The study protocol was reviewed and approved by the Minimal Risk (Health Sciences) Institutional Review Board at the University of Wisconsin–Madison.

Consistent with a previous study (*5*), vertical transmission risk by pregnancy was classified based on presence of maternal HCV infection (anti-HCV antibody or HCV RNA). Women with HCV infection reported before their date of delivery were categorized into three risk groups: 1) high risk (evidence of viremia [RNA-positive] during pregnancy); 2) possible risk (evidence of viremia before pregnancy but no RNA results during pregnancy); and 3) unknown viremic risk (anti-HCV antibody-positive but no RNA results). Women in the cohort whose first reported HCV infection was after delivery were categorized separately, because HCV infection status during pregnancy was not known. The proportion of pregnancies at risk for vertical transmission was calculated as the number of pregnancies among Medicaid recipients who had evidence of HCV infection among all pregnancies in Medicaid recipients.

Among infants born to women at high risk, Medicaid encounter data were searched for evidence of HCV testing, indicated by a Current Procedural Terminology code or an *International Classification of Diseases, 9th and 10th Revisions*, Clinical Modification code for HCV infection from the date of birth through June 30, 2016 (last date with complete and available data). Medicaid encounter data for infants were linked by name and date of birth to WEDSS to identify evidence of HCV infection. Infants were classified as having been tested according to recommendations if the infant had an anti-HCV antibody test after age 18 months or two or more HCV RNA tests after age 2 months (*3*). HCV vertical transmission was determined through WEDSS data and was defined as a positive

laboratory report of HCV infection in an infant tested for HCV per recommendations (*3*).

Among 146,267 Wisconsin Medicaid recipients who had a birth during 2011–2015, evidence of HCV infection before the delivery date was documented for 608 (0.4%) women. Among these women, 180 (30%) were classified as being at high risk, two of whom had HIV coinfection; 151 (25%) were classified as being at possible risk; and 277 (46%) were classified as having an unknown viremic risk. An additional 472 women had an HCV infection reported after their date of delivery (Figure 1). The proportion of women with an HCV infection before their date of delivery increased 93% from 2011 (2.7 per 1,000) to 2015 (5.2 per 1,000) (Figure 2); an increase from 1 in 368 pregnancies to 1 in 192.

The median age of women with evidence of HCV viremia during pregnancy was 26 years (range = 18–47 years) (Table). Among the 180 women who had evidence of HCV viremia during pregnancy, 142 (79%) were non-Hispanic white, compared with 52% of women who did not have any evidence of HCV infection during pregnancy (Table).

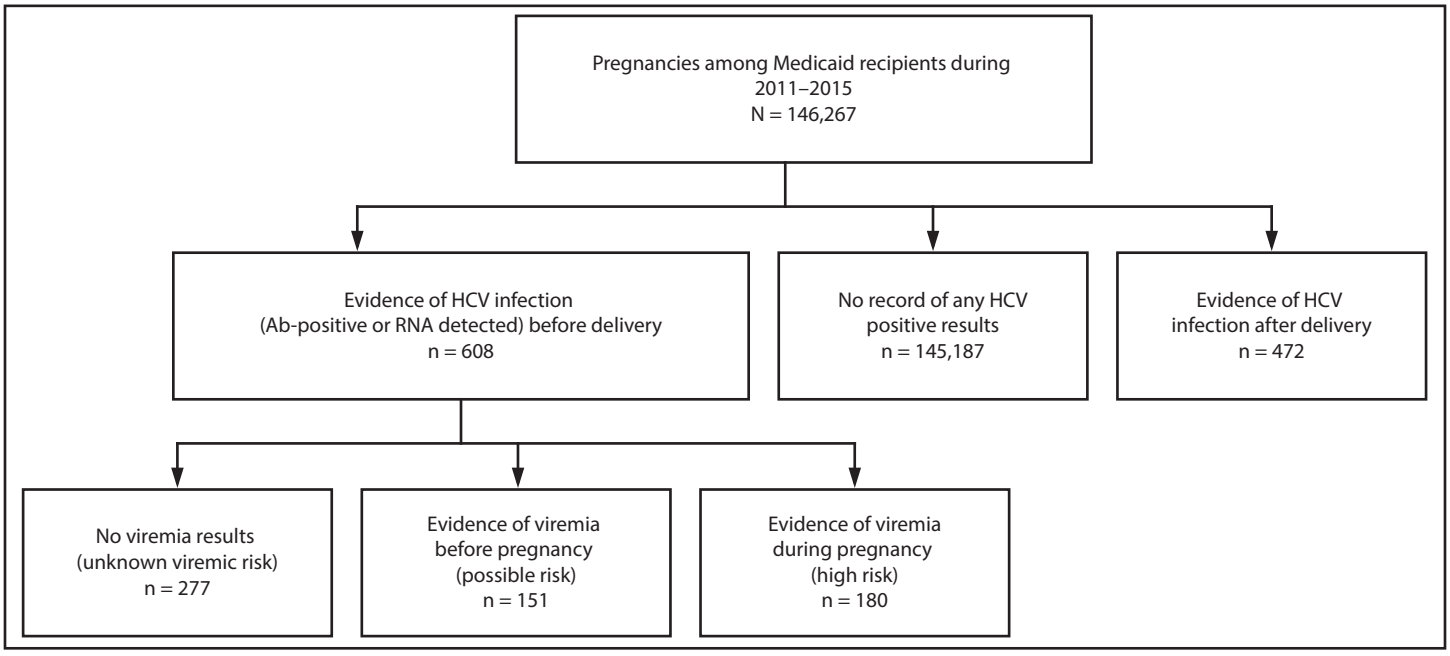
Among 183 infants born to women who had evidence of HCV viremia during pregnancy, 92 (50%) were continuously enrolled in Medicaid for ≥18 months (range = 18–66 months). Among these infants, 31 (34%) were tested for HCV according to recommendations, including 24 who had an anti-HCV antibody test at age >18 months and seven who had at least two RNA tests at age >2 months. Vertical transmission was documented in seven (4%) of the 183 infants born to women with evidence of HCV viremia during pregnancy.

Discussion

Consistent with national and other state studies (*2*,*4*), these findings demonstrate that among Wisconsin Medicaid recipients, the rate of HCV infection among pregnant women is increasing. A recent national study used birth certificates to document maternal HCV infection and found that 1 in 308 infants were born to HCV-infected women in 2014 (*2*). In Wisconsin, an estimated 30% of children born to women with HCV infection do not have HCV indicated on their birth certificate (Wisconsin Division of Public Health, unpublished data, 2017). The current study which used surveillance data mandated by state statute to identify maternal HCV infection and therefore might provide more complete HCV case ascertainment, found that the rate of births to Wisconsin Medicaid-recipients with HCV infection approximately doubled from 2011 to 2015, from 2.7% to 5.2%.

The age, race, and ethnicity of women with HCV infection during pregnancy in this study were similar to those in previously reported studies (*1*,*2*,*4*) and are consistent with trends among young adults with recent HCV infection in Wisconsin (Wisconsin Division of Public Health, unpublished data, 2016). Of interest is the young age of women who had evidence

FIGURE 1. Classification of vertical transmission risk based on hepatitis C virus (HCV) infection status* among Medicaid recipients — Wisconsin Medicaid data and the Wisconsin Electronic Disease Surveillance System, Wisconsin, 2011–2015



Abbreviation: Ab = antibody.

* Women with an HCV infection reported before their date of delivery were categorized into three risk groups: women who had evidence of viremia (RNA-positive) during pregnancy (high risk), women who had evidence of viremia before pregnancy but did not have RNA results during pregnancy (possible risk), and women who were anti-HCV antibody-positive but did not have viremia results (unknown viremic risk).

of HCV infection before delivery and after delivery (median age 27 and 24 years, respectively). Without appropriate treatment for HCV, infants subsequently born to HCV-infected women are at risk for mother-to-infant transmission.

Among a subset of infants born to women with evidence of HCV viremia during pregnancy, 4% had confirmed infection. Prior studies have indicated a lack of adequate HCV testing among children born to HCV-infected women (*4*,*9*). In the current study, only 34% of Wisconsin Medicaid-recipient infants born to women with evidence of HCV viremia during pregnancy were tested for HCV according to recommendations (*3*), revealing a substantial gap in monitoring infants at risk for HCV vertical transmission.

The findings in this report are subject to at least four limitations. First, statewide surveillance data were used to identify HCV infection status and vertical transmission risk category. These data rely on reports from risk-based HCV testing and laboratory reporting and are likely to underestimate the number of women and children with HCV infection. Second, HCV RNA–negative results were not reportable at the time of analysis. Therefore, the number of women with resolved HCV infection is unknown. However, because there are no approved treatment regimens for HCV during pregnancy, it is unlikely that women classified as at high risk had resolved

Summary

What is already known about this topic?

Nationally, the number and rate of hepatitis C virus (HCV) infections among women of childbearing age has increased, suggesting that the number of infants born to HCV-infected women has also increased.

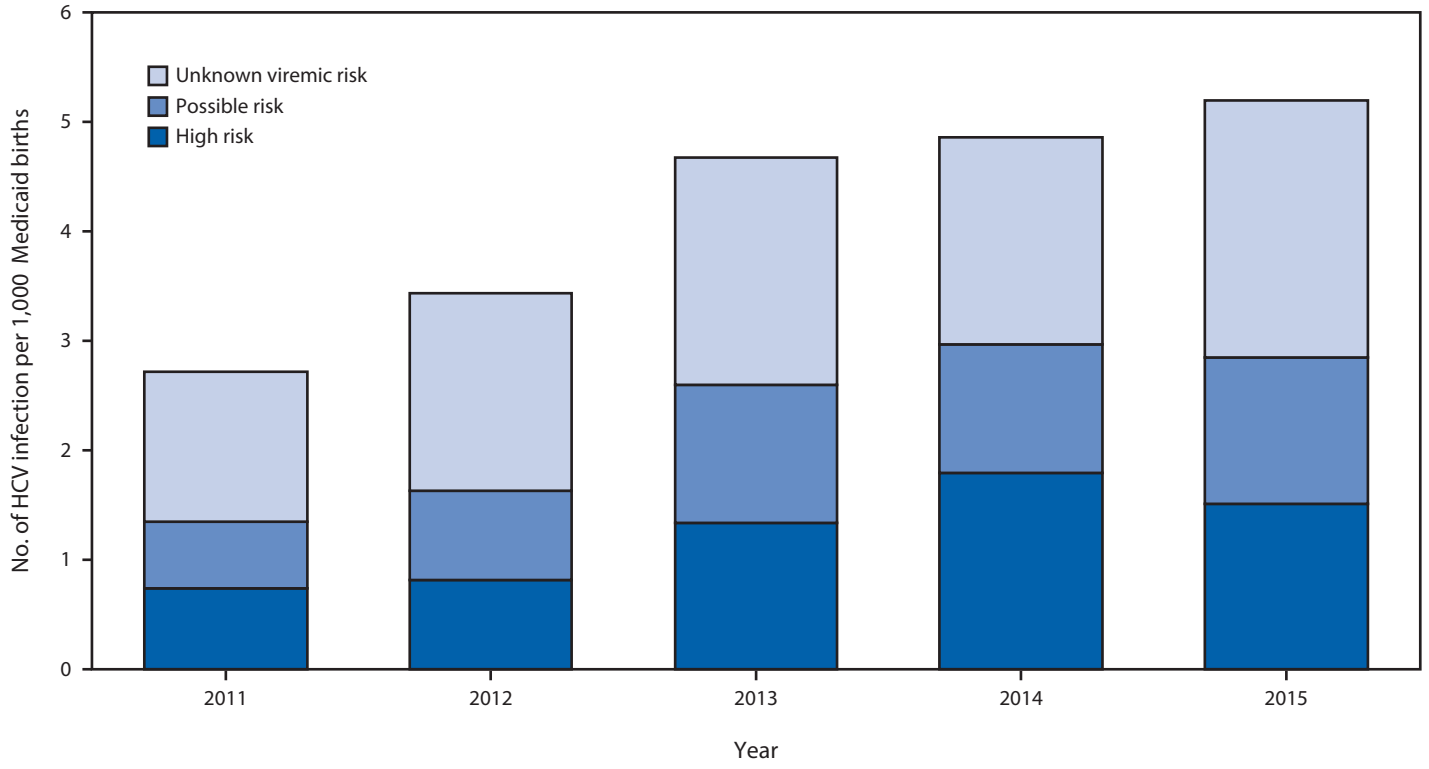
What is added by this report?

Among Wisconsin Medicaid recipients, the rate of HCV infection during pregnancy is increasing. During 2011–2015, the proportion of women who had HCV infection before their date of delivery increased 93%, from 1 in 368 pregnancies to 1 in 192 pregnancies. Among the infants born to women who had evidence of HCV viremia during pregnancy, 34% received HCV testing per the recommendations and evidence of vertical transmission was documented in 4% of infants.

What are the implications for public health practice?

As the rate of HCV infection among women of childbearing age continues to increase nationally, practices for screening pregnant women for HCV and for monitoring infants born to HCV-infected mothers should be improved. Enhanced identification through testing all pregnant women with HCV risk factors and improved public health surveillance of infants at risk for HCV vertical transmission will improve identification, detection, and care for HCV-infected women and infants at risk for HCV vertical transmission.

FIGURE 2. Proportion of pregnant Medicaid recipients with evidence of hepatitis C virus (HCV) infection before delivery, by risk category* — Wisconsin Medicaid data and the Wisconsin Electronic Disease Surveillance System, Wisconsin, 2011–2015



* Unknown viremic risk = anti-HCV antibody-positive, but no viremia (RNA) results available; Possible risk = evidence of viremia before pregnancy, but no RNA results during pregnancy; High risk = evidence of viremia (RNA-positive) during pregnancy.

TABLE. Demographic characteristics of pregnant Medicaid recipients by hepatitis C virus (HCV) risk status — Wisconsin Electronic Disease Surveillance System and Wisconsin Medicaid data, Wisconsin, 2011–2015

	No. (%)			
Characteristic	Evidence of HCV infection before delivery (n = 608)	Evidence of viremia during pregnancy* (n = 180)	Evidence of HCV infection after delivery (n = 472)	No record of any HCV positive results (n = 145,187)
Race,†				
White, non-Hispanic	449 (74)	142 (79)	356 (76)	74,720 (52)
Black, non-Hispanic	48 (8)	5 (3)	14 (3)	25,398 (18)
American Indian, non-Hispanic	28 (5)	12 (7)	32 (7)	3,031 (2)
Asian, non-Hispanic	10 (2)	2 (1)	3 (0.6)	6,967 (5)
Hispanic or Latino	35 (6)	5 (3)	38 (8)	23,260 (16)
Other, non-Hispanic	18 (3)	8 (4)	8 (2)	3,028 (2)
Unknown	20 (3)	6 (3)	19 (4)	8,639 (6)
Age group (yrs)§				
<19	19 (3)	2 (1)	58 (12)	15,937 (11)
20–29	369 (61)	123 (68)	341 (72)	91,396 (63)
30–39	200 (33)	46 (26)	71 (15)	35,569 (25)
≥40	20 (3)	9 (5)	2 (<1)	2,285 (2)
Mean (SD)	**28 (5.44)**	**28 (5.6)**	**25 (4.74)**	**27 (5.57)**
Median (Range)	**27 (17–47)**	**26 (18–47)**	**24 (14–41)**	**25 (11–51)**

Abbreviation: SD = standard deviation.
* These 180 women are a subset of the 608 with evidence of HCV infection before delivery.
† Whites, blacks, American Indians, and Asians were non-Hispanic; Hispanic or Latino persons could be of any race.
§ Mother's age at delivery.

infection before delivery. Third, only 50% of infants born to women at high risk were continuously enrolled in Medicaid, and therefore, HCV testing data for all infants were unavailable. Finally, this analysis of women and infants enrolled in Medicaid represents approximately 38% of the deliveries in Wisconsin during the study period.*

Enhanced identification through HCV screening during pregnancy and public health follow-up to monitor infants at risk for vertical transmission are needed. The current recommendation for identifying HCV-infected pregnant women is through risk-based screening (*3*,*10*). Pregnancy and postpregnancy care might provide an opportune time to test women and link HCV-infected women to HCV care or treatment, because this is a time when a woman might be likely to use health care services. To improve surveillance of HCV vertical transmission, support identification of cases, and evaluate health outcomes of infected infants, the Council of State and Territorial Epidemiologists† recently approved of and issued a position statement for reporting and national notification of perinatal HCV infection. Adoption of this position statement by state and local health departments, along with enhanced identification of HCV among women of childbearing age, can improve care for HCV-infected women and infants at risk for HCV vertical transmission

* https://www.dhs.wisconsin.gov/wish/birth/form.htm.
† http://c.ymcdn.com/sites/www.cste.org/resource/resmgr/2017PS/2017PSFinal/17-ID-08.pdf.

Acknowledgment

Susan Zahner, School of Nursing, University of Wisconsin–Madison.

Conflict of Interest

No conflicts of interest were reported.

[1]School of Nursing, University of Wisconsin–Madison; [2]Wisconsin Division of Public Health.

Corresponding author: Theresa Watts, twatts@wisc.edu.

References

1. Suryaprasad AG, White JZ, Xu F, et al. Emerging epidemic of hepatitis C virus infections among young nonurban persons who inject drugs in the United States, 2006–2012. Clin Infect Dis 2014;59:1411–9. https://doi.org/10.1093/cid/ciu643
2. Koneru A, Nelson N, Hariri S, et al. Increased hepatitis C virus (HCV) detection in women of childbearing age and potential risk for vertical transmission—United States and Kentucky, 2011–2014. MMWR Morb Mortal Wkly Rep 2016;65:705–10. https://doi.org/10.15585/mmwr.mm6528a2
3. CDC. Hepatitis C FAQs for health professionals. Atlanta, GA: US Department of Health and Human Services, CDC; 2017. https://www.cdc.gov/hepatitis/hcv/hcvfaq.htm
4. Kuncio DE, Newbern EC, Johnson CC, Viner KM. Failure to test and identify perinatally infected children born to hepatitis C virus-infected women. Clin Infect Dis 2016;62:980–5. https://doi.org/10.1093/cid/ciw026
5. Benova L, Mohamoud YA, Calvert C, Abu-Raddad LJ. Vertical transmission of hepatitis C virus: systematic review and meta-analysis. Clin Infect Dis 2014;59:765–73. https://doi.org/10.1093/cid/ciu447
6. Cottrell EB, Chou R, Wasson N, Rahman B, Guise J-M. Reducing risk for mother-to-infant transmission of hepatitis C virus: a systematic review for the U.S. Preventive Services Task Force. Ann Intern Med 2013;158:109–13. https://doi.org/10.7326/0003-4819-158-2-201301150-00575
7. Robinson JL, Doucette K. The natural history of hepatitis C virus infection acquired during childhood. Liver Int 2012;32:258–70. https://doi.org/10.1111/j.1478-3231.2011.02633.x
8. European Paediatric Hepatitis C Virus Network. Three broad modalities in the natural history of vertically acquired hepatitis C virus infection. Clin Infect Dis 2005;41:45–51. https://doi.org/10.1086/430601
9. Delgado-Borrego A, Smith L, Jonas MM, et al. Expected and actual case ascertainment and treatment rates for children infected with hepatitis C in Florida and the United States: epidemiologic evidence from statewide and nationwide surveys. J Pediatr 2012;161:915–21. https://doi.org/10.1016/j.jpeds.2012.05.002
10. National Institutes of Health. NIH consensus statement on management of hepatitis C:2002. NIH Consens State Sci Statements 2002;19:1–46.

Rapid Field Response to a Cluster of Illnesses and Deaths — Sinoe County, Liberia, April–May, 2017

John Doedeh, MD[1]; Joseph Asamoah Frimpong, MPhil[2]; Kwuakuan D.M. Yealue II, MPH[3]; Himiede W. Wilson, MPhil[4]; Youhn Konway[1]; Samson Q. Wiah[1]; Vivian Doedeh[1]; Umaru Bao[1]; George Seneh[1]; Lawrence Gorwor[1]; Sylvester Toe[2,5]; Emmanuel Ghartey[2,6]; Lawrence Larway[2,7]; Dedesco Gweh[2,8]; Philemon Gonotee[1]; Thomas Paasewe[1]; George Tamatai[1]; James Yarkeh[1]; Samuel Smith[1]; Annette Brima-Davis, MD[1]; George Dauda[1]; Thomas Monger[1]; Leleh W. Gornor-Pewu[1]; Siafa Lombeh[1]; Jeremias Naiene, MD[3]; Nathaniel Dovillie, MSc[4]; Mark Korvayan[4]; Geraldine George[9]; Garrison Kerwillain[9]; Ralph Jetoh, MD[4]; Suzanne Friesen, MPP[10]; Carl Kinkade, MCRP[10]; Victoria Katawera, MSc[3]; Maame Amo-Addae, MBChB[2]; Roseline N. George, MPH[4]; Miatta Z. Gbanya, MPH[9]; E. Kainne Dokubo, MD[10]

On April 25, 2017, the Sinoe County Health Team (CHT) notified the Liberia Ministry of Health (MoH) and the National Public Health Institute of Liberia of an unknown illness among 14 persons that resulted in eight deaths in Sinoe County. On April 26, the National Rapid Response Team and epidemiologists from CDC, the World Health Organization (WHO) and the African Field Epidemiology Network (AFENET) in Liberia were deployed to support the county-led response. Measures were immediately implemented to identify all cases, ascertain the cause of illness, and control the outbreak. Illness was associated with attendance at a funeral event, and laboratory testing confirmed *Neisseria meningitidis* in biologic specimens from cases. The 2014–2015 Ebola virus disease (Ebola) outbreak in West Africa devastated Liberia's already fragile health system, and it took many months for the country to mount an effective response to control the outbreak. Substantial efforts have been made to strengthen Liberia's health system to prevent, detect, and respond to health threats. The rapid and efficient field response to this outbreak of *N. meningitidis* resulted in implementation of appropriate steps to prevent a widespread outbreak and reflects improved public health and outbreak response capacity in Liberia.

Investigation and Results

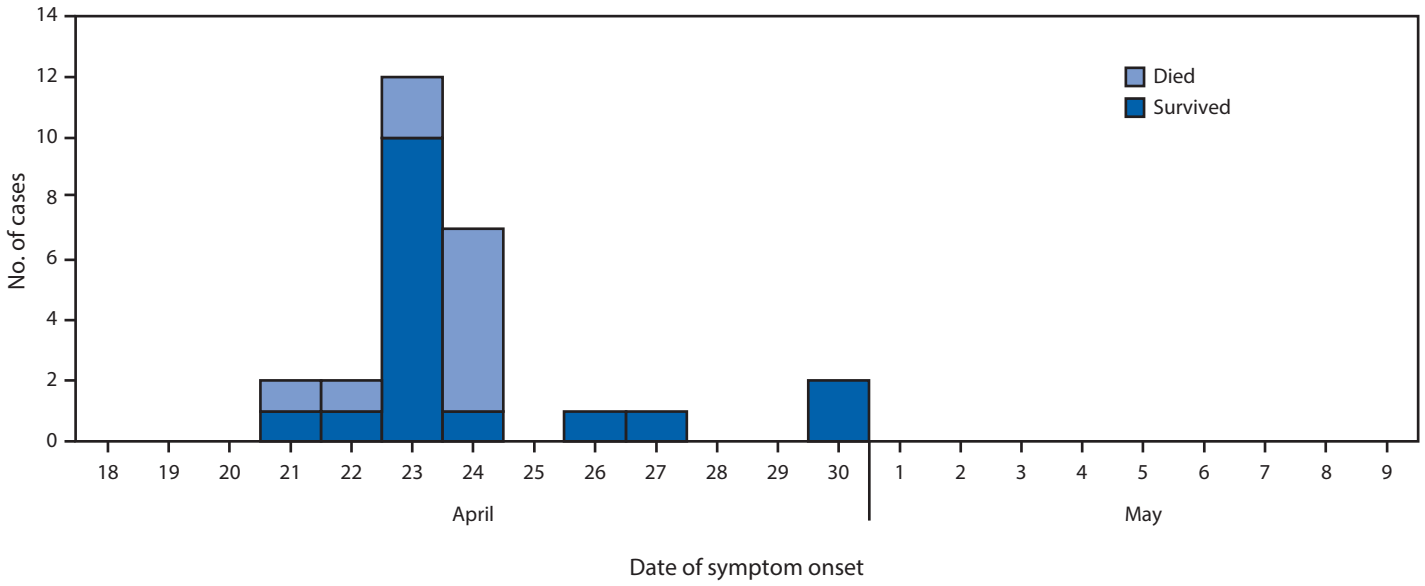
Sinoe, one of 15 counties in Liberia, is located in the southeastern part of the country and has an estimated population of 102,391 (*1*). The county has 33 clinics and one hospital (F.J. Grante Memorial Hospital), which serves as the referral health facility. In the early hours of April 25, 10 patients were admitted to F.J. Grante Hospital in critical condition with symptoms including headache, altered mental status, generalized weakness, abdominal pain, vomiting, and diarrhea, which started after they attended a funeral event in Sinoe County on April 21 and 22. Five of the patients rapidly deteriorated and died within a few hours of admission. Three other patients with the same symptoms died before arrival at the hospital. Clinicians reported that a female patient aged 11 years with similar symptoms was admitted to the isolation ward on April 23 following illness onset the previous day and died a few hours after admission.

Sinoe CHT immediately notified national health authorities of the illnesses and deaths, and launched a county-led response with support from technical partners, using an Incident Management System that had been established during the 2014–2015 Ebola outbreak response (*2*). The multisectorial response comprised epidemiology/surveillance and data management, case management, infection prevention and control, laboratory, social mobilization and health promotion, psychosocial, and dead body management. All activities were coordinated by the County Health Officer and County Superintendent with support from technical partners; daily analyses and situational reports were shared with stakeholders.

Epidemiologic investigations were aimed at identifying all cases and establishing linkages and potential exposures. The investigation was reviewed in accordance with CDC's human subjects review procedures and was determined to be nonresearch, routine public health activity. Based on symptoms reported among ill persons, a case was defined as the onset of two or more symptoms including headache, vomiting, mental confusion, or weakness, on or after April 10, 2017, in any person who had visited or lived in Sinoe County. A questionnaire was developed to gather demographic information, symptoms and onset date, as well as data on foods consumed, exposure to ill persons, travel history, and other potential exposures. Liberia Field Epidemiology Training Program–trained surveillance officers conducted case investigations and active case finding, with supervision from CDC, WHO, AFENET, and national-level epidemiologists.

Twenty-seven cases were identified over the course of the investigation in Sinoe County; 16 (59%) occurred in females. The median patient age was 19 years (range = 10–54 years). The outbreak peaked on April 23 with 12 cases (Figure 1) and resulted in 10 deaths (case fatality ratio = 37%). Most cases were clustered around Teah Town community in Greenville city, Sinoe County (Figure 2), which recorded 11 cases with six deaths. A number of patients were family members or friends of one another, resided in the same household or neighboring houses, and attended the same school or place of worship. Information was also obtained from close contacts of patients and persons who attended the funeral but had not fallen ill.

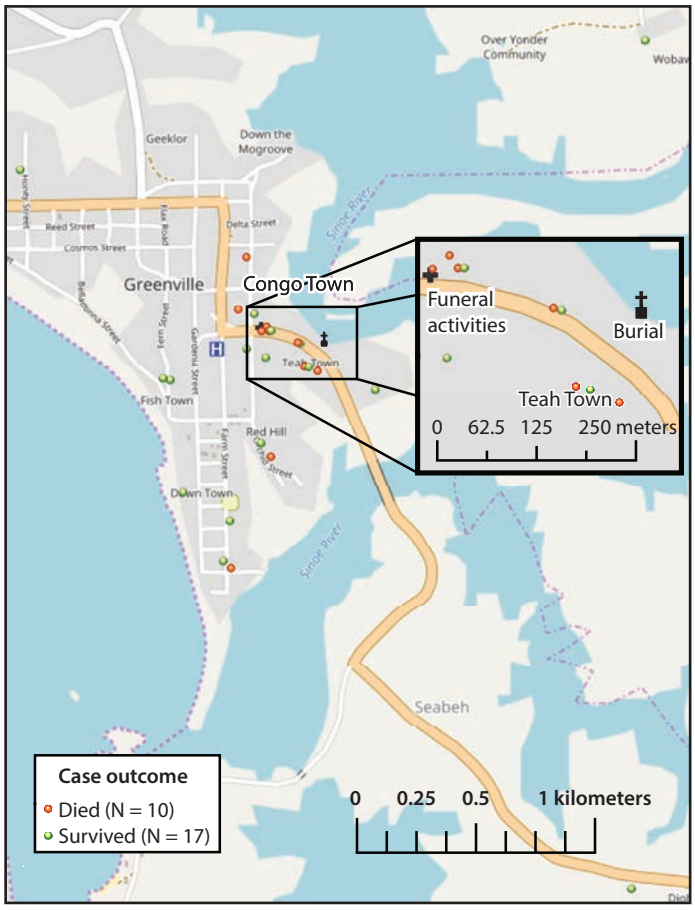
FIGURE 1. Number of cases of unexplained illnesses and deaths (N = 27) by date of symptom onset and outcome — Sinoe County, Liberia, April–May, 2017



The outbreak was hypothesized to be linked to attendance at funeral events on April 21–22 (overnight wake on April 21 and funeral service and burial in the early afternoon on April 22, followed by a repast in the late afternoon on April 22). A 1:2 unmatched case-control study with 25 case-patients and 50 controls was conducted to compare the odds of exposure among case-patients and controls (asymptomatic funeral attendees and community members). Statistically significant association with exposure was determined at a $p<0.05$. The inferential analysis showed that cases were 22 times more likely to have attended the funeral wake than were controls (odds ratio [OR] = 22.15, 95% confidence interval [CI] = 2.78–176.61) ($p<0.05$). Further analyses showed an association with food served at the wake, with the strongest association observed with consumption of tea (OR = 11.23, 95% CI 3.61–34.96). There were no reports of travel outside Liberia and no significant associations observed with other exposures analyzed.

Blood, urine, and stool specimens were collected from patients, and oral swab and pericardial fluid specimens were collected from decedents. Twenty-three specimens tested negative for Lassa fever and Ebola virus by reverse transcription–polymerase chain reaction at the National Reference Laboratory in Liberia. Hematologic and chemistry analyses of biologic specimens were unrevealing, and water samples from Sinoe County tested negative for coliforms. Food samples from the funeral event were collected for further analysis and biologic specimens from patients were sent to international laboratories for additional diagnostic evaluation.

FIGURE 2. Unexplained cluster of illnesses and deaths: spot map of cases and location of funeral events — Sinoe County, Liberia, April–May, 2017



Public Health Response

Active case search and heightened surveillance in the community and health facilities were initiated to identify additional cases and persons at risk. Patients and their family members were interviewed by surveillance officers, clinical information was obtained from medical records, and a database was created to manage the epidemiologic, clinical, and laboratory data. In addition to the 27 cases, 60 funeral attendees and 152 contacts of cases in Sinoe County were identified and monitored daily.

Patients evaluated at the hospital were admitted to the isolation unit or emergency ward under close observation. Because the etiology of illness was initially unknown, clinicians provided supportive treatment, based on symptoms and physical examination findings of each patient, with intravenous fluids, supplemental oxygen, empiric antimicrobial therapy with broad spectrum antibiotics (including Ceftriaxone, Ciprofloxacin, and Metronidazole), and antimalarial therapy. Aside from one additional death that occurred on April 26, all seventeen subsequent patients who were managed at the hospital survived. Infection prevention and control standards and protocols were emphasized in health facilities and promoted in the community and at points of entry. Use of personal protective equipment by health care workers was reinforced, assessments for personal protective equipment availability were conducted, and adequate infection prevention and control supplies were provided to health facilities.

The social mobilization and health promotion team engaged community and religious leaders to raise awareness, dispel rumors, and overcome community resistance. Social mobilizers conducted house-to-house awareness activities and provided information to the public through radio talk shows and street broadcasters, encouraging ill persons to seek care at health facilities. A town hall meeting was convened to solicit information from community members and for health officials to answer questions from the public. Social mobilizers also accompanied surveillance officers during active case search, facilitating entry and surveillance activities in the community. The psychosocial team provided Psychosocial First Aid for bereaved families and conducted daily visits to patients who had been discharged from the hospital and patients who refused to seek care at the health facility. The dead body management team provided safe and dignified burials for decedents. Specimens collected from patients were transported daily via an existing sample transport network for testing at the National Reference Laboratory. Aliquots of specimens were sent to CDC for additional diagnostic evaluation and tested negative for heavy metals and organophosphates.

In addition to the 27 cases with 10 deaths reported in Sinoe County, four epidemiologically-linked cases, including three deaths, were reported in Montserrado and Grand Bassa Counties. The last death occurred on May 3 in Grand Bassa County and the last case linked to the cluster was reported on May 7. On May 8, Liberia MOH declared that the illnesses and deaths were attributable to a probable outbreak of meningococcal disease, based on detection of *N. meningitidis* in specimens tested at CDC headquarters in Atlanta.

Discussion

Unexplained health events have significant implications when illness results from an infectious etiology and immediate control measures are not implemented (*3*). The presentation of cases and preliminary epidemiologic data suggested a common source outbreak or toxic exposure, and a concerted effort was made to rule out possible infectious etiologies. Building on response structures established during the Ebola epidemic (*2*), the CHT rapidly established all technical components of the response with support from the national rapid response team and technical partners, and was able to respond immediately to the health threat at its source, a requirement for an effective outbreak response (*4*).

The 2014 Ebola epidemic devastated Liberia's already fragile health system, which was ill-prepared to respond to the initial cases of Ebola and prevent spread of infection (*5*,*6*). With support from international partners, the widespread outbreak was brought under control, and Liberia was declared free of Ebola virus transmission. The West Africa Ebola epidemic demonstrated that global health security relies on resilient health systems in all countries that are capable of rapidly detecting and controlling public health threats at their source (*7*). Support from CDC and other partners has increased capacity in core areas of disease surveillance, laboratory systems, workforce development and emergency operations, strengthening Liberia's public health system against future disease outbreaks.

A robust surveillance system with capacity for immediate disease detection and reporting can facilitate response efforts and limit the magnitude of a potential outbreak (*8*). In Liberia, event-based surveillance for diseases of high epidemic potential or high morbidity and mortality is implemented through the Integrated Disease Surveillance and Response system, which captures 14 priority diseases and conditions, including unexplained clusters of health events and deaths (*9*). The prompt detection and immediate notification by district and county-level surveillance officers trained through the CDC-supported Liberia Field Epidemiology Training Program enabled the rapid response. Enhanced in-country laboratory capacity facilitated rapid testing and rule-out of Ebola and Lassa fever. Effective case management likely increased survival among patients, even before the diagnosis was confirmed.

Although the cause of illnesses and deaths was initially unknown, response measures were implemented while

Summary

What is already known about this topic?

The 2014–2015 Ebola virus disease (Ebola) outbreak in West Africa devastated Liberia's already fragile health system, and it took many months for the country to mount an effective response to the epidemic. Substantial efforts have been made to strengthen Liberia's health system to prevent, detect, and respond to future health threats.

What is added by this report?

In April 2017, a cluster of 27 cases of unexplained illness, including 10 deaths, occurred in Sinoe County, Liberia. Response measures were immediately implemented to ascertain the cause of illness, control the outbreak and prevent new cases and deaths. Epidemiologic investigations revealed that the cases occurred in persons who attended a funeral event in Sinoe County, and laboratory testing confirmed *Neisseria meningitidis* as the cause of illness. The Liberia Ministry of Health declared that the illnesses and deaths were attributable to an outbreak of meningococcal disease.

What are the implications for public health practice?

The rapid response to the cluster of illnesses and deaths is a reflection of the increased public health and outbreak response capacity established in Liberia during and subsequent to the Ebola epidemic, which has enhanced global health security. The response also highlights the importance of enhanced surveillance systems, improved laboratory capacity, a trained workforce and emergency management capacity to prevent widespread disease outbreaks.

additional investigations were underway to determine the etiology and source of the outbreak. In 2014, an initial cluster of illnesses and deaths caused by Ebola took more than 90 days from detection to coordination of the emergency response and led to a widespread epidemic. In contrast, response efforts for this cluster of illnesses and deaths were initiated within less than 24 hours of detection. After effective control of the outbreak, WHO issued a notice on July 6, 2017, assessing the risk for recurrence of the meningococcal disease outbreak as low (*10*). Compared with the insufficient early response to the Ebola outbreak in Liberia in 2014, the rapid and effective response to this outbreak demonstrates the marked improvements in public health capacities in Liberia. Because public health emergencies such as Ebola and meningococcal disease outbreaks can rapidly spread internationally, these improvements in response capacity in Liberia contribute to enhance global health security.

Acknowledgments

Staff members of F.J. Grante Memorial Hospital, Sinoe County, Liberia; Sinoe County Health Team, Liberia; Sinoe County Superintendent and Authorities; Liberia Ministry of Health; National Public Health Institute of Liberia; African Field Epidemiology Network; World Health Organization; CDC; CDC Global Disease Detection Operations Center; CDC National Center for Environmental Health; CDC National Center for Immunization and Respiratory Diseases.

Conflict of Interest

No conflicts of interest were reported.

[1]Sinoe County Health Team, Liberia;[2]Liberia Field Epidemiology Training Program; [3]World Health Organization, Liberia; [4]National Public Health Institute of Liberia; [5]Grand Gedeh County Health Team, Liberia; [6]Grand Kru County Health Team, Liberia; [7]Ricercess County Health Team, Liberia; [8]Maryland County Health Team, Liberia; [9]Ministry of Health, Liberia; [10]CDC, Liberia.

Corresponding author: E. Kainne Dokubo, vic8@cdc.gov, 404-797-7459.

References

1. Republic of Liberia. 2008 population and housing census. Monrovia, Liberia: Liberia Institute of Statistics and Geo-information Services; 2009. http://www.lisgis.net/pg_img/NPHC%202008%20Final%20Report.pdf
2. Pillai SK, Nyenswah T, Rouse E, et al. Developing an incident management system to support Ebola response—Liberia, July–August 2014. MMWR Morb Mortal Wkly Rep 2014;63:930–3.
3. Hajjeh RA, Relman D, Cieslak PR, et al. Surveillance for unexplained deaths and critical illnesses due to possibly infectious causes, United States, 1995–1998. Emerg Infect Dis 2002;8:145–53. https://doi.org/10.3201/eid0802.010165
4. Gates B. The next epidemic—lessons from Ebola. N Engl J Med 2015;372:1381–4. https://doi.org/10.1056/NEJMp1502918
5. Spengler JR, Ervin ED, Towner JS, Rollin PE, Nichol ST. Perspectives on West Africa Ebola virus disease outbreak, 2013–2016. Emerg Infect Dis 2016;22:956–63. https://doi.org/10.3201/eid2206.160021
6. Agua-Agum J, Allegranzi B, Ariyarajah A, et al.; WHO Ebola Response Team. After Ebola in West Africa—unpredictable risks, preventable epidemics. N Engl J Med 2016;375:587–96. https://doi.org/10.1056/NEJMsr1513109
7. Kieny MP, Dovlo D. Beyond Ebola: a new agenda for resilient health systems. Lancet 2015;385:91–2. https://doi.org/10.1016/S0140-6736(14)62479-X
8. Kasolo F, Yoti Z, Bakyaita N, et al. IDSR as a platform for implementing IHR in African countries. Biosecur Bioterror 2013;11:163–9. https://doi.org/10.1089/bsp.2013.0032
9. Ministry of Health Liberia; World Health Organization; CDC. National technical guidelines for integrated disease surveillance and response. Monrovia, Liberia: Ministry of Health Liberia; Geneva, Switzerland: World Health Organization; Atlanta, GA: US Department of Health and Human Services, CDC; 2016. http://moh.gov.lr/wp-content/uploads/2016/12/IDSRTechnical_Guidelines_20161128.pdf
10. World Health Organization. Meningococcal septicaemia associated with attending a funeral—Liberia. Geneva, Switzerland: World Health Organization; 2017. http://www.who.int/csr/don/06-july-2017-meningococcal-septicaemia-liberia/en/

Morbidity and Mortality Weekly Report

Rapid Laboratory Identification of *Neisseria meningitidis* Serogroup C as the Cause of an Outbreak — Liberia, 2017

Jaymin C. Patel, PhD[1,2]; Josiah George[3]; Jeni Vuong, MS[2]; Caelin C. Potts, PhD[2,4]; Catherine Bozio, PhD[1,2]; Thomas A. Clark, MD[5]; Jerry Thomas, MD[6]; Joshua Schier, MD[7]; Arthur Chang, MD[7]; Jessica L. Waller, MS[2]; Maureen H. Diaz, PhD[2]; Melissa Whaley, MS, MPH[2]; Laurel T. Jenkins, MS[2]; Serena Fuller, MPH[8]; Desmond E. Williams, MD, PhD[8]; John T. Redd, MD[8]; Ray R. Arthur, PhD[8]; Fahn Taweh, MPH[3]; Yatta Vera Walker[3]; Patrick Hardy, MSc[3]; Maxwell Freeman, MSc, MLS[3]; Victoria Katawera, MSc[9]; Gulu Gwesa, MSc[8]; Miatta Z. Gbanya, MPH[10]; Peter Clement, MD[9]; Henry Kohar, MSc[3]; Mardia Stone, MD[3]; Mosoka Fallah, PhD[3]; Tolbert Nyenswah, MPH[3]; Jonas M. Winchell, PhD[2]; Xin Wang, PhD[2]; Lucy A. McNamara, PhD[2]; E. Kainne Dokubo, MD[8]; LeAnne M. Fox, MD[2]

On April 25, 2017, a cluster of unexplained illness and deaths among persons who had attended a funeral during April 21–22 was reported in Sinoe County, Liberia (*1*). Using a broad initial case definition, 31 cases were identified, including 13 (42%) deaths. Twenty-seven cases were from Sinoe County (*1*), and two cases each were from Grand Bassa and Monsterrado counties, respectively. On May 5, 2017, initial multipathogen testing of specimens from four fatal cases using the Taqman Array Card (TAC) assay identified *Neisseria meningitidis* in all specimens. Subsequent testing using direct real-time polymerase chain reaction (PCR) confirmed *N. meningitidis* in 14 (58%) of 24 patients with available specimens and identified *N. meningitidis* serogroup C (NmC) in 13 (54%) patients. *N. meningitidis* was detected in specimens from 11 of the 13 patients who died; no specimens were available from the other two fatal cases. On May 16, 2017, the National Public Health Institute of Liberia and the Ministry of Health of Liberia issued a press release confirming serogroup C meningococcal disease as the cause of this outbreak in Liberia.

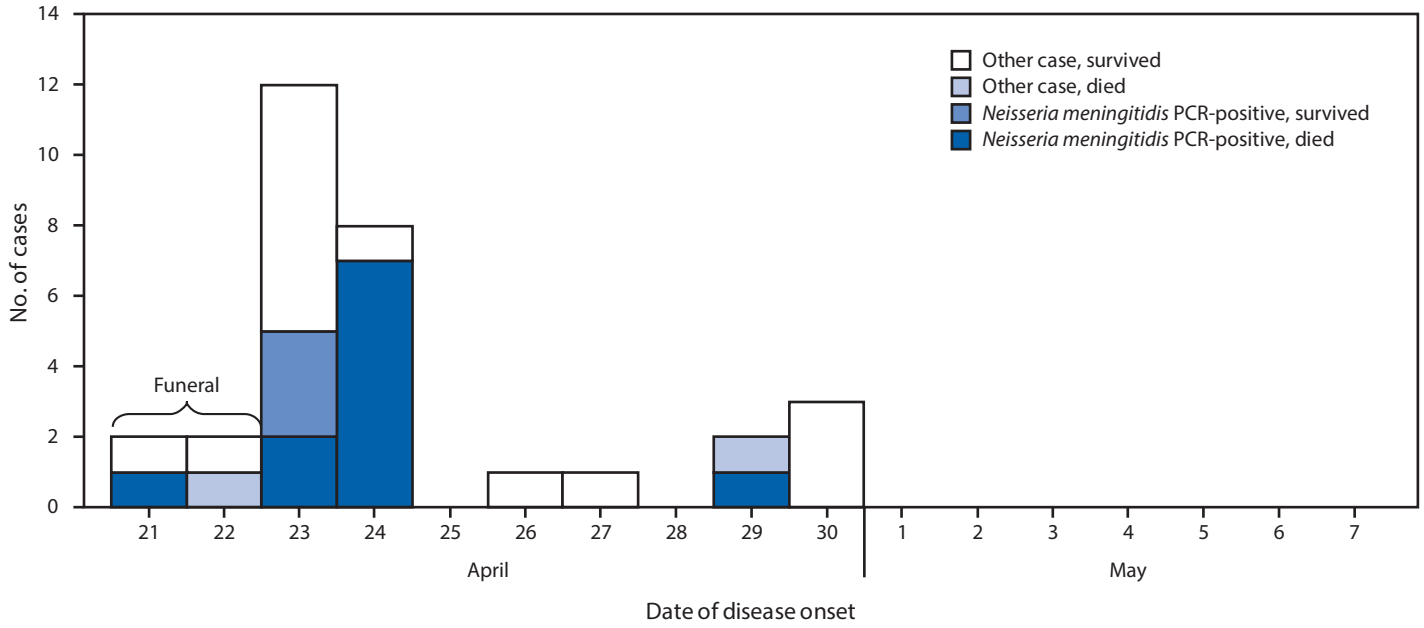
Meningococcal disease, caused by the bacterium *N. meningitidis*, is a serious febrile illness that most commonly manifests as meningitis or septicemia. *N. meningitidis* is classified into 12 serogroups based on its polysaccharide capsule; however, six serogroups (A, B, C, W, X, and Y) are responsible for a majority of meningococcal disease cases worldwide.* Meningococcal meningitis is characterized by sudden onset of fever, headache, stiff neck, nausea, vomiting, photophobia, or confusion. Meningococcal septicemia often begins with nonspecific signs and symptoms such as fever, vomiting, and diarrhea; in later stages, a hemorrhagic purpuric rash often occurs. However, absence of fever as well as hypothermia have been reported among persons with severe meningococcal septicemia (*2*,*3*). Worldwide, the greatest burden of meningococcal disease is in the African meningitis belt, which stretches from Senegal to Ethiopia, but does not include Liberia. Historically, *N. meningitidis* serogroup A (NmA) was responsible for majority of the epidemics in the meningitis belt. However, since 2010, the phased introduction of a meningococcal serogroup A conjugate vaccine (PsA–TT, MenAfriVac) throughout the meningitis belt, has substantially reduced NmA incidence and eliminated NmA epidemics (*4*). Recently, the region has experienced epidemics of NmC occurring in Niger (2015, 2017) (*5*) and Nigeria (2017).†

The cases of unexplained illness in Liberia were tightly clustered in time, with illness onset from April 21, 2017, through April 30, 2017 (Figure). The outbreak case definition comprised two or more symptoms including headache, vomiting, mental confusion, or weakness, with illness onset on or after April 10, 2017, in any person who visited or lived in Sinoe County (*1*). Among the 31 reported cases, the predominant reported signs and symptoms included weakness (28; 90%), abdominal pain (25; 81%), headache (24; 77%), and vomiting (20; 65%); fever was reported in only six (19%) patients. There were no reports of travel outside Liberia among the funeral attendees. Upon identification of the cluster, oral swab and blood specimens from patients were immediately tested in Liberia for Ebola virus and Lassa virus; both were ruled out. Because most of the patients were afebrile, a noninfectious etiology was considered likely; however, the nonspecific symptoms reported could have also been caused by an infection. Specimens collected from patients during the outbreak investigation were sent to multiple international laboratories for additional testing. On May 2, 2017, seven specimens (three whole blood, three oral swabs, and one plasma) from four fatal cases and three urine specimens from three nonfatal cases were received at CDC headquarters in Atlanta for testing. The urine specimens from the three nonfatal cases were tested for toxic metals and organophosphate insecticide metabolites; findings were not consistent with an exposure that could explain the outbreak. On May 5, 2017, six specimens (three whole blood, one plasma, and two oral swab specimens) from the four fatal cases were tested using the TAC assay. Developed at CDC, the TAC assay is a rapid diagnostic microfluidics-based real-time PCR assay that allows for simultaneous detection of approximately 40 viral, bacterial, and parasitic pathogens

* http://www.who.int/csr/disease/meningococcal/en/.

† Nigeria Centre for Disease Control. Cerebrospinal Meningitis Outbreak in Nigeria. Situational Report, 2017. http://ncdc.gov.ng/themes/common/files/sitreps/bd9846806324bec6e408c3c4e696e63e.pdf.

FIGURE. Date of onset of outbreak cases (N = 31), by laboratory and outcome status — Liberia, 2017*



Abbreviation: PCR = polymerase chain reaction.
* Other cases include PCR-negative and untested outbreak cases.

found in blood or cerebrospinal fluid (*6*). *N. meningitidis* was detected in all six specimens. On May 6, 2017, all specimens from the four fatal cases, including the six specimens tested by TAC assay and the additional oral swab specimen, underwent confirmatory testing by direct real-time PCR at CDC. Using a molecular target different from the one used in the TAC assay, *N. meningitidis* species was confirmed in all seven specimens and NmC was identified as the specific serogroup in all seven specimens.

On May 9, 2017, CDC staff members deployed to Liberia to establish direct real-time PCR capacity for *N. meningitidis* testing in Liberia. Working with Liberian counterparts, the CDC team tested 56 additional specimens from 24 of the 31 cases initially identified as part of the outbreak. Overall, *N. meningitidis* was detected in specimens from 14 (58%) patients, 13 (54%) of which were confirmed as NmC and one which was nongroupable Nm (negative for invasive serogroups A, B, C, W, X, and Y). Notably, *N. meningitidis* was detected in specimens from 11 of the 13 patients who died; specimens from the other two fatal cases were not available for testing. On May 16, 2017, the National Public Health Institute of Liberia and the Ministry of Health of Liberia declared that the cluster of illness had been confirmed as a serogroup C meningococcal disease outbreak.

Patients who tested positive for *N. meningitidis* by PCR (14 patients) had more severe illness than did those who tested negative (10 patients). The interval from symptom onset to hospital admission was shorter among PCR-positive patients (median = 1 day, range = 0–2 days) than among PCR-negative patients (median = 6.5 days; range = 1–10 days), and 11 of the 14 PCR-positive patients died, whereas all 10 PCR-negative patients survived. Among the 11 PCR-positive patients who died, the median interval from symptom onset to death was 1 day (range = 0–4 days).

In addition to rapid testing of outbreak specimens in Liberia, the CDC team trained the Liberian National Public Health Reference Laboratory staff members in the use of direct real-time PCR and culture for the three main bacterial meningitis pathogens in sub-Saharan Africa, *N. meningitidis*, *Haemophilus influenzae*, and *Streptococcus pneumoniae*. The CDC team also provided training on transport and storage of specimens from patients with suspected meningitis. These trainings strengthened capacity for meningitis testing in Liberia.

Discussion

In this outbreak, after ruling out Ebola and Lassa virus, the low prevalence of fever, high prevalence of gastrointestinal symptoms, and clustered onset of illness resulted in a broad differential diagnosis that initially focused on toxic exposures rather than infectious disease. In addition, because Liberia is not located within the African meningitis belt, there was not a high index of suspicion for meningococcal disease. The prompt identification of the cluster by the Liberian authorities and the rapid response from CDC, which included testing using the TAC assay and direct real-time PCR, allowed *N. meningitidis*

to be identified as the cause of the outbreak. Because *N. meningitidis* often colonizes the nasopharynx asymptomatically and can be transmitted by asymptomatic carriers, it is not possible to ascertain how the outbreak strain of NmC was introduced into this population.[§]

The high prevalence of gastrointestinal symptoms among cases in this outbreak is unusual for a meningococcal disease cluster; however, a serogroup W meningococcal disease cluster with a high prevalence of gastrointestinal symptoms and a high case-fatality rate was recently reported from England (*7*). Generally, gastrointestinal symptoms are more commonly observed with meningococcal septicemia than with meningitis. The available data on meningococcemia in the African meningitis belt are sparse, but meningitis appears to be a more common clinical manifestation of *N. meningitidis* infection in this region than meningococcemia. Furthermore, in previous outbreaks, reported meningococcemia cases also presented with symptoms of meningitis (*8*,*9*). The high case-fatality rate is consistent with findings from other meningococcal disease outbreaks (*7*,*8*).

The use of a broad initial case definition was appropriate, given that the etiology of the outbreak was unknown; however, this case definition could capture patients with mild symptoms who are unlikely to have meningococcal disease. *N. meningitidis* was not detected in specimens from all patients, and the patients whose specimens tested negative by PCR had milder illness than did those who tested positive. This finding suggests that some PCR-negative patients likely did not have meningococcal disease; however, meningococcal disease cannot be ruled out definitively for patients who tested negative, because some specimens might have been collected several days after antibiotic treatment was initiated, when PCR might have lower sensitivity to detect *N. meningitidis (10)*.

This experience illustrates the importance of rapid laboratory confirmation in an outbreak investigation. The rapid detection of and response to the outbreak by Liberian health authorities is particularly noteworthy and highlights the impact of global health security capacity-building efforts on improving public health laboratory and emergency response capacities. This investigation also highlights the utility of the TAC assay in diagnosing outbreaks of unknown etiology, and shows the effectiveness of direct real-time PCR as a diagnostic tool for rapid response. Determination of the etiology of this outbreak enabled Liberian health authorities to implement appropriate response measures. With PCR capacity for identification of common causes of bacterial meningitis now available within the country, Liberia is in a stronger position to rapidly diagnose and effectively respond to additional meningococcal disease cases or outbreaks.

[§] http://www.sciencedirect.com/science/article/pii/S1473309910702516.

Summary

What is already known about this topic?

Meningococcal disease caused by the bacterium *Neisseria meningitidis* is a serious illness that commonly manifests as meningitis or septicemia. Globally, the highest disease burden is observed in the African meningitis belt that stretches from Senegal to Ethiopia; however, sporadic meningococcal disease cases and outbreaks also occur worldwide.

What is added by this report?

Following the detection of an outbreak of an unknown etiology surrounding a funeral event in Liberia, a rapid laboratory response using the Taqman Array Card (TAC) and confirmatory direct real-time polymerase chain reaction (PCR) assays identified *N. meningitidis* serogroup C as the cause of the outbreak.

What are the implications for public health practice?

Prompt and accurate detection of outbreaks allows public health officials to respond quickly and implement appropriate control measures. This report underscores the utility of TAC assay and direct real-time PCR in diagnosing outbreaks of unknown etiology.

Acknowledgments

Barbara Mahon, Susan Hariri, Alison Albert, Stephen Hadler, Sarah Meyer, Cynthia Hatcher, Division of Bacterial Diseases, CDC; staff members of the National Public Health Institute of Liberia and the Ministry of Health of Liberia.

Conflict of Interest

No conflicts of interest were reported.

[1]Epidemic Intelligence Service, CDC; [2]Divison of Bacterial Diseases, National Center of Immunization and Respiratory Diseases, CDC; [3]National Public Health Institute of Liberia, [4]Laboratory Leadership Service, CDC; [5]Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion, CDC; [6]Division of Laboratory Services, National Center for Environmental Health, CDC; [7]Division of Environmental Hazards and Health Effects, National Center for Environmental Health, CDC; [8]Division of Global Health Protection, Center for Global Health, CDC; [9]World Health Organization, Monrovia, Liberia; [10]Ministry of Health and Social Welfare of Liberia, Liberia.

Corresponding author: Jaymin C. Patel, isr0@cdc.gov, 404-718-5539.

References

1. Doedeh J, Frimpong JA; Yealue II KDM, et al. Rapid field response to a cluster of illnesses and deaths in Sinoe County—Liberia, April–May, 2017. MMWR Morb Mortal Wkly Rep 2017;66:1140–3.
2. Lodder MC, Schildkamp RL, Bijlmer HA, Dankert J, Kuik DJ, Scholten RJ. Prognostic indicators of the outcome of meningococcal disease: a study of 562 patients. J Med Microbiol 1996;45:16–20. https://doi.org/10.1099/00222615-45-1-16
3. Rumbus Z, Matics R, Hegyi P, et al. Fever is associated with reduced, hypothermia with increased mortality in septic patients: a meta-analysis of clinical trials. PLoS One 2017;12:e0170152. https://doi.org/10.1371/journal.pone.0170152

4. Trotter CL, Lingani C, Fernandez K, et al. Impact of MenAfriVac in nine countries of the African meningitis belt, 2010–15: an analysis of surveillance data. Lancet Infect Dis 2017;17:867–72. https://doi.org/10.1016/S1473-3099(17)30301-8
5. Sidikou F, Zaneidou M, Alkassoum I, et al.; MenAfriNet consortium. Emergence of epidemic *Neisseria meningitidis* serogroup C in Niger, 2015: an analysis of national surveillance data. Lancet Infect Dis 2016;16:1288–94. https://doi.org/10.1016/S1473-3099(16)30253-5
6. Kodani M, Yang G, Conklin LM, et al. Application of TaqMan low-density arrays for simultaneous detection of multiple respiratory pathogens. J Clin Microbiol 2011;49:2175–82. https://doi.org/10.1128/JCM.02270-10
7. Campbell H, Parikh SR, Borrow R, Kaczmarski E, Ramsay ME, Ladhani SN. Presentation with gastrointestinal symptoms and high case fatality associated with group W meningococcal disease (MenW) in teenagers, England, July 2015 to January 2016. Euro Surveill 2016;21:30175. https://doi.org/10.2807/1560-7917.ES.2016.21.12.30175
8. Greenwood BM, Bradley AK, Cleland PG, et al. An epidemic of meningococcal infection at Zaria, Northern Nigeria. 1. General epidemiological features. Trans R Soc Trop Med Hyg 1979;73:557–62. https://doi.org/10.1016/0035-9203(79)90052-X
9. Evans-Jones LG, Whittle HC, Onyewotu II, Egler LJ, Greenwood BM. Comparative study of group A and group C meningococcal infection. Arch Dis Child 1977;52:320–3. https://doi.org/10.1136/adc.52.4.320
10. Bronska E, Kalmusova J, Dzupova O, Maresova V, Kriz P, Benes J. Dynamics of PCR-based diagnosis in patients with invasive meningococcal disease. Clin Microbiol Infect 2006;12:137–41. https://doi.org/10.1111/j.1469-0691.2005.01327.x

Progress Toward Regional Measles Elimination — Worldwide, 2000–2016

Alya Dabbagh, PhD[1]; Minal K. Patel, MD[1]; Laure Dumolard, PhD[1]; Marta Gacic-Dobo, MSc[1]; Mick N. Mulders, PhD[1]; Jean-Marie Okwo-Bele, MD[1]; Katrina Kretsinger, MD[1]; Mark J. Papania, MD[2]; Paul A. Rota, PhD[3]; James L. Goodson, MPH[2]

The fourth United Nations Millennium Development Goal, adopted in 2000, set a target to reduce child mortality by two thirds by 2015. One indicator of progress toward this target was measles vaccination coverage (*1*). In 2010, the World Health Assembly (WHA) set three milestones for measles control by 2015: 1) increase routine coverage with the first dose of a measles-containing vaccine (MCV1) among children aged 1 year to ≥90% at the national level and to ≥80% in every district; 2) reduce global annual measles incidence to <5 cases per million population; and 3) reduce global measles mortality by 95% from the 2000 estimate (*2*).* In 2012, WHA endorsed the Global Vaccine Action Plan,† with the objective of eliminating measles in four World Health Organization (WHO) regions by 2015 and in five regions by 2020. Countries in all six WHO regions have adopted goals for measles elimination by or before 2020. Measles elimination is defined as the absence of endemic measles virus transmission in a region or other defined geographic area for ≥12 months, in the presence of a high quality surveillance system that meets targets of key performance indicators. This report updates a previous report (*3*) and describes progress toward global measles control milestones and regional measles elimination goals during 2000–2016. During this period, annual reported measles incidence decreased 87%, from 145 to 19 cases per million persons, and annual estimated measles deaths decreased 84%, from 550,100 to 89,780; measles vaccination prevented an estimated 20.4 million deaths. However, the 2015 milestones have not yet been met; only one WHO region has been verified as having eliminated measles. Improved implementation of elimination strategies by countries and their partners is needed, with focus on increasing vaccination coverage through substantial and sustained additional investments in health systems, strengthening surveillance systems, using surveillance data to drive programmatic actions, securing political commitment, and raising the visibility of measles elimination goals.

Immunization Activities

To estimate coverage with MCV1 and the second dose of measles-containing vaccine (MCV2) through routine immunization services,§ WHO and the United Nations Children's Fund (UNICEF) use data from administrative records (administrative coverage is calculated by dividing the vaccine doses administered by the estimated target population) and immunization coverage surveys reported annually by 194 countries. During 2000–2016, estimated MCV1 coverage increased globally from 72% to 85% (Table 1), although coverage has not increased since 2009. Considerable variability in regional coverage exists. Since 2012, MCV1 coverage has remained essentially unchanged in the African Region (AFR) (72%), the Region of the Americas (AMR) (92%), and the Eastern Mediterranean Region (EMR) (77%). In the European Region (EUR), MCV1 coverage has declined from 95% to 93% since 2012, with 51% of EUR member states reporting lower coverage since 2013. In the South-East Asia Region (SEAR), MCV1 coverage increased slightly since 2012, from 84% to 87%. The Western Pacific Region (WPR) is the only region that has achieved and sustained MCV1 coverage >95% (since 2008). Since 2000, the number of countries with MCV1 coverage of ≥90% increased globally from 85 (44%) in 2000 to 119 (61%) in 2015, and to 123 (63%) in 2016. However, among countries with ≥90% MCV1 coverage nationally, the percentage with ≥80% MCV1 coverage in all districts declined from 46% (52 of 112) in 2010 to 45% (49 of 110) in 2015 and 36% (44 of 123) in 2016. Among the estimated 20.8 million infants who did not receive MCV1 through routine immunization services in 2016, approximately 11 million (53%) were in six countries with large birth cohorts and suboptimal coverage: Nigeria (3.3 million), India (2.9 million), Pakistan (2.0 million), Indonesia (1.2 million), Ethiopia (0.9 million), and the Democratic Republic of the Congo (0.7 million).

During 2000–2016, the number of countries providing MCV2 nationally through routine services increased from 98 (51%) to 164 (85%), with four countries (Guatemala, Haiti, Papua New Guinea, and Timor-Leste) introducing MCV2 in 2016. Estimated global MCV2 coverage steadily

* The coverage milestone is to be met by every country, whereas the incidence and mortality reduction milestones are to be met globally.

† The Global Vaccine Action Plan is the implementation plan of the Decade of Vaccines, a collaboration between WHO; the United Nations Children's Fund (UNICEF); the Bill and Melinda Gates Foundation; the National Institute of Allergy and Infectious Diseases; the African Leaders Malaria Alliance; Gavi, the Vaccine Alliance; and others to extend the full benefit of immunization to all persons by 2020 and beyond. In addition to 2015 targets, it also set a target for measles and rubella elimination in five of the six WHO regions by 2020. http://www.who.int/immunization/global_vaccine_action_plan/en; http://apps.who.int/gb/ebwha/pdf_files/wha65/a65_22-en.pdf.

§ For the first dose of measles-containing vaccine (MCV1), among children aged 1 year or, if MCV1 is given at age ≥1 year, among children aged 24 months. For MCV2, among children at the recommended age for administration of MCV2, per the national immunization schedule. WHO/UNICEF estimates of national immunization coverage are available at http://www.who.int/immunization/monitoring_surveillance/data/en.

TABLE 1. Estimates of coverage with the first and second doses of measles-containing vaccine administered through routine immunization services, reported measles cases and incidence, and estimated measles deaths,* by World Health Organization (WHO) region — worldwide, 2000 and 2016

WHO region (no. countries in region)/Year	% Coverage with MCV1†	% Countries with ≥90% MCV1 coverage	% Coverage with MCV2†	% Countries with incidence <5/million	No. reported measles cases§	Measles incidence§,¶	Estimated no. of measles deaths (95% CI)	% Estimated mortality reduction, 2000–2016
African (47)								
2000	53	9	5	8	520,102	835	340,800 (232,000–554,000)	89
2016	72	36	24	51	36,269	36	37,500 (11,900–124,200)	
Americas (35)								
2000	93	63	43	89	1,754	2.1	NA	—
2016	92	74	54	100	12	0.02	NA	
Eastern Mediterranean (21)								
2000	72	57	29	17	38,592	90	55,300 (35,000–87,700)	79
2016	77	57	69	47	6,264	10	11,400 (5,700–28,300)	
European (53)								
2000	91	60	48	45	37,421	50	400 (130–2,000)	80
2016	93	83	88	85	4,175	5	80 (0–1,400)	
South-East Asia (11)								
2000	63	30	3	0	78,558	51	143,000 (101,500–199,900)	73
2016	87	64	75	27	27,530	14	39,000 (27,600–69,700)	
Western Pacific (27)								
2000	85	48	2	30	177,052	105	10,600 (5,200–52,400)	83
2016	96	63	93	67	57,879	31	1,800 (500–46,000)	
Total (194)								
2000	72	44	15	38	853,479	145	550,100 (374,000–896,500)	84
2016	85	63	64	69	132,137	19	89,780 (45,700–269,600)	

Abbreviations: CI = confidence interval; MCV1 = first dose of measles-containing vaccine; MCV2 = second dose of measles-containing vaccine; NA = not applicable; UNICEF = United Nations Children's Fund.

* Mortality estimates for 2000 might be different from previous reports. When the model used to generate estimated measles deaths is rerun each year using the new WHO/UNICEF Estimates of National Immunization Coverage data, as well as updated surveillance data, adjusted results for each year, including the baseline year, are also produced and updated.

† Coverage data: WHO/UNICEF Estimates of National Immunization Coverage, July 15, 2017 update. http://www.who.int/immunization/monitoring_surveillance/data/en.

§ Reported case data: measles cases (2016) from World Health Organization, as of July 15, 2017 (http://apps.who.int/immunization_monitoring/globalsummary/timeseries/tsincidencemeasles.html). Reported cases are a sizeable underestimate of the actual number of cases, accounting for the inconsistency between reported cases and estimated deaths.

¶ Cases per 1 million population; population data from United Nations, Department of Economic and Social Affairs, Population Division, 2016. Any country not reporting data on measles cases for that year was removed from both the numerator and denominator.

increased from 15% in 2000 to 60% in 2015 and 64% in 2016 (Table 1). During 2016, approximately 119 million persons received supplementary doses of measles-containing vaccine (MCV) during 33 mass immunization campaigns, known as supplementary immunization activities (SIAs),¶ implemented in 31 countries (Table 2). Based on doses administered, SIA coverage was ≥95% in 20 (61%) SIAs. Among the six countries that conducted post-SIA coverage surveys, estimated coverage was ≥95% in three, 90%–94% in two, and 84% in one.

¶ Supplemental immunization activities (SIAs) generally are carried out using two target age ranges. An initial, nationwide catch-up SIA focuses on all children aged 9 months–14 years, with the goal of eliminating susceptibility to measles in the general population. Periodic follow-up SIAs then focus on all children born since the last SIA. Follow-up SIAs generally are conducted nationwide every 2–4 years and focus on children aged 9–59 months; their goal is to eliminate any measles susceptibility that has developed in recent birth cohorts and to protect children who did not respond to MCV1.

Disease Incidence

Countries report the aggregate number of incident measles cases**,†† to WHO and UNICEF annually through the Joint Reporting Form. In 2016, 189 (97%) countries conducted

** http://apps.who.int/immunization_monitoring/globalsummary/timeseries/tsincidencemeasles.html.

†† Measles cases are defined differently in different countries. Some countries define measles cases as those that are laboratory-confirmed or epidemiologically linked; others define measles cases as those that are laboratory-confirmed, epidemiologically linked, or clinically compatible. Laboratory-confirmed cases are suspected measles cases with specimens that have detectable measles virus-specific immunoglobulin class M (IgM) antibodies, or specimens from which measles virus can be isolated or measles virus genome can be detected in appropriate clinical specimens by a proficient laboratory. Epidemiologically linked confirmed measles cases are suspected measles cases that have not been confirmed by a laboratory but are geographically and temporally related to a laboratory-confirmed case or, in the event of a chain of transmission, to another epidemiologically confirmed measles case, with dates of rash onset between cases occurring 7–21 days apart. Clinically compatible measles cases are suspected measles cases with fever and maculopapular rash and cough, coryza, or conjunctivitis, for which no adequate clinical specimen was collected and which have not been linked epidemiologically to a laboratory-confirmed case of measles or to a laboratory-confirmed case of another communicable disease.

TABLE 2. Measles supplementary immunization activities (SIAs)* and the delivery of other child health interventions, by World Health Organization (WHO) region and country — worldwide, 2016

WHO region/country	Age group targeted	Extent of SIA	No. children reached in targeted age group (%)†	% coverage based on survey results	Other interventions delivered
African					
Botswana	9 mos–14 yrs	N	674,150 (95)	97	Rubella vaccine
Burundi (2015–2016)§	18–23 mos	N	30,443 (22)	—	—
Central African Republic (2015–2016)§	6 mos–10 yrs	N	1,529,441 (84)	—	Vitamin A, deworming
Chad	9–59 mos	N	2,756,733 (110)	—	—
Comoros	9–59 mos	SN	83,371 (76)	—	Vitamin A, deworming
Democratic Republic of the Congo	6–59 mos	N	10,921,820 (100)	—	—
Equatorial Guinea	6–59 mos	N	127,874 (85)	—	—
Ethiopia	6 mos–15 yrs	SN	24,986,589 (97)	94	—
Gambia	9 mos–14 yrs	N	779,654 (97)	97	Rubella vaccine, vitamin A, deworming
Guinea	9–59 mos	N	2,412,923 (103)	—	Vitamin A, deworming
Kenya	9 mos–14 yrs	N	19,154,577 (101)	95	Rubella vaccine
Madagascar	9–59 mos	N	3,547,466 (96)	—	Vitamin A, deworming
Namibia	9 mos–39 yrs	N	1,908,193 (103)	—	Rubella vaccine
Nigeria	9–59 mos	N	19,065,787 (131)	84	—
Sao Tome and Principe	9 mos–14 yrs	N	77,285 (107)	—	Rubella vaccine
Swaziland	9 mos–14 yrs	N	373,508 (90)	94	Rubella vaccine, vitamin A, deworming
Zambia	9 mos–14 yrs	N	7,741,505 (108)	—	Rubella vaccine
Americas					
Haiti	9–59 mos	N	1,420,220 (100)	—	Rubella vaccine, OPV, IPV, vitamin A
Honduras	1–4 yrs	N	735,066 (96)	—	Mumps and rubella vaccine
Mexico	1–4 yrs	N	8,229,851 (94)	—	Mumps and rubella vaccine
Nicaragua	1–4 yrs	N	568,422 (105)	—	Mumps and rubella vaccine
Peru	2–5 yrs	N	1,662,728 (78)	—	Rubella vaccine
Eastern Mediterranean					
Egypt	11–20 yrs	SN	642,178 (94)	—	Rubella vaccine
Egypt	6–7 yrs (1st grade)	SN	258,464 (102)	—	Rubella vaccine
Qatar	1–13 yrs	N	166,145 (87)	—	Mumps and rubella vaccine
South-East Asia					
Bangladesh	9–59 mos	SN	100,863 (101)	—	Rubella vaccine
Indonesia	9–59 mos	SN	3,638,183 (86)	—	—
Nepal	9–59 mos	N	2,528,539 (101)	—	Rubella vaccine
Western Pacific					
Malaysia	6 m–17 yrs	SN	139,382 (85)	—	Rubella vaccine
Malaysia	1–17 yrs	SN	572 (99)	—	Rubella vaccine
Mongolia	18–30 yrs	N	549,846 (88)	—	Rubella vaccine
Papua New Guinea	9 mos–15 yrs	SN	436,854 (63)	—	Rubella vaccine
Vietnam	16–17 yrs	N	1,787,588 (95)	—	Rubella vaccine

Abbreviations: IPV = inactivated polio vaccine; N = National; OPV = oral polio vaccine; SIA = supplementary immunization activity; SN = subnational.

* SIAs generally are carried out using two approaches: 1) An initial, nationwide catch-up SIA targets all children aged 9 months to 14 years; it has the goal of eliminating susceptibility to measles in the general population. Periodic follow-up SIAs then target all children born since the last SIA. 2) Follow-up SIAs are generally conducted nationwide every 2–4 years and target children aged 9–59 months; their goal is to eliminate any measles susceptibility that has developed in recent birth cohorts and to protect children who did not respond to the first measles vaccination. The exact age range for follow-up SIAs depends on the age-specific incidence of measles, coverage with 1 dose of measles-containing vaccine, and the time since the last SIA.

† Values >100% indicate that the intervention reached more persons than the estimated target population.

§ Rollover national campaigns started the previous year or will continue into the next year.

case-based surveillance in at least part of the country, and 191 (98%) had access to standardized quality-controlled testing through the WHO Global Measles and Rubella Laboratory Network. Nonetheless, surveillance was weak in many countries; fewer than half of countries (64 of 134; 48%) achieved the sensitivity indicator target of two or more discarded measles and rubella§§ cases per 100,000 population in 2016 compared with 2015 (80 of 135; 59%).

§§ A discarded case is defined as a suspected case that has been investigated and discarded as nonmeasles and as nonrubella using 1) laboratory testing in a proficient laboratory or 2) epidemiological linkage to a laboratory-confirmed outbreak of a communicable disease that is not measles or rubella. The discarded case rate is used to measure the sensitivity of measles surveillance.

During 2000–2016, the number of measles cases reported annually worldwide decreased 85%, from 853,479 in 2000 to 214,812 in 2015 and then to 132,137 in 2016; measles incidence decreased 87%, from 145 to 19 cases per 1 million population (Table 1). Compared with 2015, 2016 incidence decreased from 29 to 19 cases per million, although three fewer countries (173 of 194; 89%) reported case data in 2016 than did in 2015 (176 of 194; 92%).¶¶ The percentage of reporting countries with fewer than five measles cases per million population increased from 38% (64/169) in 2000 to 69% (119/173) in 2016. During 2000–2016, measles incidence of fewer than five cases per million was sustained in AMR (Table 1).

During 2015–2016, the number of reported measles cases declined globally and in all regions (AFR, 31%; AMR, 98%; EMR, 71%; EUR, 84%; SEAR, 44%, and WPR, 11%). In addition to aggregate reporting, countries report measles case-based data to WHO monthly. In some countries large discrepancies exist between the two reporting systems. During 2016, some countries either did not report or reported only a fraction of monthly reported measles cases through the Joint Reporting Form (e.g., India reported 70,798 measles cases through monthly reporting, but only 17,250 through the Joint Reporting Form).

Genotypes of viruses isolated from measles cases were reported by 60 (55%) of the 110 countries that reported at least one measles case in 2016. Among the 24 recognized measles virus genotypes, 11 were detected during 2005–2008, eight during 2009–2014, six in 2015, and five in 2016, excluding those from vaccine reactions and cases of subacute sclerosing panencephalitis, a fatal progressive neurologic disorder caused by persistent measles infection (*4*).*** In 2016, among 4,796 reported measles virus sequences,††† 666 were genotype B3 (36 countries); 44 were D4 (four); 1,407 were D8 (43); 87 were D9 (four); and 2,592 were H1 (13).

Disease and Mortality Estimates

A previously described model for estimating measles disease and mortality was updated with new measles vaccination coverage data, case data, and United Nations population estimates for all countries during 2000–2016, enabling derivation of a new series of disease and mortality estimates (*5*). Based on the updated data, the estimated number of measles cases declined from 29,068,400 (95% confidence interval [CI] = 20,606,800–55,859,000) in 2000 to 6,976,800 (95% CI = 4,190,500–28,657,300) in 2016. During this period, the number of estimated measles deaths declined 84%, from 550,100 (95% CI = 374,000–896,500) in 2000 to 89,780 (95% CI = 45,700–269,600) in 2016 (Table 1). Compared with no measles vaccination, measles vaccination prevented an estimated 20.4 million deaths during 2000–2016 (Figure).

Regional Verification of Measles Elimination

In 2016, four WHO regions had functioning regional verification commissions. In September 2016, the AMR regional verification commission declared the region free of endemic measles (*6*). In 2016, the EUR commission verified measles elimination in 24 countries (*7*). Two SEAR countries (Bhutan and Maldives) were verified as having eliminated measles in 2017 (*8*). The WPR commission reclassified Mongolia as having reestablished endemic measles virus transmission because of an outbreak that lasted >12 months; thus, five WPR countries (Australia, Brunei, Cambodia, Japan, and South Korea) and two areas (Macao Special Autonomous Region [SAR] [China] and Hong Kong SAR [China]) had verified measles elimination status in 2016 (*9*).

Discussion

During 2000–2016, increased coverage with MCV administered through routine immunization programs worldwide, combined with SIAs, contributed to an 87% decrease in reported measles incidence and an 84% reduction in estimated measles mortality. Measles vaccination prevented an estimated 20.4 million deaths during this period, and during 2016, for the first time ever, estimated measles deaths declined to fewer than 100,000. Furthermore, the number of countries with measles incidence of fewer than five per million population has increased, although considerable underreporting occurred, and AMR has maintained an incidence of fewer than five cases per million population during 2000–2016. The decreasing number of circulating measles virus genotypes suggests interruption of some chains of transmission. However, the 2015 global control milestones were not met, global MCV1 coverage has stagnated, global MCV2 coverage has reached only 64%, and SIA quality was inadequate to achieve ≥95% coverage in several countries. With suboptimal MCV coverage, outbreaks continued to occur among unvaccinated persons, including school-aged children and young adults.

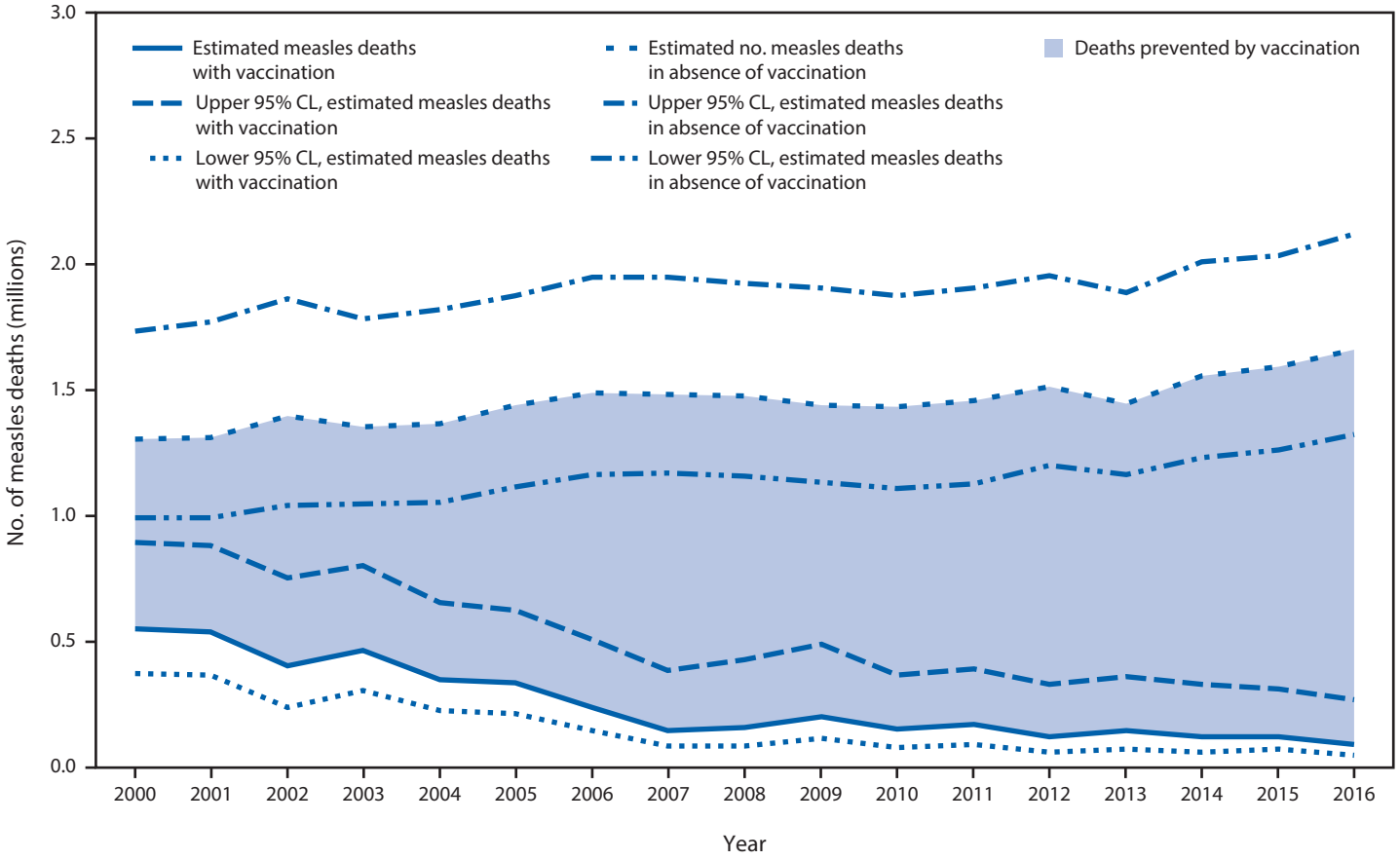
The 2016 Mid-term Review of the Global Measles and Rubella Strategic Plan 2012–2020 concluded that measles elimination strategies were sound, and the WHO Strategic Advisory Group of Experts on Immunization endorsed its findings. The review noted, however, that implementation of the strategies needs improvement. Measures should focus on

¶¶ Twenty-one countries did not report measles case data in 2016: Antigua and Barbuda, Belgium, Cabo Verde, Cook Islands, Ireland, Italy, Kiribati, Marshall Islands, Monaco, Morocco, Mozambique, Nauru, Niue, Poland, Portugal, Samoa, Singapore, Switzerland, Tuvalu, United States, and Vanuatu.

*** http://dx.doi.org/10.1016/B978-0-444-53488-0.00027-4.

††† Sequences were for the 450 nucleotides coding for the carboxy-terminal 150 amino acids of the nucleoprotein of measles virus. Data (as of September 16, 2017) are available from the Measles Nucleotide Surveillance database. http://www.who-measles.org/Public/Web_Front/main.php.

FIGURE. Estimated annual number of measles deaths with and without vaccination programs — worldwide, 2000–2016*



Abbreviation: CL = confidence limit.
* Deaths prevented by vaccination is indicated by the shaded area between estimated deaths with vaccination and those without vaccination (cumulative total of 20.4 million deaths prevented during 2000–2016).

strengthening immunization and surveillance systems. The Measles and Rubella Initiative should increase its emphasis on using surveillance data to drive programmatic actions.

The findings in this report are subject to at least three limitations. First, SIA coverage data might be biased by inaccurate reports of the number of doses delivered, doses administered to children outside the target age group, and inaccurate estimates of the target population size. Second, large differences between the estimated and reported incidence indicate variable surveillance sensitivity, making comparisons between countries and regions difficult to interpret. Finally, the accuracy of the results from the measles mortality model is affected by biases in all model inputs, including country-specific measles vaccination coverage and measles case-based surveillance data.

The decrease in measles mortality to fewer than 100,000 deaths in 2016 is one of five main contributors (along with decreases in mortality from diarrhea, malaria, pneumonia, and neonatal intrapartum deaths) to the decline in overall child mortality worldwide and progress toward the fourth United Nations Millennium Development Goal, but continued work is needed to help achieve measles elimination goals (*10*). Of concern is the possibility that the gains made and future progress in measles elimination could be reversed when polio-funded resources supporting routine immunization services, measles SIAs, and measles surveillance diminish and disappear after polio eradication. Countries with the highest measles mortality rely most heavily on polio-funded resources and are at highest risk for reversal of progress after polio eradication is achieved. Improved implementation of elimination strategies by countries and their partners is needed, with focus on increasing vaccination coverage with substantial and sustained additional investments in health systems, strengthening surveillance systems, using surveillance data to drive programmatic actions, securing political commitment, and raising the visibility of measles elimination goals.

Conflict of interest

No conflicts of interest were reported.

Summary

What is already known about this topic?

The fourth United Nations Millennium Development Goal, adopted in 2000, set a target to reduce child mortality by two thirds by 2015. One indicator of progress toward this target was measles vaccination coverage.

What is added by this report?

For the first time, annual estimated measles deaths were fewer than 100,000, in 2016. This achievement follows an increase in the number of countries providing the second dose of measles-containing vaccine (MCV2) nationally through routine immunization services to 164 (85%) of 194 countries, and the vaccination of approximately 119 million persons against measles during supplementary immunization activities in 2016. During 2000–2016, annual reported measles incidence decreased 87%, from 145 to 19 cases per million persons, annual estimated measles deaths decreased 84%, from 550,100 to 89,780, and an estimated 20.4 million deaths were prevented. However, the 2015 measles elimination milestones have not yet been met, and only one World Health Organization region has been verified as having eliminated measles.

What are the implications for public health practice?

To achieve measles elimination goals, countries and their partners need to act urgently to secure political commitment, raise the visibility of measles elimination, increase vaccination coverage, strengthen surveillance, and mitigate the threat of decreasing resources once polio eradication is achieved. Polio eradication resources have supported routine immunization services and surveillance activities.

[1]Department of Immunization, Vaccines, and Biologicals, World Health Organization; [2]Global Immunization Division, Center for Global Health, CDC; [3]Division of Viral Diseases, National Center for Immunization and Respiratory Diseases, CDC.

Corresponding author: James L. Goodson, jgoodson@cdc.gov, 404-639-8170.

References

1. United Nations General Assembly. United Nations millennium declaration. New York, NY: United Nations General Assembly; 2000. http://www.un.org/millenniumgoals/
2. World Health Organization. Global eradication of measles: report by the Secretariat. Geneva, Switzerland: World Health Organization; 2010. http://apps.who.int/gb/ebwha/pdf_files/wha63/a63_18-en.pdf
3. Patel MK, Gacic-Dobo M, Strebel PM, et al. Progress toward regional measles elimination—worldwide, 2000–2015. MMWR Morb Mortal Wkly Rep 2016;65:1228–33. https://doi.org/10.15585/mmwr.mm6544a6
4. Genetic diversity of wild-type measles viruses and the global measles nucleotide surveillance database (MeaNS). Wkly Epidemiol Rec 2015;90:373–80.
5. Simons E, Ferrari M, Fricks J, et al. Assessment of the 2010 global measles mortality reduction goal: results from a model of surveillance data. Lancet 2012;379:2173–8. https://doi.org/10.1016/S0140-6736(12)60522-4
6. Pan American Health Organization. Region of the Americas is declared free of measles. Washington, DC: Pan American Health Organization; 2016. http://www.paho.org/hq/index.php?option=com_content&view=article&id=12528&Itemid=1926&lang=en
7. World Health Organization, Regional Office for Europe. Fifth meeting of the European Regional Verification Commission for Measles and Rubella Elimination (RVC). Copenhagen, Denmark: World Health Organization, Regional Office for Europe; 2016. http://www.euro.who.int/__data/assets/pdf_file/0005/330917/5th-RVC-meeting-report.pdf?ua=1
8. World Health Organization, Regional Office for South-East Asia. Bhutan, Maldives eliminate measles. New Delhi, India: World Health Organization, Regional Office for South-East Asia; 2017. http://www.searo.who.int/mediacentre/releases/2017/1651/en/
9. World Health Organization, Regional Office for the Western Pacific. Fifth annual meeting of the Regional Verification Commission for Measles Elimination in the Western Pacific. Manila, Philippines: World Health Organization, Regional Office for the Western Pacific; 2016. http://iris.wpro.who.int/bitstream/handle/10665.1/13528/RS-2016-GE-25-AUS-eng.pdf?ua=1
10. Liu L, Oza S, Hogan D, et al. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals. Lancet 2016;388:3027–35. https://doi.org/10.1016/S0140-6736(16)31593-8

Notes from the Field

Postexposure Prophylaxis for Rabies After Consumption of a Prepackaged Salad Containing a Bat Carcass — Florida, 2017

Vikram Krishnasamy, MD[1,2]; Matthew R. Mauldin, PhD[3]; Matthew E. Wise, PhD[2]; Ryan Wallace, DVM[3]; Laura Whitlock, MPH[2]; Colin Basler, DVM[2]; Clint Morgan, MS[3]; Dana Grissom[4]; Sherry Worley[4]; Danielle Stanek, DVM[5]; Jamie DeMent, MNS[5]; Pamela Yager[3]; William Carson[3]; Rene E. Condori, MS[3]; Yoshinori Nakazawa, PhD[3]; Claire Walker[3]; Yu Li, PhD[3]; Christopher Wynens, DVM[6]; Allison Wellman, MPH[6]; James Ellison, PhD[3]; Emily Pieracci, DVM[3]

On April 3, 2017, two Florida residents consumed part of the same prepackaged salad before reportedly discovering the partial remains of a bat carcass in the salad. Bats are known reservoirs for rabies virus, which causes rabies disease in both animals and humans (*1*). The persons who ate the salad contacted the Florida Department of Health (FLDOH), which notified CDC's Poxvirus and Rabies Branch. CDC and FLDOH determined that the immediate concern was for potential rabies virus exposure, because approximately 6% of bats submitted to U.S. public health departments annually test positive for rabies virus (*2*,*3*).

Although percutaneous exposures are more likely to result in successful transmission of rabies virus to humans (*1*), transmission can occur when infectious material, such as saliva or nervous tissue from an infected animal, comes into direct contact with human mucosa (*2*). Infection with rabies virus causes an acute, progressive encephalitis that is nearly always fatal once clinical signs have begun. The disease is preventable if exposed persons receive timely postexposure prophylaxis (PEP), which includes human rabies immunoglobulin and 4 doses of inactivated rabies vaccine administered over 14 days (*4*).

FLDOH submitted the bat carcass to CDC for rabies virus testing on April 4. Polymerase chain reaction and direct fluorescent antibody tests were inconclusive because of the deteriorated condition of the carcass. However, because the cranium of the bat was intact, exposure to brain material by the persons who consumed the salad was unlikely, although exposure to the bat's organs or peripheral nervous tissue was possible. PEP was recommended because laboratory test results were inconclusive and exposure to nervous tissue could not be ruled out.

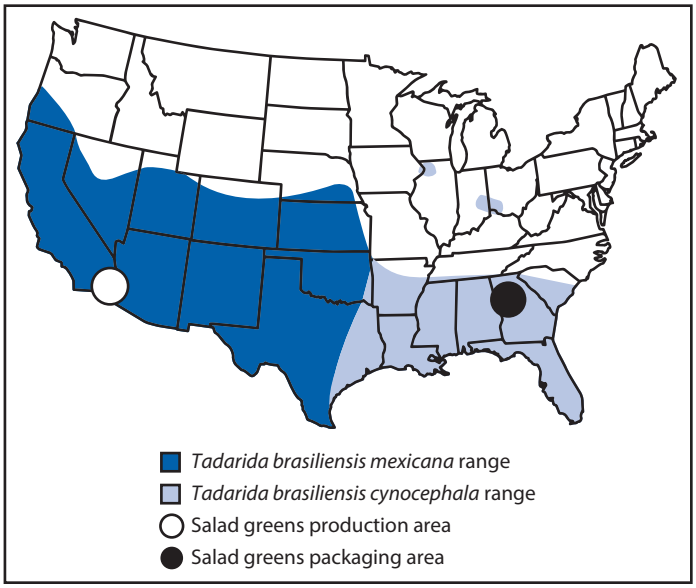
The salad was purchased from a company A store location. After being notified of the investigation, company A removed the lot of prepackaged salad from all store locations on April 5. Company B (the prepackaged salad supplier) recalled the affected lot of salads on April 8. CDC advised consumers to contact their local health department for PEP evaluation only if the consumer had eaten a recalled prepackaged salad and had found animal material in the salad. CDC was not notified of any other reports of dead bats in prepackaged salads.

To identify where the bat might have been introduced into the prepackaged salad, CDC performed genetic analyses on the bat to determine its subspecies. Based on morphology and phylogenetic analyses (Bayesian inference and haplotype network analyses) of mitochondrial DNA sequence data (Cytb and D-loop), the bat was identified as a Mexican free-tailed bat (*Tadarida brasiliensis mexicana*), which is found throughout the southwestern United States. It is genetically distinct from *T. brasiliensis cynocephala*, which occurs in the southeastern United States (Figure) (*5*).

The investigation determined that cutting and harvesting of greens for the recalled salad occurred in fields in the west and southwest United States before they were transported to a processing plant in Georgia. At the processing plant, the greens were washed with chlorinated water and packaged. Given the physical condition of the bat (e.g., decomposed, bisected) and the geographic location of the fields and the processing plant, along with the genetic identification of the bat, investigators concluded the bat most likely came into contact with the salad material in the field during harvesting and cutting and was then transported to the processing facility.

Several factors likely reduced the risk for rabies virus transmission to the two Florida consumers. No rabies virus was detected in the specimen, the bat's cranium was intact, and the salad was rinsed before packaging, thereby diluting any potential virus. In

FIGURE. Distribution of *Tadarida brasiliensis mexicana* and *T. brasiliensis cynocephala* bat species in areas of production and packaging of salad greens — United States, 2017.



addition, mucosal membrane exposures have rarely been proven to result in rabies disease, and rabies virus does not survive more than a few days outside a host (*2*). Although this exposure was likely of low risk, this investigation was an example of effective industry and government collaboration to remove a product of concern from the marketplace rapidly to protect consumers.

Conflict of interest

No conflicts of interest were reported.

[1]Epidemic Intelligence Service, Division of Scientific Education and Professional Development, Center for Surveillance, Epidemiology, and Laboratory Services, CDC; [2]Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging and Zoonotic Infectious Diseases, CDC; [3]Division of High Consequence Pathogens and Pathology, National Center for Emerging and Zoonotic Infectious Diseases, CDC; [4]Florida Department of Health in Santa Rosa County; [5]Florida Department of Health; [6]Food and Drug Administration.

Corresponding author: Vikram Krishnasamy, vkrishnasamy@cdc.gov, 404-718-5504.

References

1. Fooks AR, Banyard AC, Horton DL, Johnson N, McElhinney LM, Jackson AC. Current status of rabies and prospects for elimination. Lancet 2014;384:1389–99. https://doi.org/10.1016/S0140-6736(13)62707-5
2. Manning SE, Rupprecht CE, Fishbein D, et al.; Advisory Committee on Immunization Practices. Human rabies prevention—United States, 2008: recommendations of the Advisory Committee on Immunization Practices. MMWR Recomm Rep 2008;57(No. RR-3).
3. Birhane MG, Cleaton JM, Monroe BP, et al. Rabies surveillance in the United States during 2015. J Am Vet Med Assoc 2017;250:1117–30. https://doi.org/10.2460/javma.250.10.1117
4. Rupprecht CE, Briggs D, Brown CM, et al. Use of a reduced (4-dose) vaccine schedule for postexposure prophylaxis to prevent human rabies: recommendations of the Advisory Committee on Immunization Practices. MMWR Recomm Rep 2010;59(No. RR-2).
5. Hall ER. 1981. The mammals of North America, vol 1. 2nd ed. New York, New York: John Wiley and Sons.

Notes from the Field

High Volume of Lyme Disease Laboratory Reporting in a Low-Incidence State — Arkansas, 2015–2016

Natalie A. Kwit, DVM[1,2]; Elizabeth A. Dietrich, PhD[2,3]; Christina Nelson, MD[2]; Richard Taffner[4]; Jeannine Petersen, PhD[2]; Martin Schriefer, PhD[2]; Paul Mead, MD[2]; Susan Weinstein, DVM[4]; Dirk Haselow, MD[4]

Although Arkansas lies within the geographic range of the principal Lyme disease tick vector, *Ixodes scapularis*, because of ecologic and entomologic factors, the risk for human infection is low, and no confirmed Lyme disease cases were reported in Arkansas during 2008–2014 (*1*). However, during 2015–2016, the Arkansas Department of Health (ADH) received several hundred potentially positive serologic laboratory reports for Lyme disease. Recommended serologic testing for Lyme disease is a two-tiered process; only if the first-tier enzyme immunoassay is positive or equivocal should the second-tier western blot be performed. A positive overall result can only be concluded when results of both individual tests are documented (*2*). Laboratory reports submitted to ADH during 2015–2016 did not always include complete or overall positive two-tiered serology results or associated clinical information needed to make a case determination. To facilitate Lyme disease surveillance in the setting of a high volume of reports and to ascertain whether local transmission of Lyme disease has occurred, ADH and CDC reviewed laboratory reports and clinical data, classified cases according to the surveillance definition, and investigated cases with potential for confirmation of Lyme disease.

Paper laboratory reports of Lyme disease testing sent to ADH were matched by patient name and birth date with electronic laboratory surveillance data to consolidate reports. Reports were then sorted and prioritized for follow-up based on recommended laboratory criteria for diagnosis and available information. Among the 911 Lyme disease laboratory reports submitted to ADH during 2015–2016, a total of 582 combined reports for unique patients were identified. Among 295 reports with sufficient information to make a determination, 282 (95.6%) did not meet the Council of State and Territorial Epidemiologists surveillance criteria for Lyme disease.* Eleven (3.7%) met the probable (three reports) or suspected (eight) Lyme disease surveillance case definition, and two reports (0.7%) met the confirmed case definition. Further investigation of the two confirmed cases revealed that both patients were likely infected in high-incidence states. One patient had signs of arthritis soon after moving to Arkansas from the northeastern United States, but did not receive a diagnosis of and treatment for Lyme disease until nearly 1 year later, underscoring the fact that even where Lyme disease is rare, providers need to obtain a travel history and consider the diagnosis in patients with compatible symptoms who have lived in or visited states where Lyme disease is common.

Lyme disease is the most common vectorborne disease in the United States, caused by the spirochete *Borrelia burgdorferi* sensu stricto and the recently discovered *Borrelia mayonii* (*3*), but risk for infection is not uniform. In 2015, 95% of cases in the United States were reported from 14 states concentrated in the Northeast, mid-Atlantic, and upper Midwest regions (*1*). In Arkansas, host-seeking *I. scapularis* ticks are much less abundant, less prone to biting humans, rarely infected with *B. burgdorferi*, and prefer feeding on nonreservoir hosts (*4*). However, the occurrence of travel-related infections and the need to monitor for emergence of locally acquired infection underscore the importance of Lyme disease surveillance in Arkansas and other low-risk states.

Of the hundreds of Lyme disease reports submitted to ADH during 2015–2016, many had incomplete information or negative laboratory results; however, the ADH Lyme disease surveillance system did identify two confirmed, travel-associated infections. The absence of similarly confirmed, locally acquired cases supports the view that autochthonous transmission of Lyme disease is either exceedingly rare or has not occurred in Arkansas. The risk for other tickborne diseases in Arkansas results in frequent requests for Lyme disease testing as part of a general tickborne disease serologic panel, even when Lyme disease is not suspected by the clinician. Strong clinical evidence supported by positive two-tiered serologic testing is essential to securing a diagnosis of Lyme disease in low-incidence states (*2,5*).

For reporting Lyme disease to public health authorities, health care providers should follow infectious disease testing recommendations and reporting guidelines set forth by state health departments and only submit reports for cases that have complete and positive test results and associated clinical information. Given that multiple laboratory tests, potentially performed and reported by different laboratories, might be necessary to determine Lyme disease case status, health departments need an efficient process to manage and interpret incoming laboratory reports.

* https://wwwn.cdc.gov/nndss/conditions/lyme-disease/case-definition/2017.

Conflict of Interest

No conflicts of interest were reported.

[1]Epidemic Intelligence Service, CDC; [2]Division of Vector-Borne Diseases, National Center for Emerging and Zoonotic Infectious Diseases, CDC; [3]Laboratory Leadership Service, CDC; [4]Arkansas Department of Health.

Corresponding author: Elizabeth A. Dietrich, bzb_public@cdc.gov, 970-221-6400.

References

1. CDC. Lyme disease incidence rates by state, United States, 2005–2015. Atlanta, GA: US Department of Health and Human Services, CDC; 2016. https://www.cdc.gov/lyme/stats/tables.html
2. CDC. Recommendations for test performance and interpretation from the Second National Conference on Serologic Diagnosis of Lyme Disease. MMWR Morb Mortal Wkly Rep 1995;44:590–1.
3. Pritt BS, Mead PS, Johnson DKH, et al. Identification of a novel pathogenic Borrelia species causing Lyme borreliosis with unusually high spirochaetaemia: a descriptive study. Lancet Infect Dis 2016;16:556–64. https://doi.org/10.1016/S1473-3099(15)00464-8
4. Mead PS. Epidemiology of Lyme disease. Infect Dis Clin North Am 2015;29:187–210. https://doi.org/10.1016/j.idc.2015.02.010
5. Forrester JD, Brett M, Matthias J, et al. Epidemiology of Lyme disease in low-incidence states. Ticks Tick Borne Dis 2015;6:721–3. https://doi.org/10.1016/j.ttbdis.2015.06.005

Notes from the Field

Postflooding Leptospirosis — Louisiana, 2016

Alean A. Frawley, DO[1,2]; Ilana J. Schafer, DVM[3]; Renee Galloway, MPH[3]; Aileen Artus, MPH[3]; Raoult C. Ratard, MD[1]

In August 2016, extensive flooding occurred in south-central Louisiana. Approximately 1 month after the flood, the Louisiana Office of Public Health received notification through electronic laboratory reporting of two patients with serologic evidence of leptospirosis (immunoglobulin M antibodies to *Leptospira* species). Both patients were hospitalized with severe illness at the time of laboratory testing and recovered after appropriate treatment. Hospital record review revealed that both patients were exposed to floodwater before illness onset. Because these two (sentinel) patients with leptospirosis represented a marked increase over the three cases reported in their respective parishes of residence during the previous 28 years (*1*), an investigation was undertaken to identify other cases of leptospirosis related to the 2016 flood.

Leptospirosis is a bacterial disease caused by infection with pathogenic *Leptospira* species *(2)*. Humans can be infected through direct contact with urine from an infected animal or by contact with urine-contaminated soil or water, often during flooding (*3*). Approximately 90% of patients with leptospirosis experience a nonspecific, self-limited illness with symptoms of fever, chills, nausea, or headache (*2*). Pain in the calf and low back muscles and conjunctival suffusion without purulent discharge are distinctive features (*2*). Approximately 10% of patients develop severe illness, which is characterized by any combination of jaundice, renal failure, aseptic meningitis, cardiac arrhythmia, gastrointestinal symptoms, pulmonary hemorrhage, or circulatory collapse and is associated with a 5%–15% case fatality rate (*2*).

Suspected leptospirosis cases were defined as the occurrence of fever with at least two nonspecific symptoms (myalgia, headache, jaundice, conjunctival suffusion, or maculopapular or petechial rash), or at least one diagnosis indicating severe illness (aseptic meningitis, renal insufficiency, pulmonary complications, electrocardiogram abnormalities, gastrointestinal symptoms, hemorrhage, or jaundice with acute renal failure) during August 13–September 21, 2016 in a patient exposed to floodwater (*4*). The Louisiana Early Events Detection System (LEEDS), a statewide electronic syndromic surveillance system, was queried to identify patients treated in hospitals serving the flood region during August 13–September 21 who had signs, symptoms, or diagnoses compatible with leptospirosis. The dates were selected to include the flooding period (August 11–August 20) and a leptospirosis incubation period beginning 2 days after flooding started and continuing through 30 days after water recession (*2*). Hospital records of patients meeting the symptoms or diagnosis components of the case definition were reviewed; patients without fever or with laboratory evidence supporting an alternative diagnosis were eliminated. The remaining patients were interviewed to ascertain floodwater exposure; those with floodwater exposure provided whole blood and urine specimens for leptospirosis polymerase chain reaction (PCR) testing and a serum specimen for microscopic agglutination test (MAT) testing. MAT was also performed on serum from both sentinel patients. An acute urine specimen from one sentinel patient was tested by PCR. All laboratory testing was performed by CDC.

LEEDS queries yielded 69 patients warranting medical record review. After eliminating patients who did not meet the case definition based on medical record review, 13 of 18 patients who met the case definition were contacted for interview; among these, four reported floodwater exposure and submitted blood and urine specimens. MAT and PCR were negative for *Leptospira* spp. infection among all LEEDS-identified patients. Leptospirosis was confirmed by MAT in both sentinel patients; urine PCR identified *Leptospira kirschneri* DNA in one sentinel patient.

Leptospira species are prevalent among Louisiana wildlife. According to the Louisiana Department of Wildlife and Fisheries (LDWF), anti-*Leptospira* spp. seroprevalence in the Louisiana feral swine population was 71% in 2015 (Rusty Berry, DVM, LDWF, personal communication, November 9, 2016), which is markedly higher than the 26% estimated by the United States Department of Agriculture in 2012 (*5*). LDWF surveillance also identified a substantial increase in leptospirosis in the deer population, from an average seroprevalence of 7% during 2007–2012 to 42% during the 2015–2016 hunting season. (Rusty Berry, DVM, LDWF, personal communication, November 9, 2016 and July 6, 2017).

No additional confirmed cases of postflooding leptospirosis were identified. Nonetheless, cases might have been missed because of flood-related access to care difficulties and patients not seeking medical care for less than severe illness. However, given the endemicity of *Leptospira* spp. among Louisiana wildlife, including documented *L. kirschneri* in feral swine isolates (*6*), and the two recent flood-related cases of leptospirosis, a high index of suspicion for leptospirosis among patients with compatible symptoms and exposure to untreated water is warranted, especially during flooding. Educating the public about leptospirosis prevention and clinicians about its clinical presentation might decrease the prevalence of severe disease by enabling early identification and treatment.

Acknowledgments

Rusty Berry, Louisiana Department of Wildlife and Fisheries; Angie Orellana, Gillian Richardson, Lauren Elmendorf, Infectious Disease Epidemiology Section, Louisiana Office of Public Health.

Conflict of Interest

No conflicts of interest were reported.

[1]Infectious Disease Epidemiology Section, Louisiana Department of Health; [2]Epidemic Intelligence Service, CDC; [3]Division of High-Consequence Pathogens and Pathology, National Center for Emerging and Zoonotic Infectious Diseases, CDC.

Corresponding author: Alean A. Frawley, alean.frawley@la.gov, 504-568-8327.

References

1. Louisiana Office of Public Health. Leptospirosis annual report 2016. Leptospirosis. Baton Rouge, LA: Louisiana Office of Public Health; 2017. http://new.dhh.louisiana.gov/assets/oph/Center-PHCH/Center-CH/infectious-epi/Annuals/Leptospirosis_LaIDAnnual.pdf
2. American Academy of Pediatrics. Leptospirosis. In: Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. Red book: 2015 report of the Committee on Infectious Diseases. 30th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2015:510–13. https://redbook.solutions.aap.org/book.aspx?bookid=1484
3. CDC. Leptospirosis infection. Atlanta, GA: US Department of Health and Human Services, CDC; 2015. https://www.cdc.gov/leptospirosis/infection/index.html
4. CDC. Leptospirosis (*Leptospira interrogans*) 2013 case definition. Atlanta, GA: US Department of Health and Human Services, CDC; 2013. https://wwwn.cdc.gov/nndss/conditions/leptospirosis/case-definition/2013/
5. United States Department of Agriculture, Animal and Plant Health Inspection Service, National Wildlife Research Center. National Wildlife Disease Program fiscal year 2012 annual report. Washington DC: United States Department of Agriculture, Animal and Plant Inspection Service, National Wildlife Research Center; 2012. https://www.aphis.usda.gov/wildlife_damage/nwdp/pdf/NWDP%202012%20Annual%20Report%20Final.pdf
6. LaCour JM. Feral hogs in Louisiana: an overview. Presented at the Louisiana Department of Wildlife and Fisheries. Baton Rouge, LA; April 3, 2014. http://www.wlf.louisiana.gov/sites/default/files/pdf/document/37570-feral-hogs-louisiana-overview-commission-meeting-webpost-4-3-14-kr-bb/feral_hogs_in_louisiana_an_overview_commission_meeting_for_webpost_4_3_14_kr_bb.pdf

Erratum

Vol. 66, No. 40

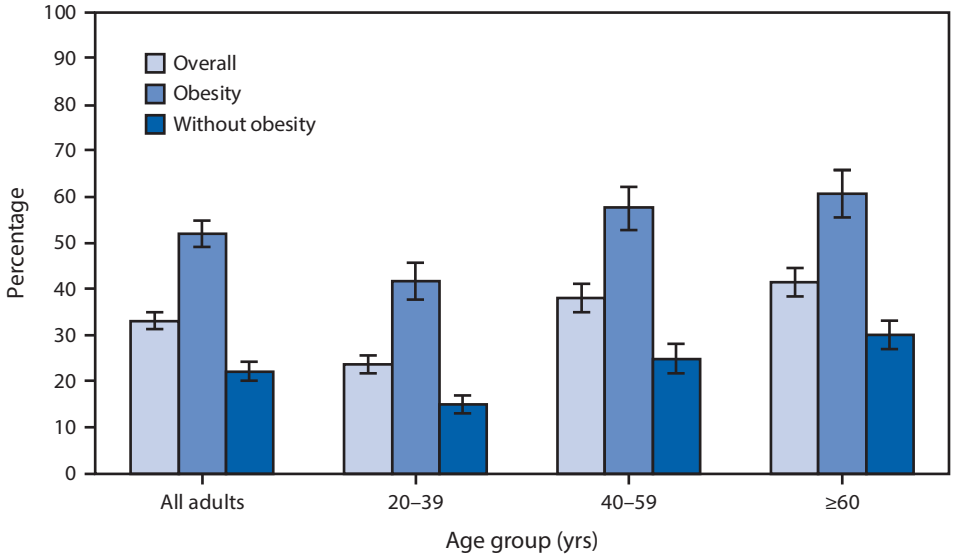
In the report "Vaccination Coverage for Selected Vaccines, Exemption Rates, and Provisional Enrollment Among Children in Kindergarten — United States, 2016–17 School Year," on page 1074 the first sentence of footnote "§§" should have read "**All 50 states and DC required 2 doses of a measles-containing vaccine.**"

On page 1077, in Table 1, footnote "**" should have read "**Most states require 2 doses of MMR; Alaska, New Jersey, and Oregon require 2 doses of measles, 1 dose of mumps, and 1 dose of rubella vaccines. Georgia, New York, New York City, North Carolina, Pennsylvania, and Virginia require 2 doses of measles and mumps, and 1 dose of rubella vaccines. Iowa requires 2 doses of measles and 2 doses of rubella vaccines.**"

QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Adults Aged ≥20 Years Who Reported Being Told by a Doctor or Health Professional to Increase Their Physical Activity,† by Age Group and Obesity Status§ — National Health and Nutrition Examination Survey, United States, 2011–2014



* With 95% confidence intervals indicated with error bars.
† Based on the question "To lower your risk for certain diseases, during the past 12 months, have you ever been told by a doctor or health professional to increase your physical activity or exercise?"
§ Obesity status was based on measured body mass index (BMI), which was calculated as weight in kilograms divided by height in meters squared, rounded to one decimal place. Obesity was defined as BMI ≥30.

During 2011–2014, 33.2% of adults aged ≥20 years reported that a doctor or health professional told them to increase their physical activity. More than half (52.2%) of adults aged ≥20 years with obesity reported that a doctor or health professional told them to increase their physical activity compared with less than a quarter (22.3%) of adults without obesity. This pattern remained the same for all age groups examined. For both adults with and without obesity, the proportion who reported being told to increase their physical activity increased with age.

Source: National Center for Health Statistics, National Health and Nutrition Examination Survey, 2011–2014. https://www.cdc.gov/nchs/nhanes.htm.

Reported by: Marissa L. Zwald, PhD, mzwald@cdc.gov, 301-458-4041; Brian Kit, MD; Lara J. Akinbami, MD; Tala H.I. Fakhouri, PhD; Steven M. Frenk, PhD.

The *Morbidity and Mortality Weekly Report (MMWR)* Series is prepared by the Centers for Disease Control and Prevention (CDC) and is available free of charge in electronic format. To receive an electronic copy each week, visit *MMWR*'s free subscription page at *https://www.cdc.gov/mmwr/mmwrsubscribe.html*. Paper copy subscriptions are available through the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; telephone 202-512-1800.

Readers who have difficulty accessing this PDF file may access the HTML file at *https://www.cdc.gov/mmwr/index2017.html*. Address all inquiries about the *MMWR* Series, including material to be considered for publication, to Executive Editor, *MMWR* Series, Mailstop E-90, CDC, 1600 Clifton Rd., N.E., Atlanta, GA 30329-4027 or to mmwrq@cdc.gov.

ISSN: 0149-2195 (Print)