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Receipt of Breast Milk by Gestational Age — United States, 2017

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Breast milk is the optimal source of infant nutrition. For the nearly one in 10 infants born prematurely in the United States annually (*1*), breast milk is especially beneficial, helping prevent sepsis and necrotizing enterocolitis and promoting neurologic development (*2*). National estimates of newborn feeding practices by gestational age have not been available previously. CDC analyzed 2017 birth certificate data from 48 states and the District of Columbia (3,194,873; 82.7% of all births) to describe receipt of breast milk among extremely preterm (20–27 weeks), early preterm (28–33 weeks), late preterm (34–36 weeks), and term (≥37 weeks) infants with further stratification by maternal and infant characteristics. The prevalence of infants receiving any breast milk was 83.9% overall and varied by gestational age, with 71.3% of extremely preterm infants, 76.0% of early preterm infants, 77.3% of late preterm infants, and 84.6% of term infants receiving any breast milk. Disparities in receipt of breast milk by several sociodemographic factors, including maternal race/ethnicity, were noted across gestational age groups. These estimates suggest that many infants, particularly infants at high risk for medical complications, might not be receiving breast milk. Efforts are needed to increase the implementation of existing evidence-based policies and practices that support breast milk feeding, particularly for medically fragile infants (*2*,*3*).

The National Vital Statistics System birth data are a census of all live births in the United States. Federal guidance includes procedures for collecting uniform birth data using the U.S. Standard Certificate of Live Birth (*4*).* Data collected include nutrition information determined from medical record indication of receipt of any breast milk or colostrum during the period between delivery and hospital discharge, including both mother's own and donor breast milk (*4*). Preterm infants often have extended hospital stays (*5*); however, state statutes require completion and filing of birth certificates soon after delivery, usually within 5–10 days of birth. Therefore, among preterm infants, this item likely captures receipt of breast milk only between delivery and completion of the birth certificate. Gestational age was ascertained from the birth certificate's obstetric estimate of completed weeks of gestation and categorized as extremely preterm (20–27 weeks), early preterm (28–33 weeks), late preterm (34–36 weeks), and term (≥37 weeks)† (*4*). On birth certificates, maternal sociodemographic data are typically collected through maternal self-report and neonatal intensive care unit (NICU) admission is collected from the medical record (*4*).

* https://www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf.

† Gestational age terms are those commonly used by various medical, research, and public health organizations. However, because there is a lack of consensus regarding the age ranges for each category, categories were defined in this report using completed weeks' gestation as the following: extremely preterm (20–27 weeks), early preterm (28–33 weeks), late preterm (34–36 weeks), and term (≥37 weeks). The lower limit of 20 completed weeks' gestation was used to exclude births where resuscitation was unlikely.

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Analysis was restricted to infants with gestational ages ≥20 weeks who were not transferred to another facility within 24 hours of delivery and who were living at the time of birth certificate completion. Only births delivered to residents of 48 states and the District of Columbia in 2017 were included; births delivered to residents of California and Michigan were not available for analysis (15.1% of U.S. resident births). The percentage of infants who received breast milk was calculated overall and by gestational age using SAS (version 9.4; SAS Institute). Receipt of breast milk was further stratified by maternal characteristics and infant NICU admission.

Overall, 83.9% of infants received breast milk during the first few days of life (Table). Term infants were more likely to have received breast milk than were preterm infants, with percentages increasing with gestational age: 71.3% of extremely preterm infants, 76.0% of early preterm infants, 77.3% of late preterm infants, and 84.6% of term infants.

Among extremely preterm infants, 67.1% of those delivered to black mothers and 60.7% of those delivered to American Indian/Alaska Native mothers received breast milk, compared with approximately 75% of extremely preterm infants delivered to mothers of other racial/ethnic groups. This racial/ethnic disparity was observed across gestational age groups. In general, across gestational age groups, infants of mothers who were younger, less educated, unmarried, and participating in Medicaid or the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) were less likely to receive breast milk than were infants of older, more educated, and married mothers, those with private insurance, other coverage, or who were self-pay, and those not participating in WIC. In addition, receipt of breast milk by NICU admission differed by gestational age, with higher prevalences of receipt of breast milk among late preterm and term infants who were not admitted to a NICU.

Discussion

Although breast milk is especially beneficial for preterm infants, fewer preterm than term infants received breast milk in the first few days of life. Disparities in receipt of breast milk by gestational age could be explained by multiple factors. Gastrointestinal tract or oral-motor immaturity might inhibit enteral feeding (through the mouth or through a tube directly into the infant's stomach) for some preterm infants, necessitating the use of parenteral, or intravenous, nutrition (*6*). In addition, mothers of preterm infants might be unable to produce sufficient breast milk and might lack access to donor milk. The American Academy of Pediatrics recommends that all preterm infants receive breast milk; if mother's milk is unavailable or contraindicated, then fortified pasteurized donor milk should be used (*2*). Data from CDC's 2015 Maternity Practices in Infant Nutrition and Care survey indicate that among U.S. hospitals with level 3 and level 4 NICUs, approximately 66% and 73%, respectively, report using any donor milk (*7*).

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TABLE. Number of infants receiving breast milk among live infants not transferred to another facility,* by gestational age† and maternal and infant characteristics — 48 states§ and the District of Columbia, National Vital Statistics System, 2017

	Receipt of breast milk by gestational age									
	Extremely preterm		Early preterm		Late preterm		Term		Overall	
Characteristic	Total no.¶	No. received (%)	Total no.¶	No. received (%)	Total no.¶	No. received (%)	Total no.¶	No. received (%)	Total no.¶	No. received (%)
Overall	**13,225**	**9,433(71.3)**	**60,385**	**45,883 (76.0)**	**225,279**	**174,084 (77.3)**	**2,895,984**	**2,451,442 (84.6)**	**3,194,873**	**2,680,842 (83.9)**
Maternal race/ethnicity**										
Hispanic	2,704	1,981 (73.3)	12,014	9,588 (79.8)	46,371	38,551 (83.1)	597,800	528,165 (88.4)	658,889	578,285 (87.8)
White	4,820	3,557 (73.8)	28,131	21,913 (77.9)	114,473	89,810 (78.5)	1,599,178	1,371,958 (85.8)	1,746,602	1,487,238 (85.2)
Black	4,620	3,102 (67.1)	15,198	10,455 (68.8)	44,636	29,580 (66.3)	436,677	320,136 (73.3)	501,131	363,273 (72.5)
Asian	545	415 (76.1)	2,700	2,217 (82.1)	10,886	9,553 (87.8)	155,841	143,134 (91.8)	169,972	155,319 (91.4)
American Indian/Alaska Native	107	65 (60.7)	527	360 (68.3)	2,268	1,525 (67.2)	24,199	18,739 (77.4)	27,101	20,689 (76.3)
Native Hawaiian/Other Pacific Islander	20	15 (75.0)	147	118 (80.3)	587	444 (75.6)	6,586	5,510 (83.7)	7,340	6,087 (82.9)
Multiracial	322	243 (75.5)	1,257	956 (76.1)	4,864	3,759(77.3)	60,134	50,523 (84.0)	66,577	55,481 (83.3)
Maternal age group (yrs)										
≤19	902	622 (69.0)	3,227	2,334 (72.3)	11,649	8,122 (69.7)	150,865	111,202 (73.7)	166,643	122,280 (73.4)
20–29	6,325	4,520 (71.5)	27,406	20,653 (75.4)	105,814	79,487 (75.1)	1,447,576	1,192,173 (82.4)	1,587,121	1,296,833 (81.7)
30–39	5,421	3,882 (71.6)	26,716	20,563 (77.0)	97,796	78,407 (80.2)	1,214,657	1,075,184 (88.5)	1,344,590	1,178,036 (87.6)
≥40	577	409 (70.9)	3,036	2,333 (76.8)	10,020	8,068 (80.5)	82,886	72,883 (87.9)	96,519	83,693 (86.7)
Maternal highest education level										
Less than a high school diploma	1,929	1,250 (64.8)	8,891	5,987 (67.3)	32,739	21,455 (65.5)	375,711	277,369 (73.8)	419,270	306,061 (73.0)
High school diploma	3,936	2,716 (69.0)	16,562	11,734 (70.8)	60,428	42,069 (69.6)	728,084	557,575 (76.6)	809,010	614,094 (75.9)
Some college	4,177	3,048 (73.0)	18,037	14,114 (78.3)	66,933	53,016 (79.2)	825,306	707,817 (85.8)	914,453	777,995 (85.1)
College graduate	3,035	2,338 (77.0)	16,229	13,623 (83.9)	63,359	56,336 (88.9)	947,414	893,004 (94.3)	1,030,037	965,301 (93.7)
Maternal marital status										
Married	6,044	4,571 (75.6)	31,440	25,806 (82.1)	125,837	106,251 (84.4)	1,758,860	1,593,226 (90.6)	1,922,181	1,729,854 (90.0)
Unmarried	7,181	4,862(67.7)	28,945	20,077 (69.4)	99,442	67,833 (68.2)	1,137,124	858,216 (75.5)	1,272,692	950,988 (74.7)
Payment source at delivery										
Medicaid	6,665	4,484 (67.3)	28,806	20,184 (70.1)	105,068	72,518 (69.0)	1,220,031	935,374 (76.7)	1,360,570	1,032,560 (75.9)
Private insurance	5,371	4,100 (76.3)	26,561	21,868 (82.3)	102,270	87,359 (85.4)	1,426,621	1,295,629 (90.8)	1,560,823	1,408,956 (90.3)
Self-pay	580	385 (66.4)	2,260	1,618 (71.6)	8,122	6,158 (75.8)	121,236	107,838 (88.9)	132,198	115,999 (87.7)
Other	505	398 (78.8)	2,374	1,936 (81.6)	8,445	7,037 (83.3)	111,100	98,552 (88.7)	122,424	107,923 (88.2)
WIC participation during pregnancy										
Yes	4,919	3,409 (69.3)	22,841	16,644 (72.9)	88,406	62,876 (71.1)	1,057,343	815,648 (77.1)	1,173,509	898,577 (76.6)
No	8,106	5,896 (72.7)	36,716	28,681 (78.1)	134,117	109,275 (81.5)	1,805,233	1,608,321 (89.1)	1,984,172	1,752,173 (88.3)
Infant NICU admission										
Yes	12,188	8,802 (72.2)	53,277	40,482 (76.0)	80,465	61,245 (76.1)	120,583	94,370 (78.3)	266,513	204,899 (76.9)
No	1,036	630 (60.8)	7,091	5,391 (76.0)	144,675	112,742 (77.9)	2,773,425	2,355,451 (84.9)	2,926,227	2,474,214 (84.6)

Abbreviations: NICU = neonatal intensive care unit; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
* Excludes infants transferred to another facility within 24 hours of delivery and those who died before completion of the birth certificate.
† Extremely preterm: 20–27 weeks' gestation; early preterm: 28–33 weeks' gestation; late preterm: 34–36 weeks' gestation; term: ≥37 weeks' gestation.
§ Includes all states except California and Michigan.
¶ Denominators might not sum to total because of missing maternal or infant data.
** All racial/ethnic groups are non-Hispanic unless otherwise specified.

Multiple demographic factors are known to be associated with breastfeeding, including maternal age, race/ethnicity, education, and marital status.§ This analysis determined that many of these demographic predictors of breastfeeding are consistent across gestational ages. Infants delivered to black and American Indian/Alaska Native mothers are more likely to be born at earlier gestational ages (*1*) and are less likely to receive any breast milk. Together, these factors place these infants at increased risk for morbidity and mortality (*2*,*8*).¶,**

Hospitals and health care providers have the opportunity to improve infant nutrition. Substantial evidence has demonstrated that use of maternity care practices supportive of breastfeeding have resulted in increased breastfeeding initiation, duration, and exclusivity among term infants (*3*). Mothers of

§ https://www.cdc.gov/breastfeeding/data/nis_data/rates-any-exclusive-bf-socio-dem-2015.htm.

¶ https://www.cdc.gov/reproductivehealth/maternalinfanthealth/pretermbirth.htm.
** https://www.cdc.gov/reproductivehealth/maternalinfanthealth/infantmortality.htm.

preterm infants will likely need additional support to establish and maintain a milk supply (*9*). Hospitals and health care providers can implement evidence-based policies and practices to ensure that all mother-infant dyads receive support for breast milk feeding (*3*). Prenatal breastfeeding education delivered consistently throughout the entire prenatal period might help ensure that all mothers, even those who deliver prematurely, are prepared to breastfeed or pump breast milk (*3*). In addition, hospitals can support increased access to donor milk for mothers of preterm infants, if needed and desired, to help preterm infants receive breast milk as soon as receipt is medically feasible (*2*). Finally, to address the challenges that caregivers could encounter when feeding infants hospitalized for extended periods, hospitals might also consider providing support such as helping mothers prepare for long-term breast milk pumping and providing follow-up lactation consultations throughout an infant's hospitalization.

Quality improvement initiatives, such as CDC-supported state-based perinatal quality collaboratives,[††] seek to rapidly implement these best practices in hospitals and work to increase use of human milk in the neonatal intensive care setting and improve support for breastfeeding in hospitals and in the community. Increased implementation of similar initiatives in hospitals serving larger proportions of racial/ethnic groups with lower breast milk feeding rates might help to decrease disparities in breast milk feeding and improve infant morbidity and mortality.

CDC's National Immunization Survey is used for routine surveillance of breastfeeding initiation, duration, and exclusivity; however, this data source does not include gestational age. Overall rates of receipt of breast milk calculated from 2017 birth certificate data are comparable to breastfeeding initiation rates estimated from the survey data (83.2% among infants born in 2015).[§§]

The findings in this report are subject to at least three limitations. First, birth certificate data do not allow for analysis of breast milk feeding duration or exclusivity, which are important indicators of optimal infant feeding practices. Second, because an infant's birth certificate might be completed before enteral nutrition is medically feasible, birth certificate data might not capture properly delayed introduction of breast milk among preterm or medically fragile infants. Finally, although analysis was restricted to infants not transferred to another facility, some variables might be misclassified. A comparison of birth certificate data with medical records in eight hospitals across two states found high exact agreement for obstetric estimate of gestation within 2 weeks (99.7% and 98.1% in each state) and high sensitivity for receipt of breast milk (90.7% and 96.2%). However, moderate false discovery rates for receipt of breast milk (the percentage of births with birth certificate but not medical record indication) (19% and 16% for each of the two states) suggest there might be discrepancies between medical records and birth certificate reporting in some hospitals (*10*). In addition, rates of breast milk feeding among extremely and early preterm infants not admitted to the NICU should be interpreted with caution. These infants likely required advanced medical care but might have been misclassified as non-NICU admissions because of incorrect birth certificate data or NICU admission after completion of the birth certificate.

Infants' receipt of breast milk as soon as is medically feasible can help prevent infection and promote growth and development. Receipt of breast milk is important for preterm infants because breast milk also helps protect against necrotizing enterocolitis (*2*), an important contributor to gastrointestinal morbidity and mortality among preterm infants. Hospital enactment and provision of evidence-based policies and practices that support breast milk feeding and donor milk access for all infants at high risk (*2*,*3*), as well as development of infant feeding policies and practices that promote breast milk feeding among mother-infant dyads facing challenges associated with extended infant hospitalizations, could help reduce gestational age disparities in the receipt of breast milk and increase the proportion of all infants receiving the benefits of breast milk.

Summary

What is already known about this topic?

Breast milk is the optimal source of infant nutrition. Data on breast milk intake by gestational age are limited.

What is added by this report?

Rates of receipt of breast milk among extremely preterm, early preterm, late preterm, and term infants were 71.3%, 76.0%, 77.3%, and 84.6%, respectively, among infants delivered to residents of 48 states and the District of Columbia in 2017.

What are the implications for public health practice?

Disparities in receipt of breast milk by gestational age exist. Hospital implementation of policies and practices that ensure that all mothers and their infants receive support for breast milk feeding and that preterm infants receive breast milk as soon as is medically feasible might help reduce these disparities.

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[††] https://www.cdc.gov/reproductivehealth/maternalinfanthealth/pqc.htm.
[§§] https://www.cdc.gov/breastfeeding/data/nis_data/results.html.

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References

1. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Drake P. Births: final data for 2017. Natl Vital Stat Rep 2018;67:1–50 https://www.cdc.gov/nchs/data/nvsr/nvsr67/nvsr67_08-508.pdf.
2. American Academy of Pediatrics. Breastfeeding and the use of human milk: breastfeeding. Pediatrics 2012;129:e827–41. https://doi.org/10.1542/peds.2011-3552
3. World Health Organization. Evidence for the ten steps to successful breastfeeding. Geneva, Switzerland: World Health Organization, Division of Child Health and Development; 1998. https://www.who.int/nutrition/publications/evidence_ten_step_eng.pdf
4. National Center for Health Statistics. Guide to completing the facility worksheet for the certificate of live birth and report of fetal death. Atlanta, GA: US Department of Health and Human Services, CDC, National Center for Health Statistics; 2016. https://www.cdc.gov/nchs/data/dvs/GuidetoCompleteFacilityWks.pdf
5. Manuck TA, Rice MM, Bailit JL, et al.; Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. Preterm neonatal morbidity and mortality by gestational age: a contemporary cohort. Am J Obstet Gynecol 2016;215:103.e1–14. https://doi.org/10.1016/j.ajog.2016.01.004
6. Neu J. Gastrointestinal development and meeting the nutritional needs of premature infants. Am J Clin Nutr 2007;85:629S–34S. https://doi.org/10.1093/ajcn/85.2.629S
7. Perrin MT. Donor human milk and fortifier use in United States level 2, 3, and 4 neonatal care hospitals. J Pediatr Gastroenterol Nutr 2018;66:664–9. https://doi.org/10.1097/MPG.0000000000001790
8. Chen A, Rogan WJ. Breastfeeding and the risk of postneonatal death in the United States. Pediatrics 2004;113:e435–9. https://doi.org/10.1542/peds.113.5.e435
9. Lau C. Breastfeeding challenges and the preterm mother-infant dyad: a conceptual model. Breastfeed Med 2018;13:8–17. https://doi.org/10.1089/bfm.2016.0206
10. Martin JA, Wilson EC, Osterman MJ, Saadi EW, Sutton SR, Hamilton BE. Assessing the quality of medical and health data from the 2003 birth certificate revision: results from two states. Natl Vital Stat Rep 2013;62:1–19.

Annual Out-of-Pocket Expenditures and Financial Hardship Among Cancer Survivors Aged 18–64 Years — United States, 2011–2016

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In the United States in 2019, an estimated 16.9 million persons are living after receiving a cancer diagnosis (*1*). These cancer survivors face many challenges, including functional limitations, serious psychological distress (*2*), and other lasting and late effects of cancer treatments. Because of the high cost of cancer therapy, many cancer survivors are more likely to face substantial out-of-pocket health care expenditures and financial hardship, compared with persons without a history of cancer (*3,4*). Out-of-pocket expenditures and financial hardship associated with cancer have been higher among survivors aged 18–64 years than they have been among older survivors (*5*). To estimate annual out-of-pocket expenditures and financial hardship among cancer survivors aged 18–64 years, compared with persons without a cancer history, CDC, the American Cancer Society, and the National Cancer Institute analyzed data from the 2011–2016 Medical Expenditure Panel Survey (MEPS).* The average annual out-of-pocket spending per person was significantly higher among cancer survivors ($1,000; 95% confidence interval [CI] = $886–$1,113) than among persons without a cancer history ($622; CI = $606–$639). Financial hardship was common; 25.3% of cancer survivors reported material hardship (e.g., problems paying medical bills), and 34.3% reported psychological hardship (e.g., worry about medical bills). These findings add to accumulating evidence documenting the financial difficulties of many cancer survivors. Mitigating the negative impact of cancer in the United States will require implementation of strategies aimed at alleviating the disproportionate financial hardship experienced by many survivors. These strategies include systematic screening for financial hardship at cancer diagnosis and throughout cancer care, integration of discussions about the potential for adverse financial consequences of treatments in shared treatment decision-making, and linkage of patients and survivors to available resources to ensure access to high-quality evidence-based care.

MEPS is conducted by the U.S. Department of Health and Human Services' Agency for Healthcare Research and Quality and is an annual, nationally representative household survey of the civilian noninstitutionalized population that collects detailed information on demographic characteristics, health status, health insurance coverage, household income, and health care expenditures, including out-of-pocket spending. This report used pooled data from the 2011–2016 MEPS (average annual response rate of 46.0%) and the 2011 and 2016 MEPS Experiences with Cancer self-administered questionnaires completed by cancer survivors (response rates of 90.0% and 81.2%, respectively). MEPS self-administered questionnaires included questions about how cancer, its treatment, and lasting effects of treatment affected access to care, employment, and financial situation. All analyses were conducted using SAS (version 9.4; SAS Institute) and Stata/IC (version 14; StataCorp) to account for the complex survey design and nonresponse. Statistical tests were two-sided, and differences were considered statistically significant if $p<0.05$.

Cancer survivors were identified as persons who responded affirmatively to the MEPS question "Have you ever been told by a doctor or other health professional that you had cancer or a malignancy of any kind?" Out-of-pocket spending was estimated in two ways: 1) annual out-of-pocket spending in 2016 dollars (https://www.bea.gov/) and 2) high annual out-of-pocket burden (defined as spending >20% of annual family income on medical care). Multivariable generalized linear regression with a gamma distribution and a log link was used to estimate annual out-of-pocket spending, comparing persons with and without a cancer history, and adjusted for the following sociodemographic characteristics: age group, sex, race/ethnicity, health insurance status, employment status, number of MEPS priority conditions† (excluding cancer), marital status, and educational attainment. Multivariable logistic regression was used to evaluate the association between cancer history and high annual out-of-pocket burden adjusted for the same sociodemographic characteristics.

Financial hardship associated with cancer, its treatment, or the lasting effects of that treatment was measured in material and psychological domains. Material hardship was measured by asking survivors whether they ever had to borrow money, go into debt, or file for bankruptcy or had been unable to cover their share of medical costs. Psychological hardship was considered being worried about large medical bills. The percentages of material and psychological financial hardship

* http://meps.ahrq.gov/mepsweb/.

† https://meps.ahrq.gov/data_stats/MEPS_topics.jsp?topicid=41Z-1.

were estimated using multivariable logistic regression analyses adjusted for the same sociodemographic characteristics.

Cancer survivors were more likely to be older, female, non-Hispanic white (white), married, privately insured, working full-time, and have higher education and multiple chronic conditions than were persons without a cancer history (Table 1). Approximately one half of cancer survivors (54.2%) received their diagnosis at least 5 years before the survey. In unadjusted analysis, cancer survivors had higher mean annual out-of-pocket expenditures and were more likely to have high out-of-pocket burden than were persons without a cancer history.

TABLE 1. Number and percentage of cancer survivors and persons without a history of cancer, aged 18–64 years (N = 123,771), by demographic characteristics — Medical Expenditure Panel Survey (MEPS), United States, 2011–2016

Characteristic	Cancer survivors* (n = 4,753) % (95% CI)	Persons without a history of cancer* (n = 119,018) % (95% CI)	Chi-square p-value
Age group at interview (yrs)			
18–39	15.9 (14.3–17.5)	48.9 (48.1–49.6)	<0.001
40–49	19.6 (17.9–21.4)	20.5 (20.0–21.0)	
50–64	64.6 (62.2–66.8)	30.6 (29.9–31.3)	
Sex			
Men	34.5 (32.1–37.0)	49.9 (49.5–50.2)	<0.001
Women	65.5 (63.1–68.0)	50.1 (49.7–50.5)	
Race/Ethnicity			
White, non-Hispanic	76.5 (74.4–78.4)	61.2 (59.2–63.1)	<0.001
Black, non-Hispanic	8.7 (7.6–9.9)	12.5 (11.3–13.8)	
All other races/Ethnicities	14.9 (13.1–16.8)	26.3 (24.3–28.3)	
Marital status			
Married	60.6 (57.8–63.2)	51.4 (50.5–52.3)	<0.001
Not married†	39.5 (36.8–42.2)	48.6 (47.7–49.5)	
Education			
Less than high school graduate	10.9 (9.6–12.3)	14.1 (13.5–14.8)	<0.001
High school graduate	26.4 (24.2–28.7)	27.5 (26.7–28.3)	
Some college or more	62.7 (60.3–65.1)	58.4 (57.4–59.5)	
Health insurance			
Any private	71.9 (69.7–74.1)	71.3 (70.1- 72.5)	<0.001
Public only§	19.2 (17.2–21.3)	13.1 (12.3–13.9)	
Uninsured	8.9 (7.5–10.5)	15.6 (14.8–16.5)	
Family income			
Poor (<100% FPL)	14.4 (13–15.8)	12.9 (14.3–16.1)	0.0604
Near poor and low income (100%–200% FPL)	15.5 (14.1–17.0)	16.5 (17.4–18.6)	
Middle and high income (>200% FPL)	70.1 (68.0–72.2)	70.6 (65.6–68.1)	
Employment status			
Full-time	54.2 (51.7–56.6)	64.2 (45.3–46.7)	<0.001
Part-time	4.8 (3.8–6.0)	5.7 (4.0–4.4)	
Not working	41.0 (38.7–43.4)	30.2 (49.2–50.5)	
MEPS priority conditions¶			
Zero or one	47.8 (45.3–50.3)	75.4 (74.8–76.0)	<0.001
Two	20.6 (18.8–22.5)	12.8 (12.4–13.1)	
Three or more	31.6 (29.2–34.2)	11.9 (11.4–12.3)	
Yrs since last cancer treatment**			
<5	45.5 (41.8–50.0)	N/A	N/A
≥5 or never treated/Missing	54.2 (50.0–58.2)	N/A	N/A
Out-of-pocket health care expenditure			
% with high out-of-pocket burden††	2.3 (1.8–2.9)	1.0 (0.9–1.1)	<0.001
Mean (95% CI), $	1,158 (1,051–1,265)	564 (546–583)	<0.001
Median (IRQ), $	488 (1,271)	135 (554)	<0.001

Abbreviations: CI = confidence interval; FPL = federal poverty level; IQR = interquartile range; N/A = not applicable.

* Sample sizes were unweighted.

† Not married included widowed, divorced, separated, or never married.

§ Public insurance included Medicare, Medicaid, State Children's Health Insurance Program, and/or other public hospital/physician coverage. TRICARE and CHAMPVA were treated as private coverage, as were employer-based, union-based, and other private insurance.

¶ Conditions included arthritis, asthma, diabetes, emphysema, heart disease (angina, coronary heart disease, heart attack, or other heart condition or disease), high cholesterol, hypertension, attention deficit hyperactivity disorder or attention deficit disorder, and stroke, and excluded cancer.

** Years since last cancer treatment top-coded at ≥20 by MEPS. This question was only asked of cancer survivors who participated in MEPS Experiences with Cancer Survey in 2011 or 2016.

†† High health care out-of-pocket burden was defined as having annual out-of-pocket expenditures on health care services >20% of annual family income.

In adjusted analyses, mean annual out-of-pocket spending was $1,000 (CI = $886–$1,113) for cancer survivors and $622 (CI = $606–$639) for persons without a cancer history (p<0.001) (Table 2). Cancer survivors also had higher annual out-of-pocket expenditures than did persons without a cancer history in each sociodemographic stratum. Annual out-of-pocket spending was higher among persons with and without a cancer history who were older and who had more MEPS priority conditions.

Cancer survivors were more likely to report high out-of-pocket burden (>20% of annual family income), compared with persons without a cancer history (1.9% versus 1.0%; p<0.001). Among cancer survivors, annual out-of-pocket spending was higher among those with private health insurance coverage than those without health insurance ($1,114 versus $959; p<0.001), but out-of-pocket burden was higher among the uninsured (2.8%) than among those with private insurance (1.9%) or public insurance (1.5%). Out-of-pocket spending was highest among survivors who were not working

TABLE 2. Mean annual out-of-pocket expenditure and prevalence of high out-of-pocket burden* among cancer survivors and persons without a history of cancer, aged 18–64 years (N = 123,771) — Medical Expenditure Panel Survey (MEPS), United States, 2011–2016

	Mean out-of-pocket cost† (2016 U.S. dollars)			High out-of-pocket burden*		
Characteristic	Cancer survivors (n = 4,753) $ (95% CI)	Persons without a history of cancer (n = 119,018) $ (95% CI)	p-value	Cancer survivors (n = 4,753) % (95% CI)	Persons without a history of cancer (n = 119,018) % (95% CI)	p-value
Total	**1,000 (886–1,113)**	**622 (606–639)**	**<0.001**	**1.9 (1.4–2.5)**	**1.0 (1.0–1.1)**	**<0.001**
Age group at interview (yrs)						
18–39	907 (722–1,093)	519 (496–542)	<0.001	2.0 (1.1–2.9)	0.8 (0.6–0.9)	<0.001
40–49	1,004 (852–1,156)	586 (557–615)		1.6 (0.7–2.6)	0.9 (0.7–1.1)	
50–64	1,119 (975–1,263)	756 (728–784)		2.0 (1.3–2.8)	1.4 (1.2–1.6)	
Sex						
Men	976 (801–1,151)	519 (499–539)	<0.001	2.0 (1.1–2.8)	0.9 (0.8–1.0)	<0.001
Women	1,023 (916–1,129)	721 (697–745)		1.9 (1.4–2.5)	1.1 (1.0–1.2)	
Race/Ethnicity						
White, non-Hispanic	1,10 (959–1,244)	715 (693–738)	<0.001	2.2 (1.5–2.9)	1.2 (1.1–1.4)	<0.001
Black, non-Hispanic	639 (517–761)	380 (356–403)		1.0 (0.3–1.7)	0.7 (0.6–0.8)	
All other races/Ethnicities	899 (756–1,042)	484 (456–512)		2.0 (1.1–2.9)	0.8 (0.7–0.9)	
Marital status						
Married	1,011 (882–1,139)	628 (606–649)	<0.001	1.1 (0.6–1.5)	0.5 (0.5–0.6)	<0.001
Not married§	984 (831–1,138)	616 (594–638)		2.8 (2.0–3.5)	1.6 (1.5–1.8)	
Education						
Less than high school graduate	731 (566–896)	463 (424–502)	<0.001	1.7 (0.6–2.8)	0.8 (0.7–1.0)	<0.001
High school graduate	914 (707–1,121)	508 (481–535)		1.9 (1.0–2.7)	0.9 (0.8–1.1)	
Some college or more	1,091 (969–1,214)	704 (682–726)		2.1 (1.4–2.7)	1.2 (1.1–1.3)	
Health insurance status						
Any private	1,114 (968–1,260)	680 (659–700)	<0.001	1.9 (1.1–2.6)	0.9 (0.8–1.0)	<0.001
Public only¶	471 (359–583)	325 (295–355)		1.5 (0.7–2.2)	0.9 (0.7–1.1)	
Uninsured	959 (726–1,193)	647 (604–691)		2.8 (1.4–4.3)	1.9 (1.6–2.2)	
Employment status						
Full-time	895 (803–986)	593 (572–613)	<0.001	0.6 (0.3–0.9)	0.5 (0.4–0.6)	<0.001
Part-time	1,057 (780–1,335)	600 (549–651)		2.9 (0.6–5.2)	1.2 (0.8–1.5)	
Not working	1,259 (966–1,552)	697 (664–729)		4.3 (2.9–5.7)	1.9 (1.7–2.2)	
MEPS priority conditions**						
Zero or one	891 (764–1,019)	493 (476–510)	<0.001	1.8 (1.2–2.4)	0.7 (0.6–0.8)	<0.001
Two	1,252 (1,005–1,500)	802 (755–850)		2.6 (1.3–3.9)	1.4 (1.2–1.7)	
Three or more	1,359 (1,174–1,544)	1,138 (1,073–1,203)		2.4 (1.1–3.8)	2.0 (1.7–2.4)	

Abbreviation: CI = confidence interval.

* High health care out-of-pocket burden was defined as having annual out-of-pocket expenditures on health care services >20% of annual family income. Predicted high out-of-pocket burden percentages from a logistic model controlling for age, sex, race/ethnicity, health insurance status, employment status, and number of conditions (excluding cancer).

† Predicted mean out-of-pocket costs from a two-part model controlling for age, sex, race/ethnicity, health insurance status, employment status, and number of conditions (excluding cancer). All costs were adjusted to 2016 dollars using the Consumer Price Index for Medical Care.

§ Not married included widowed, divorced, separated, or never married.

¶ Public insurance included Medicare, Medicaid, State Children's Health Insurance Program, or other public hospital or physician coverage. TRICARE and CHAMPVA were treated as private coverage, as were employer-based, union-based, and other private insurance.

** Conditions included arthritis, asthma, diabetes, emphysema, heart disease (angina, coronary heart disease, heart attack, other heart condition or disease), high cholesterol, hypertension, attention deficit hyperactivity disorder or attention deficit disorder, and stroke, and excluded cancer.

(4.3%) followed by those who were working part-time (2.9%) and those who were working full-time (0.6%).

In adjusted analyses, approximately one fourth (25.3%) of cancer survivors reported material hardship associated with cancer, and one third (34.3%) reported psychological financial hardship (Table 3). The percentage of survivors who reported experiencing material or psychological financial hardship was higher among minority racial/ethnic groups than among whites and highest for persons aged 40–49 years. Survivors who were uninsured were most likely to report material financial hardship

TABLE 3. Prevalence of material and psychological financial hardship associated with cancer survivors aged 18–64 years (N = 910), cancer treatment, or lasting effects of treatment — Medical Expenditure Panel Survey (MEPS) Experiences with Cancer Survey, United States, 2011 and 2016

	Material hardship (need to borrow money, go into debt, declare bankruptcy, or be unable to cover cost share)	Psychological hardship (worry about medical bills)
Characteristic	**% (95% CI)***	**% (95% CI)***
Total	**25.3 (22.4–28.5)**	**34.3 (30.6–38.1)**
Age group at interview (yrs)		
18–39	27.1 (17.8–36.4)	40.5 (29.2–51.8)
40–49	34.2 (26.0–42.4)	47.2 (38.2–56.2)
50–64	22.3 (18.9–25.8)	29.7 (25.4–34.0)
Sex		
Men	22.1 (16.7–27.5)	33.7 (26.5–41.0)
Women	26.7 (22.6–30.8)	34.5 (30.2–38.8)
Race/Ethnicity		
White, non-Hispanic	23.8 (20.2–27.4)	32.6 (28.0–37.1)
Black, non-Hispanic	31.3 (22.9–39.8)	40.3 (30.9–49.7)
All other races/Ethnicities	29.8 (22.4–37.1)	40.7 (32.2–49.1)
Marital status		
Married	25.1 (20.4–29.8)	34.7 (30.1–39.3)
Not married†	25.6 (20.5–30.6)	33.6 (27.4–39.7)
Educational attainment		
Less than high school graduate	27.2 (17.1–37.3)	36.6 (26.5–46.7)
High school graduate	23.6 (18.0–29.2)	32.0 (25.3–38.7)
Some college or more	25.7 (21.9–29.5)	34.8 (30.3–39.4)
Family income		
Poor (<100% FPL)	26.8 (17.6–36.0)	30.6 (20.5–40.8)
Near poor and low income (100%–200% FPL)	36.1 (28.5–43.6)	32.8 (24.6–41.1)
Middle and high income (>200% FPL)	22.5 (18.5–26.4)	35.2 (30.3–40.2)
Health insurance status		
Any private	21.9 (18.1–25.7)	32.5 (27.9–37.0)
Public only§	33.1 (24.1–42.1)	35.9 (26.0–45.7)
Uninsured	36.5 (23.2–49.8)	49.4 (35.4–63.4)
Employment status		
Full-time	26.7 (22.0–31.3)	35.0 (30.0–40.0)
Part-time	30.6 (15.4–45.7)	28.7 (10.4–46.9)
Not working	23.0 (17.6–28.5)	34.1 (28.5–39.7)
MEPS priority conditions¶		
Zero or one	24.8 (19.7–29.9)	31.0 (25.8–36.1)
Two	22.8 (16.0–29.6)	33.6 (25.2–42.0)
Three or more	27.7 (22.1–33.3)	40.2 (32.9–47.4)
Yrs since last cancer treatment**		
<5	27.8 (22.9–32.6)	40.4 (34.3–46.5)
≥5 or never treated/Missing	23.3 (19.2–27.3)	29.1 (24.3–34.0)

Abbreviations: CI = confidence interval; FPL = federal poverty level.

* Predicted percentages from a logistic model controlling for age, sex, race/ethnicity, health insurance status, employment status, and number of conditions (excluding cancer).

† Not married included widowed, divorced, separated, or never married.

§ Public insurance included Medicare, Medicaid, State Children's Health Insurance Program, and/or other public hospital/physician coverage. TRICARE and CHAMPVA were treated as private coverage, as were employer-based, union-based, and other private insurance.

¶ Conditions included arthritis, asthma, diabetes, emphysema, heart disease (angina, coronary heart disease, heart attack, other heart condition or disease), high cholesterol, hypertension, attention deficit hyperactivity disorder or attention deficit disorder, and stroke, and excluded cancer.

** Years since last cancer treatment top-coded at ≥20 by MEPS. This question was only asked of cancer survivors who participated in MEPS Experiences with Cancer Survey in 2011 or 2016.

(36.5%) followed by those with public (33.1%) and private (21.9%) insurance. Psychological financial hardship was also higher among the uninsured (49.4%) than among those with public (35.9%) or private (32.5%) health insurance coverage.

Discussion

Cancer survivors aged 18–64 years in the United States had higher annual out-of-pocket expenditures and were more likely to report high out-of-pocket burden than were persons without a cancer history. Further, approximately one fourth of cancer survivors reported having material financial hardship, and one third reported having psychological financial hardship associated with cancer, its treatment, or late and lasting effects of treatment. These findings are consistent with other evidence suggesting that cancer survivors experience substantial financial difficulties coping with the costs of health care (*3,5,6*).

In 2009, the American Society of Clinical Oncology's Cost of Care Task Force identified the critical role of oncologists in addressing out-of-pocket costs of cancer care with their patients (*7*). Subsequently, in 2013, the National Academies of Science, Engineering, and Medicine (NASEM) described affordable health care as a component of high-quality cancer care.[§] In 2014, NASEM highlighted the issue of rising cancer drug costs and patient access to affordable and effective drug therapies.[¶] The 2018 President's Cancer Panel report, Promoting Value, Affordability, and Innovation in Cancer Drug Treatment, further emphasized the importance of affordability.[**] These reports and findings from the current study reflect the growing evidence that financial hardship might negatively affect survivors' health and well-being.

Access to health insurance coverage has been identified as essential to providing affordable cancer care by the American Society of Clinical Oncology (*8*) and NASEM.[††] Substantial evidence links health insurance coverage with positive health outcomes among cancer survivors (*9*). In this study, uninsured cancer survivors had lower out-of-pocket spending than did survivors with private insurance coverage, but that spending represented a larger proportion of family income. Lack of health insurance coverage was also strongly associated with both material and psychological financial hardship. Even many cancer survivors with private insurance coverage reported borrowing money, being unable to cover their share of medical care costs, going into debt, or filing for bankruptcy.

Summary

What is already known about this topic?

Many cancer survivors face substantial economic burden resulting from cancer and its treatment.

What is added by this report?

On average, cancer survivors had significantly higher annual out-of-pocket medical expenditures than did persons without a cancer history. Overall, 25% of survivors reported problems paying medical bills, and 33% reported worry about medical bills. Financial hardship was more common among the uninsured than among those with insurance coverage.

What are the implications for public health practice?

The population of cancer survivors is growing, and many struggle to pay for medical care. Evidence-based, sustainable strategies by providers, practices, and payers to reduce out-of-pocket costs could be an important component of high-quality cancer care.

The findings in this report are subject to at least four limitations. First, self-reported cancer diagnosis was not verified by medical records.[§§] Second, analyses were not stratified by cancer anatomic site because sample sizes were insufficient; therefore, these data cannot be used by policy makers or providers to determine whether survivors of cancer at certain anatomic sites are more or less likely to experience financial hardship than others. Third, some important clinical characteristics, such as stage of cancer at diagnosis and types of treatment received before the survey, were unavailable in MEPS. Finally, even though comorbidity was included in multivariable models, some out-of-pocket spending in cancer survivors might result from higher comorbidity among cancer survivors. However, measures of material and psychological hardship were specific to cancer, its treatment, and lasting effects of treatment.

This report used the most recent national data available to present evidence of substantial out-of-pocket expenditure, out-of-pocket burden, and financial hardship among cancer survivors aged 18–64 years. The number of Americans with a history of cancer is projected to increase in the next decade, and the economic burden associated with living with a cancer diagnosis will likely increase as well (*10*). The findings in this report might lead to increased awareness in all sectors of the public health and medical community that the rising cost of cancer care is a major barrier to survivors' well-being. Efforts at the provider, practice, employer, payer, state, and federal

[§] https://www.nap.edu/catalog/18359/delivering-high-quality-cancer-care-charting-a-new-course-for.

[¶] https://www.nap.edu/catalog/18956/ensuring-patient-access-to-affordable-cancer-drugs-workshop-summary.

[**] https://prescancerpanel.cancer.gov/report/drugvalue/pdf/PresCancerPanel_DrugValue_Mar2018.pdf.

[††] https://www.nap.edu/catalog/11468/from-cancer-patient-to-cancer-survivor-lost-in-transition.

[§§] https://www.air.org/sites/default/files/Health%20Insurance%20Literacy%20brief_Oct%202014_amended.pdf.

levels are needed to develop and implement evidence-based and sustainable interventions (e.g., including systematic screening for financial hardship at cancer diagnosis and throughout the cancer care trajectory, integrating discussions about the potential for adverse financial consequences of treatments in shared treatment decision-making, and linking patients and survivors to available resources) (*4*) to minimize financial hardship for cancer survivors.

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References

1. Bluethmann SM, Mariotto AB, Rowland JH. Anticipating the "silver tsunami": prevalence trajectories and comorbidity burden among older cancer survivors in the United States. Cancer Epidemiol Biomarkers Prev 2016;25:1029–36. https://doi.org/10.1158/1055-9965.EPI-16-0133
2. Rim SH, Yabroff KR, Dasari S, Han X, Litzelman K, Ekwueme DU. Preventive care service use among cancer survivors with serious psychological distress: An analysis of the medical expenditure panel survey data. Prev Med 2019;123:152–9. https://doi.org/10.1016/j.ypmed.2019.03.024
3. Pisu M, Henrikson NB, Banegas MP, Yabroff KR. Costs of cancer along the care continuum: what we can expect based on recent literature. Cancer 2018;124:4181–91. https://doi.org/10.1002/cncr.31643
4. Yabroff KR, Zhao J, Zheng Z, Rai A, Han X. Medical financial hardship among cancer survivors in the United States: what do we know? what do we need to know? Cancer Epidemiol Biomarkers Prev 2018;27:1389–1397.
5. Yabroff KR, Dowling EC, Guy GP Jr, et al. Financial hardship associated with cancer in the United States: findings from a population-based sample of adult cancer survivors. J Clin Oncol 2016;34:259–67. https://doi.org/10.1200/JCO.2015.62.0468
6. Ekwueme DU, Yabroff KR, Guy GP Jr, et al. Medical costs and productivity losses of cancer survivors—United States, 2008–2011. MMWR Morb Mortal Wkly Rep 2014;63:505–10.
7. Meropol NJ, Schrag D, Smith TJ, et al.; American Society of Clinical Oncology. American Society of Clinical Oncology guidance statement: the cost of cancer care. J Clin Oncol 2009;27:3868–74. https://doi.org/10.1200/JCO.2009.23.1183
8. American Society of Clinical Oncology. The state of cancer care in America, 2017: a report by the American Society of Clinical Oncology. J Oncol Pract 2017;13:e353–94. https://doi.org/10.1200/JOP.2016.020743
9. Ward E, Halpern M, Schrag N, et al. Association of insurance with cancer care utilization and outcomes. CA Cancer J Clin 2008;58:9–31. https://doi.org/10.3322/CA.2007.0011
10. Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010–2020. J Natl Cancer Inst 2011;103:117–28. https://doi.org/10.1093/jnci/djq495

Community Assessments for Mosquito Prevention and Control Experiences, Attitudes, and Practices — U.S. Virgin Islands, 2017 and 2018

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Aedes aegypti, the mosquito that carries dengue, chikungunya, and Zika viruses, is present throughout the U.S. Virgin Islands (USVI). To reduce mosquitoborne disease transmission, the USVI Department of Health (VIDOH) is responsible for integrated mosquito management. During January 2016–January 2018, USVI experienced its first Zika outbreak, with most cases reported during January–December 2016, as well as two Category 5 hurricanes (Irma on St. Thomas/St. John on September 6, 2017, and Maria on St. Croix on September 19, 2017). The hurricanes severely damaged mosquito protection–related building structures (e.g., screens, roofs) and infrastructure (e.g., electricity, air conditioning) and might have created an environment more conducive to mosquito breeding. VIDOH, with requested technical assistance from CDC, conducted three Community Assessments for Public Health Emergency Response (CASPERs) to provide rapid community information at the household level. The three CASPERs were conducted to inform 1) the Zika outbreak response, 2) the hurricane response, and 3) the hurricane recovery. The CASPERs assessed mosquito prevention and control-related experiences, attitudes, and practices; household and environmental conditions associated with mosquito breeding, prevention, and control; and other nonmosquito-related information to inform outbreak and disaster response planning. Approximately 40% of households were very concerned about contracting Zika virus during the Zika outbreak and hurricane responses. Environmental conditions were reported to become more favorable for mosquito breeding between the Zika outbreak and hurricane response. Between 75%–80% of the community supported mosquito-spraying in all assessments. VIDOH used these data to support real-time outbreak and hurricane response planning. Mosquito prevention and control community assessments can provide rapid, actionable information to advise both mosquito education and control and emergency response and recovery efforts. The CASPER design can be used by vector control programs to enhance routine and response operations.

The Zika outbreak response CASPER was conducted during June 26–29, 2017, on the three main islands, St. Croix, St. Thomas, and St. John. The hurricane response CASPER was conducted in two geographically distinct districts (St. Croix on November 7–8, 2017, and St. Thomas/St. John on November 13–14, 2017) to account for the two hurricanes. The same questionnaire was used for both CASPERs, and the results from both locations were similar; therefore, they were considered and analyzed together as one CASPER. The hurricane recovery CASPER was conducted during February 26–March 1, 2018, on the three main islands.

The standard CASPER two-stage cluster sampling methodology was used to select a representative sample of interviewed households (*1*). The sampling frame was defined as all 43,214 occupied households within USVI, according to the 2010 U.S. Census. Using the Geographic Information Systems CASPER toolkit (*1*), 30 clusters were selected with probability of selection proportional to the number of households within each cluster. Interview teams were trained to select seven households from each of the selected clusters by systematic random sampling, with a goal of 210 interviews for each assessment. Teams made three attempts to contact one adult resident for an interview in each household before substituting another household.

The three 2-page CASPER questionnaires included the same or similar questions regarding mosquito prevention and control experiences, attitudes, and practices, including mosquito biting activity, repellent use, and household environmental characteristics. Response frequencies and percentages, including completion rates, with 95% confidence intervals (CIs) were calculated using Epi Info (version 7.2.2.2; CDC). Weighted frequencies and percentages based on probability of selection are reported, with weighted analysis only calculated for cells with ≥5 households (*1*). A preliminary report was presented to VIDOH within 5 days of completion of each assessment.

Teams conducted 201 of the target 210 interviews for the Zika outbreak response CASPER (95.7% completion rate; 62.2% of contacted households); 387 of the target 420 interviews for the hurricane response CASPER, including 195 on St. Croix (92.9% completion rate; 84.1% of contacted households) and 192 on St. Thomas/St. John (91.4% completion rate; 84.2% of contacted households); and 200 of the target 210 interviews for the hurricane recovery CASPER (95.2% completion rate; 81.3% of contacted households). The most represented household member age group in all three CASPERs was persons aged 18–64 years (80.8%, 75.0%, and 76.6% for the Zika outbreak response, the hurricane response, and the hurricane recovery CASPERs, respectively) followed by those

aged ≥65 years (41.5% [Zika outbreak], 42.5% [hurricane response], and 42.2% [hurricane recovery]).

During the Zika outbreak response, 72.3% of households were very or somewhat concerned about contracting Zika virus, whereas 25.3% were not concerned; 78.7% were very or somewhat concerned about contracting other mosquitoborne diseases, including malaria, dengue, chikungunya, or yellow fever, and 17.8% were not concerned (Table 1). During the hurricane response, 87% of households noticed an increase in mosquito biting since the storms; however, only 61.5% were very or somewhat concerned about contracting Zika virus, 61.3% were concerned about contracting other mosquitoborne diseases, and 37.4% were not concerned. During hurricane recovery, 39.8% of households noticed an increase in mosquito biting during the preceding 4 weeks; approximately two thirds were very or somewhat concerned about contracting any mosquitoborne disease, and 32.7% were not concerned.

Barriers to use of mosquito repellent differed between the Zika outbreak and hurricane responses (Table 2). During the Zika outbreak response, approximately half (49.0%) of households had no barriers to mosquito repellent use, although nearly a quarter (23.5%) did not like the feel or smell, and one in five (19.4%) was concerned about their health when using it; 3.9% said it was too expensive. During the hurricane

TABLE 1. Weighted household mosquitoborne disease concerns from the Community Assessments for Public Health Emergency Response (CASPERs) — U.S. Virgin Islands, 2017–2018

	Zika outbreak response		Hurricane response		Hurricane recovery	
	June 2017 (n = 201)		November 2017 (n = 387*)		February 2018 (n = 200)	
Observations and concerns	Estimate†	% of HH (95% CI)	Estimate†	% of HH (95% CI)	Estimate†	% of HH (95% CI)
Noticed increase in mosquito biting in past 4 weeks§						
Yes	—§	—§	37,617	87.0 (83.4–90.7)	17,203	39.8 (31.4–48.2)
Changed daily activities	—§	—§	23,469	63.3 (57.1–69.6)	9,967	58.6 (47.3–70.0)
Did not change activities	—§	—§	13,590	36.7 (30.4–42.9)	7,031	41.4 (30.0–52.7)
No	—§	—§	5,597	13.0 (9.3–16.6)	26,011	60.2 (51.8–68.6)
Household current concern about contracting Zika virus¶						
Very concerned	17,725	41.0 (31.4–50.6)	16,113	37.3 (32.3–42.3)	—¶	—¶
Somewhat concerned	13,540	31.3 (23.8–38.9)	10,438	24.2 (18.4–29.9)	—¶	—¶
Not concerned at all	10,961	25.3 (18.5–32.2)	16,192	37.5 (32.3–42.7)	—¶	—¶
Don't know	—**	—**	471	1.1 (0.0–2.2)	—¶	—¶
Household current concern about contracting other mosquitoborne diseases¶						
Very concerned	21,216	49.1 (40.9–57.3)	16,137	37.3 (32.0–42.7)	—¶	—¶
Somewhat concerned	12,786	29.6 (21.6–37.6)	10,367	24.0 (18.2–29.8)	—¶	—¶
Dengue††	14,528	42.7 (34.7–50.8)	11,994	45.0 (36.2–53.8)	—¶	—¶
Chikungunya††	10,076	29.6 (22.0–37.3)	9,593	36.0 (28.6–43.4)	—¶	—¶
Malaria††	3,821	11.2 (6.6–15.9)	3,280	12.3 (8.2–16.4)	—¶	—¶
Yellow Fever††	—**	—**	1,775	6.7 (2.7–10.6)	—¶	—¶
Other/Don't know††	13,767	40.5 (30.9–50.0)	9,074	34.2 (26.1–42.3)	—¶	—¶
Not concerned at all	7,689	17.8 (10.9–24.7)	16,145	37.4 (31.4–43.3)	—¶	—¶
Don't know	1,523	3.5 (0.8–6.2)	565	1.3 (0.1–2.5)	—¶	—¶
Household current concern about contracting mosquitoborne diseases¶						
Very concerned	—¶	—¶	—¶	—¶	16,764	38.8 (30.3–47.3)
Somewhat concerned	—¶	—¶	—¶	—¶	12,306	28.5 (20.9–36.1)
Zika††	—¶	—¶	—¶	—¶	13,640	46.9 (36.6–57.2)
Dengue††	—¶	—¶	—¶	—¶	12,789	44.0 (33.7–54.3)
Chikungunya††	—¶	—¶	—¶	—¶	8,643	29.7 (20.0–39.5)
Malaria††	—¶	—¶	—¶	—¶	5,803	20.0 (10.7–29.2)
Yellow Fever††	—¶	—¶	—¶	—¶	3,018	10.4 (1.8–19.0)
Other/Don't know††	—¶	—¶	—¶	—¶	6,568	22.6 (14.5–30.7)
Not concerned at all	—¶	—¶	—¶	—¶	14,144	32.7 (25.4–40.0)

Abbreviations: CI = confidence interval; HH = household.

* Two geographically distinct districts were used for the hurricane response CASPER, but the same questionnaire was used, and the presented results had no significant differences; therefore, they are considered and analyzed as one CASPER, resulting in the larger "n" than in the Zika outbreak response and hurricane recovery CASPERs.

† Estimated number of U.S. Virgin Islands' households.

§ Hurricane response CASPER asked "since the storms." This question was not asked in the Zika outbreak response CASPER.

¶ Responses from the Zika outbreak and hurricane response CASPERs are not directly comparable to responses from the hurricane recovery CASPER because the questions were asked differently. Questions asked in the Zika outbreak and hurricane response CASPERs were "Currently, how concerned are you and members of your household about getting the Zika virus?" and "Currently, how concerned are you and members of your household about getting other diseases mosquitoes may carry?" The question asked in the hurricane recovery CASPER was "Currently, how concerned are you and members of your household about getting diseases mosquitoes may carry?" with a follow-up question for specific diseases.

** Number of responses was too few to be weighed.

†† Subcategories are a combination of both "very concerned" and "somewhat concerned." Multiple responses were permitted.

TABLE 2. Weighted household barriers to mosquito repellent use and household environmental characteristics from the Community Assessments for Public Health Emergency Response (CASPERs)* — U.S. Virgin Islands, 2017

	Zika outbreak response		Hurricane response	
	June 2017 (n = 201)		November 2017 (n = 387†)	
Barriers and characteristics	Estimate§	% of HH (95% CI)	Estimate§	% of HH (95% CI)
Household barriers to mosquito repellent¶				
Don't like how it feels/smells	10,159	23.5 (18.0–29.0)	5,393	12.5 (8.9–16.1)
Concerned about health	8,396	19.4 (12.6–26.2)	4,681	10.8 (7.1–14.5)
Prefer natural remedies	4,637	10.7 (5.4–16.0)	4.760	11.0 (6.8–15.2)
Too expensive	1,681	3.9 (0.8–7.0)	3,854	8.9 (5.7–12.1)
Concerned for environment	1,399	3.2 (0.3–6.2)	1,904	4.4 (2.1–6.7)
No availability	—**	—**	2,444	5.7 (2.6–8.7)
Takes too much time	—**	—**	672	1.6 (0.0–3.2)
Other††	1,440	3.3 (0.4–6.2)	2,304	5.3 (2.0–8.6)
No barriers	21,195	49.0 (41.4–56.7)	25,642	59.3 (53.5–65.2)
Household has the following¶:				
Undamaged window screens	27,801	64.3 (54.7–74.0)	12,980	30.0 (24.1–36.0)
Undamaged door screens	17,238	39.9 (30.7–49.0)	9,813	22.7 (17.0–28.4)
Air conditioning	17,711	41.0 (31.5–50.4)	8,578	19.8 (15.0–24.7)
Objects that may collect rain	11,194	25.9 (19.5–32.3)	13,096	30.3 (23.7–36.9)
Abandoned buildings nearby	10,817	25.0 (15.5–34.5)	12,960	30.0 (22.7–37.3)
Uncovered water source	6,784	15.7 (9.4–22.0)	6,320	14.6 (10.6–18.7)
None of the above§§	5,055	11.7 (4.5–18.9)	10,762	24.9 (18.6–31.2)

Abbreviations: CI = confidence interval; HH = household.

* Questions were only asked during the Zika outbreak response CASPER and the hurricane response CASPER, and not for the hurricane recovery CASPER.

† Two geographically distinct districts were used for the hurricane response CASPER, but the same questionnaire was used, and the presented results had no significant differences; therefore, they are considered and analyzed as one CASPER, resulting in the larger "n" than in the Zika outbreak response and hurricane recovery CASPERs.

§ Estimated number of U.S. Virgin Islands' households.

¶ Multiple responses were permitted.

** Number of responses was too few to be weighed.

†† Includes too time consuming, product not available, forgot, etc.

§§ Includes households that had both no sources for mosquito breeding and households with damaged screens and no air conditioning.

response, a larger percentage (59.3%) had no barriers, and fewer did not like the feel or smell (12.5%) or were concerned about their health when using it (10.8%); more than twice as many (8.9%) said it was too expensive.

Reported environmental conditions became more favorable for mosquito breeding and exposure to mosquito bites between the Zika outbreak and hurricane responses. For example, the percentages of households with undamaged window screens, undamaged door screens, and air conditioning were 64.4%, 39.9%, and 41.0%, respectively, during the Zika outbreak response. These percentages declined to 30.0%, 22.7%, and 19.8% during the hurricane response.

Community support for VIDOH to spray for mosquitoes was similar during the Zika outbreak response and hurricane recovery (76.3% each) and the hurricane response (79.2%) (Table 3), although support for specific spray methods varied. Support for truck spraying increased from 63% of households during Zika outbreak response to 78.1% during hurricane response and returned to 63% during hurricane recovery. Outdoor backpack spraying was supported by only 29.6% of households during the Zika outbreak response, increasing to 44.8% during the hurricane response and to 61.9% during hurricane recovery. Aerial spraying was supported by 12.8% of households during Zika outbreak response, 28.8% during hurricane response, and 16.4% during hurricane recovery.

Discussion

These community assessments conducted during the Zika outbreak, hurricane responses, and hurricane recovery in USVI found that households were more concerned about contracting mosquitoborne diseases shortly after the Zika outbreak than during the hurricane response and hurricane recovery, even though reported mosquito biting activity increased, and environmental conditions were more favorable for mosquito breeding and exposure to bites following the hurricanes. In addition, although mosquitoborne diseases are endemic in USVI, and the population might be aware of the risk, households had concerns after the hurricanes that did not exist during the Zika outbreak, such as lack of shelter, clean water, and electricity (*2*). These differing levels of concern did not, however, change the community's support for mosquito spraying, although support for specific spray methods varied.

VIDOH used the CASPER data to make real-time outbreak and hurricane response decisions to improve mosquito bite prevention, mosquito control, and community education. For example, because the percentage of households concerned

TABLE 3. Weighted household desired Department of Health mosquitoborne disease prevention and control actions from the Community Assessments for Public Health Emergency Response (CASPERs) — U.S. Virgin Islands (USVI), 2017–2018

Desired VIDOH prevention and control actions*,†	Zika outbreak response		Hurricane response		Hurricane recovery	
	June 2017 (n = 201)		November 2017 (n = 387§)		February 2018 (n = 200)	
	Estimate¶	% of HH (95% CI)	Estimate¶	% of HH (95% CI)	Estimate¶	% of HH (95% CI)
Spraying/Fogging (any)†	32,959	76.3 (69.2–83.3)	34,243	79.2 (75.4–83.1)	32,966	76.3 (70.7–81.9)
By truck	27,094	62.6 (55.3–70.1)	26,747	78.1 (73.4–82.8)	24,872	63.4 (56.5–70.4)
By hand (backpack)	12,779	29.6 (20.4–38.7)	15,358	44.8 (38.0–51.7)	24,286	61.9 (51.5–72.4)
By plane (aerial)	5,515	12.8 (6.5–19.1)	9,858	28.8 (22.3–35.2)	6,444	16.4 (10.5–22.4)
Other (e.g., unsure, "best way")	3,190	7.4 (3.5–11.2)	2,834	8.3 (5.4–11.2)	—**	—**
Education	16,435	38.0 (27.8–48.2)	13,179	30.5 (23.6–37.4)	—*	—*
Inspection of property	10,563	24.4 (15.1–33.8)	9,759	22.6 (16.9–28.3)	—*	—*
Other††	5,961	13.8 (8.0–19.6)	6,491	15.0 (11.0–19.1)	—*	—*
Don't know/None	1,440	3.3 (1.1–5.6)	3,011	7.0 (3.9–10.0)	—*	—*

Abbreviations: CI = confidence interval; HH = household; VIDOH = USVI Department of Health.

* Responses from the Zika outbreak and hurricane response CASPERs are not directly comparable to responses from the hurricane recovery CASPER because the questions were asked differently. Questions asked in the Zika outbreak and hurricane response CASPERs were "What actions do your HH members believe the health department should take to prevent mosquito diseases?" and "If spraying, which type(s) would you support?" The questions asked in the hurricane recovery CASPER was "Would your HH support any spraying for mosquitoes?" and "If yes, which type(s) would you support?"

† Multiple responses were permitted.

§ Two geographically distinct districts were used for the hurricane response CASPER, but the same questionnaire was used, and the presented results had no significant differences; therefore, they are considered and analyzed as one CASPER, resulting in the larger "n" than in the Zika outbreak response and hurricane recovery CASPERs.

¶ Estimated number of USVI households.

** Number of responses was too few to be weighed.

†† Other includes property services, social services or assistances, material aid, etc.

about contracting mosquitoborne diseases declined after the hurricanes compared with during the Zika outbreak response, VIDOH hurricane response education campaigns prioritized household-level mosquito bite prevention. The differing levels of support for various spray methods were also recognized and considered during decision-making. For example, these data, along with unique environmental considerations, were used by the administration in place during the responses and recovery to determine backpack spraying to be the only acceptable option.

The CASPER is a useful tool for assessing mosquitoborne disease risk factors and creating immediately useable data to guide vector-related public health campaigns (*3*). According to CDC's internal CASPER database (*4*), a limited number of CASPERs have been conducted that assess mosquito bite prevention- and control-related factors, such as knowledge of mosquitoborne diseases; ways to protect against mosquito bites; and how to identify, quantify, and manage potential mosquito breeding sites. Even fewer CASPERs have focused solely on mosquitoes. A CASPER in Long Beach, California, during a Zika outbreak identified the need for increased mosquito abatement (*5*). In two areas of Texas, CASPERs successfully assessed the prevalence of vectorborne disease risk factors and the communities' knowledge of mosquito bite prevention and Zika virus (*6*,*7*). A CASPER conducted in American Samoa identified increased vector problems and the need for vector control after a tsunami (*8*).

Summary

What is already known about this topic?

Integrated vector management is important to reduce mosquitoborne disease transmission. Community assessments are rarely used to inform mosquito management or understand related community perceptions.

What is added by this report?

Community assessments conducted in the U.S. Virgin Islands during the Zika outbreak response, hurricane response, and hurricane recovery found similar support for mosquito spraying, but support for specific spray methods varied. Concern about acquiring Zika decreased over time.

What are the implications for public health practice?

Mosquito prevention and control community assessment questions can provide rapid, actionable information to advise both community education and mosquito control in emergency response and recovery efforts. Assessments can also be used by vector control programs to enhance routine operations.

Not only is CASPER an important tool for emergency response and recovery, it is also useful for collecting community public health information unrelated to an emergency (*4*,*9*). Vector control programs can use CASPERs during nonemergency situations to enhance and increase operation efficacy by evaluating the effectiveness of community campaigns and understanding community knowledge, attitudes, and practices.

The findings in this report are subject to at least three limitations. First, data generated from the CASPERs represent

discrete points in time, which should be considered when interpreting the results to guide outbreak and hurricane response and recovery efforts. Second, the age distribution of the survey respondents is skewed, with a larger proportion of persons aged ≥65 years represented in the CASPERs than that reported by the U.S. Census; therefore, households without persons aged ≥65 years might be underrepresented. Finally, some questions were asked differently or not at all among the three CASPERs presented and are not directly comparable.

CASPERs that include mosquito prevention- and control-related questions are an important tool to inform both routine and response vector control operations and to understand how a community's perceptions and behaviors might vary by adverse event and over time.

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References

1. CDC. Community Assessment for Public Health Emergency Response (CASPER) toolkit: 2nd ed. Atlanta, GA: US Department of Health and Human Services, CDC; 2012. https://www.cdc.gov/nceh/hsb/disaster/casper/docs/cleared_casper_toolkit.pdf
2. Schnall AH, Roth JJ, Ellis B, Seger K, Davis M, Ellis EM. Addressing community needs during the hurricane response and recovery efforts through Community Assessments for Public Health Emergency Response (CASPER)—United States Virgin Islands, 2017–2018. Disaster Med Public Health Prep 2019;13:53–62. https://doi.org/10.1017/dmp.2019.6
3. Smitherman S, Hammond T, Goldberg D, Horney J. Developing a CASPER survey to assess the prevalence of risk factors for neglected tropical diseases in Texas. Health Secur 2017;15:238–43. https://doi.org/10.1089/hs.2016.0075
4. Schnall A, Nakata N, Talbert T, Bayleyegn T, Martinez D, Wolkin A. Community Assessment for Public Health Emergency Response (CASPER): an innovative emergency management tool in the United States. Am J Public Health 2017;107(S2):S186–92. https://doi.org/10.2105/AJPH.2017.303948
5. Long Beach Department of Health and Human Services. Long Beach Zika Community Assessment for Public Health Emergency Response (CASPER). Long Beach, CA: Long Beach Department of Health and Human Services; 2017. http://www.longbeach.gov/globalassets/health/media-library/documents/diseases-and-condition/information-on/zika/lb-zika-casper-final-report
6. Platz L. Final report: Zika virus Community Assessment for Public Health Emergency Response (CASPER). Round Rock, TX: Williamson County and Cities Health District; 2017. http://www.wcchd.org/about_us/docs/WCCHD%20Zika%20CASPER%20Report_Final.pdf
7. Horney J, Goldberg D, Hammond T, Stone K, Smitherman S. Assessing the prevalence of risk factors for neglected tropical diseases in Brazos County, Texas. PLoS Curr 2017;9:9.
8. Choudhary E, Chen TH, Martin C, et al. Public health needs assessments of Tutuila Island, American Samoa, after the 2009 tsunami. Disaster Med Public Health Prep 2012;6:209–16. https://doi.org/10.1001/dmp.2012.40
9. Bayleyegn TM, Schnall AH, Ballou SG, et al. Use of Community Assessments for Public Health Emergency Response (CASPERs) to rapidly assess public health issues—United States, 2003–2012. Prehosp Disaster Med 2015;30:374–81. https://doi.org/10.1017/S1049023X15004938

Progress Toward Measles Elimination — Pakistan, 2000–2018

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In 1997, the 21 countries in the World Health Organization (WHO) Eastern Mediterranean Region* (EMR) passed a resolution during the 41st session of the Regional Committee for the Eastern Mediterranean to eliminate measles† (*1*). In 2015, this goal was included as a priority in the Eastern Mediterranean Vaccine Action Plan 2016–2020 (*2*), approved at the 62nd session of the Regional Committee (*3*). To achieve measles elimination, the WHO Regional Office for the Eastern Mediterranean developed the following four-pronged strategy: 1) achieve ≥95% vaccination coverage with the first dose of measles-containing vaccine (MCV) among children in every district of each country through routine immunization services; 2) achieve ≥95% vaccination coverage with a second MCV dose in every district of each country either through implementation of a routine 2-dose vaccination schedule or through supplementary immunization activities (SIAs)§; 3) conduct high-quality, case-based measles surveillance in all countries; and 4) provide optimal measles clinical case management, including dietary supplementation with vitamin A (*4*). Pakistan, an EMR country with a population of approximately 200 million, accounts for nearly one third of the overall EMR population. This report describes progress and challenges toward measles elimination in Pakistan during 2000–2018. During the study period, estimated coverage with the first MCV dose (MCV1) increased from 57% in 2000 to 76% in 2017. The second MCV dose (MCV2) was introduced nationwide in 2009, and MCV2 coverage increased from 30% in 2009 to 45% in 2017. During 2000–2018, approximately 232.5 million children received doses of MCV during SIAs. Reported confirmed measles incidence increased from an average of 24.6 per 1 million persons during 2000–2009 to an average of 80.4 during 2010–2018, with peaks in 2013 (230.3) and 2018 (153.6). In 2017 and 2018, the rates of suspected cases discarded as nonmeasles after investigation were 2.1 and 1.5 per 100,000 population, reflecting underreporting of cases. To achieve measles elimination, additional efforts are needed to increase MCV1 and MCV2 coverage, develop strategies to identify and reach communities not accessing immunization services, and increase sensitivity of case-based measles surveillance in all districts.

Immunization Activities

MCV1 was introduced in the routine childhood immunization schedule nationwide in Pakistan in 1974 (*4*), and MCV2 was added to the schedule in 2009. The doses are administered to children at ages 9 and 15 months. Administrative vaccination coverage¶ data are reported each year from all districts** in Pakistan to the National Immunization Programme, where they are aggregated and reported to WHO and the United Nations Children's Fund (UNICEF) through the Joint Reporting Form. WHO and UNICEF use reported administrative coverage and available survey results to generate annual estimates of vaccination coverage through routine immunization services (*5*). Estimated MCV1 coverage in Pakistan increased from 57% in 2000 to 76% in 2017, and estimated MCV2 coverage increased from 30% in 2009 to 45% in 2017 (Figure). A Demographic and Health Survey implemented nationwide during 2017–2018 estimated MCV1 and MCV2 coverage at 73% and 67%, respectively. Among the eight provinces and federal areas, survey estimates of MCV1 and MCV2 coverage were highest in Punjab (85% and 82%, respectively), Islamabad (83%, 77%), and Azad Jammu and Kashmir (83%, 75%); intermediate in Gilgit-Baltistan (66%, 62%), Khyber Pakhtunkhwa (63%, 50%) and Sindh (61%, 60%); and lowest in the Federally Administered Tribal Areas (35%, 21%) and Balochistan (33%, 34%) (*6*).

During 2005–2018, approximately 232.5 million children received MCV during SIAs (Table 1). A nationwide catch-up SIA was conducted in five phases during 2007–2008 and

* The Eastern Mediterranean Region, one of six regions of the World Health Organization, consists of 21 member states and Palestine (West Bank and Gaza Strip), with a population of nearly 583 million persons. The member states are as follows: Afghanistan, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, and Yemen.

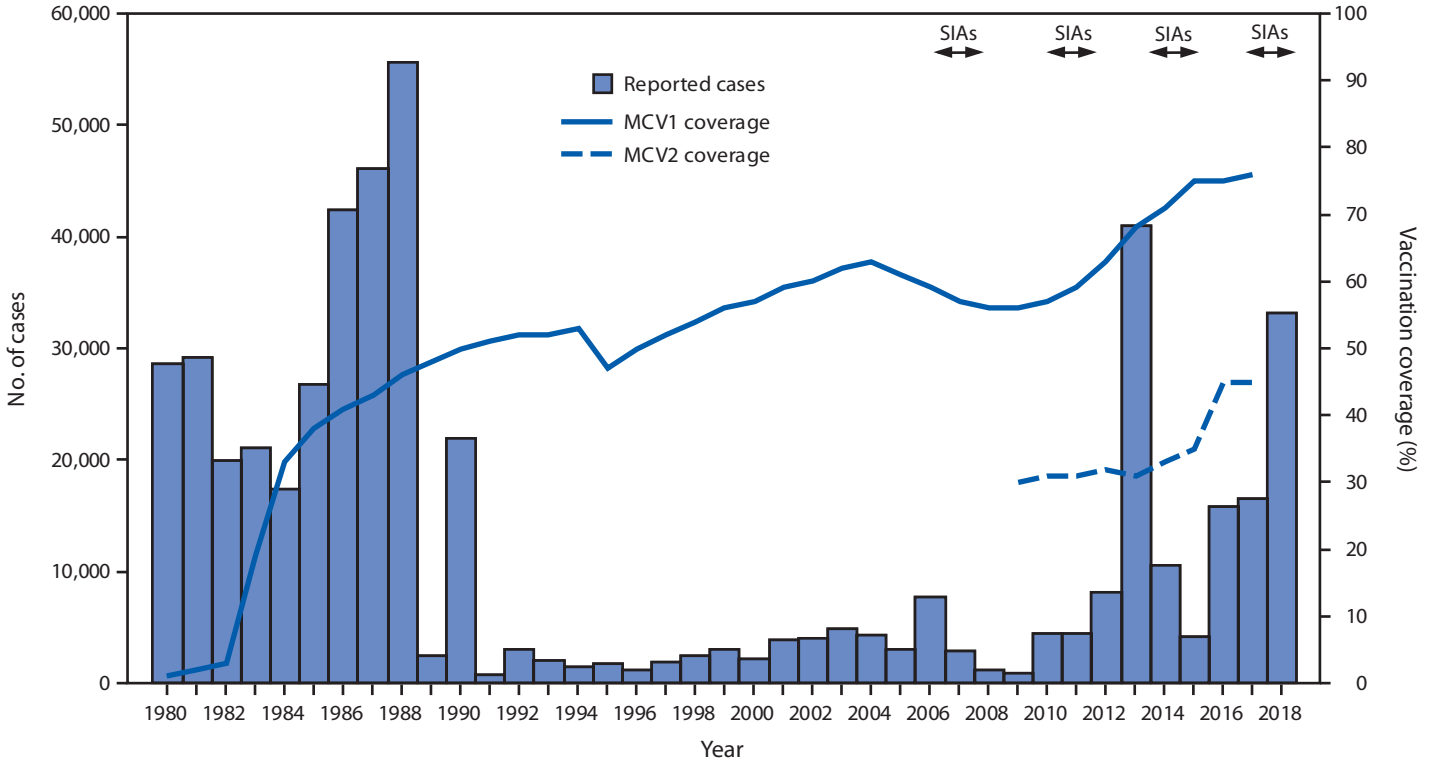
† Measles elimination is defined as the absence of endemic measles cases for a period of ≥12 months, in the presence of adequate surveillance.

§ SIAs are immunization campaigns, typically carried out using two targeted age ranges. An initial, nationwide catch-up SIA targets all children aged 9 months–14 years, with the goal of eliminating measles susceptibility in the population. Periodic follow-up SIAs then target all children born since the last SIA. Follow-up SIAs generally are conducted every 2 to 4 years and target children aged 9–59 months; the goal of a follow-up SIA is to eliminate any measles susceptibility that has accumulated in recent birth cohorts and to protect children who did not respond to the first dose of measles vaccine.

¶ Administrative vaccination coverage is the number of vaccine doses administered divided by the estimated target population.

** The total number of districts in Pakistan was 147 during 2013–2015 and 151 during 2016–2018.

FIGURE. Number of reported measles cases and estimated coverage with the first and second doses of measles-containing vaccine (MCV), and supplemental immunization activities (SIAs), by year* — Pakistan, 1980–2018



Abbreviations: MCV1 = first dose of measles-containing vaccine; MCV2 = second dose of measles-containing vaccine.
* For 1980–2012, cases were reported through the World Health Organization and United Nations Children's Fund Joint Reporting Form. For 2013–2018, cases were reported through the national case-based measles surveillance system.

reached 66.6 million children aged <15 years with >100% administrative coverage documented. Following extensive flooding in the Indus River Basin in 2010, affecting much of Khyber Pakhtunkhwa, Punjab, and Sindh Provinces, subnational measles SIAs were conducted during 2010–2011 for children aged <13 years in flood-affected areas and aged <5 years in other areas; 29.7 million children were vaccinated (94% administrative coverage). In response to a measles epidemic in 2013, a nationwide SIA was conducted in phases during 2014–2015, and 61.4 million children aged <10 years were vaccinated (103% administrative coverage). An independent post-SIA coverage survey conducted in Sindh Province estimated 83% coverage. In response to a measles epidemic during 2017–2018, a nationwide SIA was conducted in 2018, and 37.1 million children aged <5 years (children aged <7 years in Punjab Province) were vaccinated; an independent post-SIA coverage survey estimated that SIA coverage was 93.3% overall and 95.7% in Punjab. Monovalent measles vaccine was used in all SIAs.

Surveillance Activities and Measles Incidence

Aggregated measles cases[††] are reported by all health facilities in Pakistan through the National Health Management Information System and reported annually through the Joint Reporting Form. In 2009, case-based measles surveillance[§§] was initiated in Pakistan following WHO Regional Office for the Eastern Mediterranean guidelines and using the existing vaccine-preventable diseases surveillance system with some modification (*7*). During 2013–2018, the case-based surveillance system was expanded to include additional health facilities; as of 2018, there were 7,555 reporting units. WHO technical officers were appointed in every province and area

[††] Aggregate measles surveillance involves a report of a summary of suspected measles cases, by age group and location (district), but does not include a line-listing of individual cases.
[§§] Case-based measles surveillance includes individual case investigation and blood specimen collection for laboratory testing. Essential data elements to be obtained during the investigation include name or identifier, date of birth or age, sex, place of residence, vaccination status or date of last vaccination, date of rash onset, date of notification, date of investigation, date of specimen collection, and place of infection or travel history.

TABLE 1. Characteristics of measles supplementary immunization activities (SIAs)* — Pakistan, 2005–2018

Year	Age group targeted	Extent of SIA	Population reached in targeted age group, no. (%)†	Vaccination coverage estimate (%)
2005	12–59 mos	Subnational	1,232,000 (77)	—
2007	9 mos–15 yrs	National§	2,511,837 (98)	—
	9 mos–13 yrs	National§	1,282,232 (105)	—
	9 mos–13 yrs	National§	6,906,376 (100)	—
	9 mos–13 yrs	National§	20,566,497 (97)	—
2008	9 mos–13 yrs	National§	35,315,375 (103)	—
2010	9 mos–13 yrs	Subnational	13,740,906 (90)	—
	6–59 mos	Subnational	6,991,065 (95)	—
	6–59 mos	Subnational	1,007,195 (102)	—
2011	9–59 mos	Subnational	1,492,278 (106)	—
	9–59 mos	Subnational	4,849,193 (94)	—
	9–59 mos	Subnational	919,528 (105)	—
	9–59 mos	Subnational	167,678 (74)	—
	9–59 mos	Subnational	557,681 (98)	—
2012	9 mos–9 yrs	Subnational	1,954,175 (102)	—
2013	9 mos–9 yrs	Subnational	4,002,154 (108)	—
	6 mos–9 yrs	Subnational	26,986,015 (96)	—
2014	6 mos–9 yrs	National§	14,026,013 (105)	83 (Sindh Province)
	6 mos–9 yrs	National§	9,432,492 (101)	—
	6 mos–9 yrs	National§	1,439,892 (100)	—
2015	6 mos–10 yrs	National§	30,633,406 (103)	—
	6 mos–10 yrs	National§	227,762 (95)	—
	6 mos–10 yrs	National§	204,308 (124)	—
	6 mos–10 yrs	National§	3,512,771 (101)	—
	6 mos–10 yrs	National§	413,695 (100)	—
	6 mos–10 yrs	National§	1,519,242 (95)	—
2017	9–59 mos	Subnational	1,302,642 (96)	—
	9–119 mos	Subnational	144,129 (68)	—
	9–59 mos	Subnational	1,034,871 (84)	—
2018	9–119 mos	Subnational	91,111 (99)	—
	6–59 mos	Subnational	914,058 (87)	—
	9–59 mos	National	37,131,234 (105)	93
2005–2018			**232,509,811 (100)¶**	**—**

* SIAs generally are carried out using two approaches. An initial, nationwide catch-up SIA targets all children aged 9 months–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. Follow-up SIAs generally are 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 vaccine dose. The exact age range for follow-up SIAs depends on the age-specific incidence of measles, measles vaccination coverage through routine services, and the time since the last SIA. Monovalent measles vaccine was used in all SIAs.
† Values >100% indicate that the number of doses administered exceeded the estimated target population.
§ Rollover national campaigns started the previous year or will continue into the next year.
¶ Average SIA coverage, weighted by size of target population.

in the country during 2017–2018 to monitor key surveillance performance indicators.¶¶ Reporting of measles virus genotyping to the WHO global measles nucleotide surveillance database was begun in 2007 (*8*).

¶¶ Key surveillance performance indicators include 1) two or more discarded nonmeasles cases per 100,000 population at the national level per year; 2) two or more discarded nonmeasles cases per 100,000 per year in ≥80% of subnational administrative units; 3) adequate investigation of ≥80% of suspected measles cases conducted within 48 hours of notification; 4) adequate collection and testing in a proficient laboratory of specimens from ≥80% of suspected cases for detecting acute measles and rubella infection; 5) receipt of ≥80% of specimens at the laboratory within 5 days of collection; 6) report of ≥80% of serology results by the laboratory within 4 days of specimen receipt; and 7) on-time reporting of measles and rubella data to the national level by ≥80% of surveillance units.

After implementing nationwide catch-up measles SIAs during 2007–2008, the number of confirmed measles cases decreased from 7,641 in 2006 to 863 in 2009 (Figure). Following extensive flooding and large-scale population movements in 2010, the number of measles cases increased approximately eightfold, from 4,321 in 2010 to 40,923 in 2013, corresponding to an incidence of 230.3 per million. Following SIAs during 2013–2014, the number of confirmed cases declined to 4,112 in 2015, but increased to 33,007 in 2018 (incidence = 153.6 per million); the majority of these cases occurred before the nationwide SIA conducted in October 2018 (Figure) (Table 2). Overall, measles incidence averaged

24.6 cases per million population during 2000–2009, and 80.4 per million during 2010–2018.

During 2017 and 2018, the rates of suspected cases discarded after investigation were 2.1 and 1.5 per 100,000 population, respectively (Table 2). During 2007–2018, measles virus genotype results were obtained for 201 confirmed measles cases (50 D4, 150 B3, and 1 H1). D4 genotypes were found during 2007–2013, and B3 genotypes predominated during 2011–2018 with spread of B3 globally during 2010–2018.

Discussion

During 2000–2017, MCV1 and MCV2 coverage in Pakistan increased substantially, to 76% and 45%, respectively, but remained well below the WHO-recommended level of ≥95%. In addition, large-scale measles outbreaks occurred during 2012–2014 and 2016–2018, revealing coverage gaps from both routine immunization services and SIAs. The 2017–2018 Demographic and Health Survey found that coverage with all basic vaccines (1 dose of Bacille Calmette-Guérin [BCG] vaccine, 3 doses of diphtheria and tetanus toxoids and pertussis

TABLE 2. Reported measles incidence, number of measles cases by case classification, age group, and vaccination status based on measles case-based surveillance — Pakistan, 2013–2018

Characteristic	2013	2014	2015	2016	2017	2018
Reported measles cases and incidence						
No. of confirmed measles cases	40,923	10,427	4,112	15,791	16,385	33,007
Confirmed measles incidence (cases per 1 million population)	230.3	56.9	22.0	82.8	78.9	153.6
No. of measles cases by case classification						
Suspected*	44,586	11,980	5,947	19,147	21,087	36,223
Laboratory-confirmed	8,749	1,409	386	2,703	6,963	4,172
Epidemiologically linked†	0	0	0	0	0	3,366
Clinically compatible§	32,174	9,018	3,726	13,088	9,422	25,469
Discarded¶	3,663	1,553	1,835	3,356	4,702	3,216
Age group of patients with laboratory-confirmed and epidemiologically linked measles cases, no. (%)						
<9 mos	—	—	—	—	677 (10)	1,025 (14)
9 mos–4 yrs	—	—	—	—	3,549 (51)	3,805 (50)
5–9 yrs	—	—	—	—	1,441 (21)	1,903 (25)
10–14 yrs	—	—	—	—	200 (3)	281 (4)
≥15 yrs	—	—	—	—	256 (4)	195 (3)
Unknown/Missing	—	—	—	—	840 (12)	329 (4)
MCV doses received by laboratory-confirmed and epidemiologically linked measles cases, no. (%)						
≥2	—	—	—	—	781 (11)	621 (8)
1	—	—	—	—	1,083 (16)	685 (9)
0	—	—	—	—	3,777 (54)	2,389 (32)
Unknown	—	—	—	—	482 (7)	453 (6)
Missing	—	—	—	—	840 (12)	3,390 (45)
Surveillance performance indicators						
No. of discarded nonmeasles cases per 100,000 population, national level (target: ≥2)	—	—	—	—	2.1	1.5
% of suspected measles cases adequately investigated** within 48 hrs of notification (target: ≥80)	—	—	—	—	0	10
% of suspected measles cases with adequate specimens†† tested for measles in a proficient laboratory§§ (target: ≥80)	—	—	—	—	54	19
% of results reported by laboratory within 4 days of specimen receipt (target: ≥80)	—	—	—	—	21	11
% of weekly surveillance units reporting to national level on time (target: ≥80)	—	—	—	—	85	100

Abbreviation: MCV = measles-containing vaccine.

* An illness in any person a clinician suspects of having a measles infection, or in any person with fever and rash, and cough, coryza or conjunctivitis.

† Epidemiologically linked measles cases are those that occurred in geographic and temporal proximity to a laboratory-confirmed case or to another epidemiologically linked case.

§ Clinically compatible measles cases are suspected cases for which there is no laboratory confirmation or epidemiologic link.

¶ Discarded nonmeasles cases include those suspected measles cases with an adequate specimen for laboratory testing that were found to be measles immunoglobulin M (IgM) antibody negative or rubella IgM antibody positive.

** Includes collection of all the following data elements regarding each suspected case of measles: patient name or identifiers, place of residence, place of infection (at least to district level), age (or date of birth), sex, date of rash onset, date of specimen collection, measles vaccination status, date of last measles vaccination, date of notification, date of investigation, and travel history.

†† Blood specimen collected within 28 days of rash onset.

§§ A World Health Organization-accredited laboratory that has an established quality assurance program or one with oversight by a World Health Organization-accredited laboratory.

Summary

What is already known about this topic?

In the 2 decades before 2000, estimated coverage with the first measles-containing vaccine dose (MCV1) in Pakistan was ≤57%. The number of reported measles cases per year averaged approximately 29,000 during 1980–1989 and 3,900 during 1990–1999.

What is added by this report?

Estimated MCV1 coverage increased from 57% to 76% during 2000–2017, and second-dose coverage increased from 30% to 45% during 2009–2017. Approximately 232.5 million children were vaccinated with MCV during 2005–2018 vaccination campaigns. Despite these efforts, MCV coverage remained well below the recommended level of 95%, and measles incidence increased during 2010–2018.

What are the implications for public health practice?

To achieve measles elimination, efforts are needed to increase 2-dose vaccine coverage, reach communities not accessing immunization services, and increase measles surveillance sensitivity.

[DTP] vaccine, 3 doses of polio vaccine, and 1 dose of measles vaccine) ranged from 80% among children in the highest wealth quintile to 38% among children in the poorest wealth quintile and from 71% among children residing in urban areas to 63% among those in rural areas (*6*). To reduce disparities, increase vaccination coverage, and achieve measles elimination, enhanced efforts are needed to reach all children, particularly those in rural areas and poor communities. Periodic high-quality SIAs conducted according to WHO SIA guidelines, using the WHO SIA readiness assessment tool to ensure ≥95% 2-dose coverage, will require availability of adequate resources for success. For the 2018 SIA, Gavi, the Vaccine Alliance, provided funding support, and WHO, UNICEF and other international partners contributed to SIA planning, implementation, and monitoring. A postcampaign survey documented 93.3% coverage nationally, demonstrating the potential impact that appropriately funded and well-executed activities can have on improving SIA quality.

Case-based measles surveillance was introduced in 2009 and strengthened during 2017–2018. Some of the apparent increase in measles cases, especially during 2013–2018, reflects improved surveillance sensitivity. Nonetheless, WHO standard surveillance indicators reflected underreporting and low sensitivity of case detection overall. To increase case-based surveillance sensitivity to achieve measles elimination, case-based surveillance reporting sites need to be expanded to all health facilities in the country. High-quality nationwide case-based surveillance data are essential for identifying subpopulations with measles susceptibility in need of SIAs.

Pakistan remains one of only three countries worldwide that has never interrupted wild poliovirus type 1 transmission (*9*); therefore, polio eradication activities remain intense in the country. Measles elimination efforts can leverage the polio assets, experience, and capacity to identify and reach communities not accessing routine immunization services; engage local leaders and community members to ensure that all children in the target age groups participate in SIAs; use epidemiologic investigations to identify areas that need additional SIAs; and improve outbreak preparedness and response to rapidly contain outbreaks.

The Eastern Mediterranean Regional Technical Advisory Group on Immunization (RTAG) recommended forming a multipartner taskforce to apply lessons learned from the polio eradication initiative to address gaps in measles vaccination coverage. These include mapping areas where children missed by routine immunization services reside, identifying reasons for being missed, and developing a strategic plan that includes allocation of necessary resources for implementation (*10*). RTAG also recommended introduction of rubella-containing vaccine into the national infant immunization schedule by 2020. Introduction of combined measles-rubella vaccine would provide an opportunity to build population measles immunity to achieve measles and rubella elimination through a measles-rubella vaccine SIA targeting children aged <15 years.

The findings in this report are subject to at least three limitations. First, administrative coverage might overestimate vaccination coverage through erroneous inclusion of SIA doses or doses administered to children outside of target age groups, inaccurate estimates of the target population size, and inaccurate reports of the number of doses delivered. Second, surveillance data likely underestimate measles incidence because not all patients seek care and not all measles patients who seek care are reported. Finally, efforts to strengthen surveillance over time likely led to reporting bias through increased reporting efficiency annually.

To advance progress toward measles elimination in Pakistan, there is a need to raise the visibility of measles elimination efforts, including the benefits of achieving measles elimination. Without jeopardizing the focused efforts to interrupt poliovirus transmission, transitioning the substantial polio infrastructure and resources should be carefully managed to support measles elimination and broader EMR vaccination goals.

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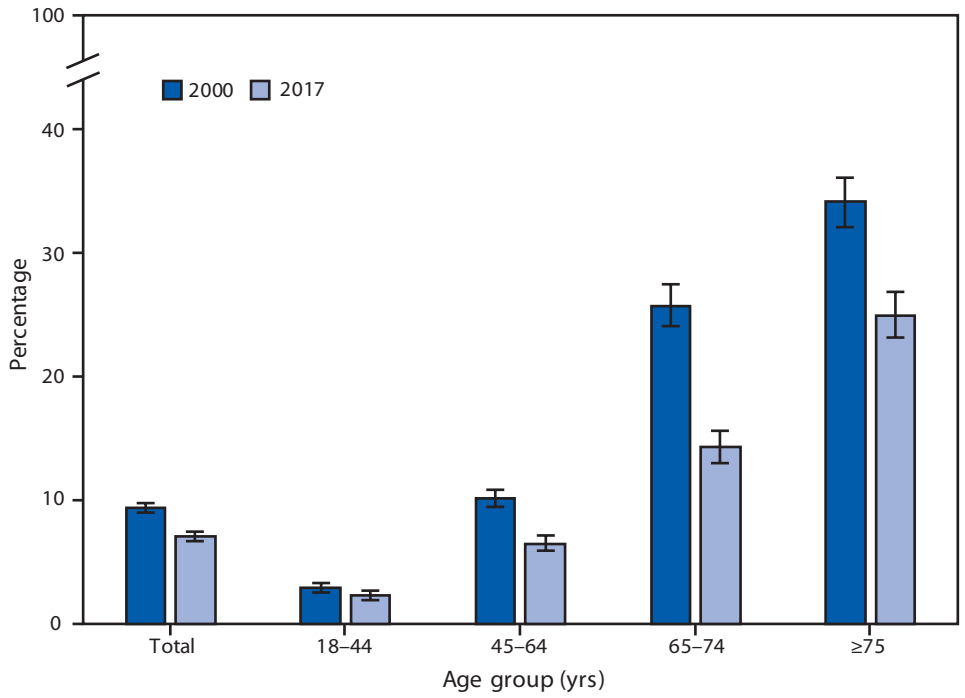
References

1. Regional Committee for the Eastern Mediterranean. Elimination and eradication of diseases, with special reference to measles and tuberculosis. Cairo, Egypt: World Health Organization, Regional Committee for the Eastern Mediterranean; 1997. http://applications.emro.who.int/docs/em_rc44_r6_en.pdf?ua=1
2. Regional Office for the Eastern Mediterranean. Eastern Mediterranean vaccine action plan 2016–2020: a framework for implementation of the global vaccine action plan. Cairo, Egypt: World Health Organization, Regional Office for the Eastern Mediterranean; 2019.
3. Regional Committee for the Eastern Mediterranean. Progress report on the prevention and control of non-communicable diseases. Cairo, Egypt: World Health Organization, Regional Committee for the Eastern Mediterranean; 2015. http://applications.emro.who.int/docs/RC_technical_papers_2015_inf_doc_3_16494_EN.pdf
4. Regional Office for the Eastern Mediterranean. Measles: regional strategy for measles elimination. Cairo, Egypt: World Health Organization, Regional Office for the Eastern Mediterranean; 2015. http://www.emro.who.int/vpi/measles/regionalstrategy.htm
5. World Health Organization; United Nations Children's Fund. Immunization, vaccines and biologicals: data, statistics and graphics. Geneva, Switzerland: World Health Organization; New York, NY: United Nations Children's Fund; 2018. https://www.who.int/immunization/monitoring_surveillance/data/en/
6. National Institute of Population Studies; ICF. Pakistan demographic and health survey 2017–18. Islamabad, Pakistan: National Institute of Population Studies; Rockville, MD: ICF; 2019. https://dhsprogram.com/pubs/pdf/FR354/FR354.pdf
7. Regional Office for the Eastern Mediterranean. Field guidelines for surveillance of measles, rubella and congenital rubella syndrome. Cairo, Egypt: World Health Organization, Regional Office for the Eastern Mediterranean; 2011 http://applications.emro.who.int/dsaf/emropub_2011_1261.pdf
8. World Health Organization. Genetic diversity of wild-type measles viruses and the global measles nucleotide surveillance database (MeaNS). Wkly Epidemiol Rec 2015;90:373–80.
9. Hsu C, Mahamud A, Safdar M, et al. Progress toward poliomyelitis eradication—Pakistan, January 2017–September 2018. MMWR Morb Mortal Wkly Rep 2018;67:1242–5. https://doi.org/10.15585/mmwr.mm6744a5
10. Regional Office for the Eastern Mediterranean. Summary report. Meeting of the Eastern Mediterranean Regional Technical Advisory Group (RTAG) on Immunization. Muscat, Oman; December 14, 2017. http://applications.emro.who.int/docs/IC_Meet_Rep_2018_EN_17034.pdf?ua=1

QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Adults Aged ≥18 Years Who Have Lost All of Their Natural Teeth,† by Age Group — National Health Interview Survey,§ 2000 and 2017



* With 95% confidence intervals shown with error bars.
† Respondents were asked in 2000 and in 2017 the question, "Have you lost all of your upper and lower natural (permanent) teeth?"
§ Estimates are based on household interviews of a sample of the civilian, noninstitutionalized U.S. population, and are shown for sample adults aged ≥18 years.

The percentage of adults aged ≥18 years who had lost all of their upper and lower natural teeth decreased from 9.3% in 2000 to 7.0% in 2017, and this pattern was consistent in each age group shown. Complete tooth loss declined from 2.9% to 2.3% among adults aged 18–44 years, from 10.1% to 6.5% among adults aged 45–64 years, from 25.6% to 14.2% among adults aged 65–74 years, and from 34.0% to 24.9% among adults aged ≥75 years.

Source: Summary Health Statistics for U.S. Adults: National Health Interview Survey, 2000. https://www.cdc.gov/nchs/data/series/sr_10/sr10_215.pdf. Tables of Summary Health Statistics, 2017. https://ftp.cdc.gov/pub/Health_Statistics/NCHS/NHIS/SHS/2017_SHS_Table_A-6.pdf.

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