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Mortality in the United States — Provisional Data, 2023

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Abstract

Final annual mortality data from the National Vital Statistics System for a given year are typically released 11 months after the end of the calendar year. Provisional data, which are based on preliminary death certificate data, provide an early estimate of deaths before the release of final data. In 2023, a provisional total of 3,090,582 deaths occurred in the United States. The age-adjusted death rate per 100,000 population was 884.2 among males and 632.8 among females; the overall rate, 750.4, was 6.1% lower than in 2022 (798.8). The overall rate decreased for all age groups. Overall age-adjusted death rates in 2023 were lowest among non-Hispanic multiracial (352.1) and highest among non-Hispanic Black or African American persons (924.3). The leading causes of death were heart disease, cancer, and unintentional injury. The number of deaths from COVID-19 (76,446) was 68.9% lower than in 2022 (245,614). Provisional death estimates provide an early signal about shifts in mortality trends. Timely and actionable data can guide public health policies and interventions for populations experiencing higher mortality.

Introduction

The National Center for Health Statistics' (NCHS) National Vital Statistics System (NVSS) collects and reports annual mortality statistics using U.S. death certificate data. Because of the time needed to investigate certain causes of death and to process and review death data, final annual mortality data for a given year are typically released 11 months after the end of the calendar year. Provisional data, which are based on preliminary death certificate data sent to NCHS, provide an early estimate of deaths before the release of final data. NVSS routinely releases provisional mortality data for all causes of death, including deaths involving COVID-19.* This report presents an overview of provisional U.S. mortality data for 2023, including a comparison with death rates from 2022 (*1*). Provisional death estimates provide an early indication of shifts in mortality trends and can guide public health policies and interventions intended to reduce mortality among populations experiencing higher mortality.

*NVSS provisional mortality data are available at https://wonder.cdc.gov. NVSS COVID-19 surveillance data are available at https://www.cdc.gov/nchs/nvss/deaths.htm.

Methods

Data Source

This report analyzed provisional NVSS death certificate data for deaths occurring among U.S. residents in the United States during January–December 2023.† NCHS tabulated the number and rates of overall deaths and COVID-19 deaths by age, sex, and race and ethnicity (categorized as non-Hispanic Asian [Asian], non-Hispanic American Indian or Alaska Native [AI/AN], non-Hispanic Black or African American [Black], non-Hispanic Native Hawaiian or Pacific Islander [NH/PI], non-Hispanic White [White], Hispanic or Latino [Hispanic], non-Hispanic persons of more than one race [multiracial], and unknown).

† Based on death records received and processed as of July 21, 2024, for deaths occurring in the United States among U.S. residents. Data included in this analysis reflect >99% of deaths that occurred in 2023.

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NCHS coded the causes of death according to the *International Classification of Diseases, Tenth Revision,* which details disease classification and the designation of underlying cause of death[§] (*2*). COVID-19 death counts and rates include deaths for which COVID-19 is listed on the death certificate as an underlying or contributing cause of death.[¶] Leading causes of death were ranked by counts based on underlying cause of death (*3*). Data in this report exclude deaths among residents of U.S. territories and foreign countries. Age was unknown for 71 (<0.01%) decedents, and race and ethnicity were unknown for 10,068 (0.33%).

Data Analyses

To describe the trend in deaths during a given year, the number of deaths were calculated for each week from all causes and from COVID-19. Age-adjusted rates were calculated for deaths overall and by sex, and race and ethnicity. Crude death rates were calculated by age. The population data used to calculate death rates are July 1, 2023, estimates based on the blended base produced by the U.S. Census Bureau (*4*,*5*). Unless otherwise specified, comparisons made in the text among rates are statistically significant ($p<0.05$ using a z-test). R software (version 4.0.3; R Foundation) was used to conduct all analyses. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[**]

[§] https://www.cdc.gov/nchs/nvss/manuals/2a-sectioni-2021.htm

[¶] The underlying cause of death is the disease or injury that initiated the train of morbid events leading directly to death. A contributing cause of death is a disease or injury also listed on the death certificate, that is not classified as the underlying cause of death.

Results

Overall Measures

In 2023, a total of 3,090,582 deaths occurred in the United States (Table). The age-adjusted rate was 750.4 deaths per 100,000 population, a decrease of 6.1% from 798.8 in 2022. The number of deaths was highest during the week ending January 7 (68,965) and during the week ending December 30 (65,257) (Figure 1). In 2023, death rates per 100,000 were lowest among persons aged 5–14 years (14.7) and highest among persons aged ≥85 years (14,285.8), similar to patterns in 2022 (Table). Death rates decreased from 2022 to 2023 for all age groups (although not significantly for ages 0–4 years). Age-adjusted death rates in 2023 were higher among males (884.2) than among females (632.8), and lower than in 2022 (males = 954.5; females = 666.1).

Age-adjusted death rates per 100,000 in 2023 differed by race and ethnicity and decreased from 2022 to 2023 for all groups (Table). Rates were lowest among multiracial (352.1) and highest among Black persons (924.3). The three leading causes of death were heart disease (680,909 deaths), cancer (613,331), and unintentional injury (222,518) (Figure 2).[††] COVID-19, listed

[**] 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

[††] The number of deaths attributed to unintentional injury were tabulated using the internal NVSS mortality database and might not match publicly available provisional counts for deaths for unintentional injury because provisional data on injury-related causes of death are publicly released with a lag of 6 months from the date of death. This delay accounts for the additional time typically needed to report injury-related death certificates, and the final 2023 death count might be higher than noted in this report.

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TABLE. Provisional* number and rate of total deaths and COVID-19–associated deaths, by demographic characteristics — National Vital Statistics System, United States, 2022–2023

Characteristic	No. of deaths (rate†)				p-value of rate difference	
	2022		2023			
	Total	COVID-19–associated§	Total	COVID-19–associated§	Total§	COVID-19–associated
Total	**3,279,857 (798.8)**	**245,614 (58.7)**	**3,090,582 (750.4)**	**76,446 (18.2)**	**<0.05**	**<0.05**
Age group, yrs						
<1	**20,553 (558.0)**	248 (6.7)	**20,140 (552.0)**	99 (2.7)	**0.27**	<0.05
1–4	**4,156 (28.0)**	162 (1.1)	**4,058 (27.3)**	68 (0.5)	**0.21**	<0.05
5–14	**6,239 (15.3)**	210 (0.5)	**6,005 (14.7)**	71 (0.2)	**<0.05**	<0.05
15–24	**35,232 (79.5)**	649 (1.5)	**33,708 (76.8)**	142 (0.3)	**<0.05**	<0.05
25–34	**74,369 (163.4)**	2,406 (5.3)	**67,427 (148.1)**	428 (0.9)	**<0.05**	<0.05
35–44	**111,605 (255.4)**	5,220 (11.9)	**105,288 (237.2)**	899 (2.0)	**<0.05**	<0.05
45–54	**183,284 (453.3)**	12,242 (30.3)	**166,707 (411.7)**	1,896 (4.7)	**<0.05**	<0.05
55–64	**417,541 (992.1)**	30,627 (72.8)	**376,433 (899.4)**	5,725 (13.7)	**<0.05**	<0.05
65–74	**668,581 (1,978.7)**	53,361 (157.9)	**627,589 (1,809.4)**	13,628 (39.3)	**<0.05**	<0.05
75–84	**824,903 (4,708.2)**	67,235 (383.7)	**798,153 (4,345.3)**	23,253 (126.6)	**<0.05**	<0.05
≥85	**933,291 (14,389.6)**	73,250 (1,129.4)	**885,003 (14,285.8)**	30,236 (488.1)	**<0.05**	<0.05
Unknown	**103 (—)**	4 (—)	**71 (—)**	1 (—)	**NA**	NA
Sex						
Female	**1,560,607 (666.1)**	112,559 (47.4)	**1,473,817 (632.8)**	37,127 (15.4)	**<0.05**	<0.05
Male	**1,719,250 (954.5)**	133,055 (73.7)	**1,616,765 (884.2)**	39,319 (22.1)	**<0.05**	<0.05
Race and ethnicity						
AI/AN, NH	**23,613 (947.9)**	2,127 (83.5)	**21,273 (830.6)**	480 (18.7)	**<0.05**	<0.05
Asian, NH	**89,591 (417.5)**	6,879 (32.0)	**85,763 (387.9)**	2,335 (10.7)	**<0.05**	<0.05
Black or African American, NH	**411,934 (1,002.8)**	28,854 (71.0)	**385,323 (924.3)**	6,823 (17.0)	**<0.05**	<0.05
NH/PI, NH	**4,592 (782.0)**	379 (64.3)	**4,461 (730.1)**	82 (13.8)	**<0.05**	<0.05
White, NH	**2,448,093 (822.2)**	180,533 (58.6)	**2,308,103 (778.1)**	60,860 (19.6)	**<0.05**	<0.05
Hispanic or Latino	**275,684 (614.7)**	25,167 (58.2)	**258,766 (559.0)**	5,393 (13.0)	**<0.05**	<0.05
Multiracial, NH	**16,904 (366.8)**	1,062 (25.1)	**16,825 (352.1)**	289 (7.0)	**<0.05**	<0.05
Unknown	**9,446 (—)**	613 (—)	**10,068 (—)**	184 (—)	**NA**	NA

Abbreviations: AI/AN = American Indian or Alaska Native; NA = not applicable; NH = non-Hispanic; NH/PI = Native Hawaiian or Pacific Islander.
* National Vital Statistics System provisional data for 2023 are incomplete. Data from December 2023 are less complete because of reporting lags. Data for 2022 are final. These data exclude deaths that occurred in the United States among residents of U.S. territories and foreign countries.
† Deaths per 100,000 standard population. Age-adjusted death rates are provided overall and by sex and race and ethnicity.
§ Deaths with confirmed or presumed COVID-19 as an underlying or contributing cause of death, with *International Classification of Diseases, Tenth Revision* code U07.1.

as the underlying cause in 49,928 deaths during 2023, ranked as the 10th leading underlying cause of death.

COVID-19 Measures

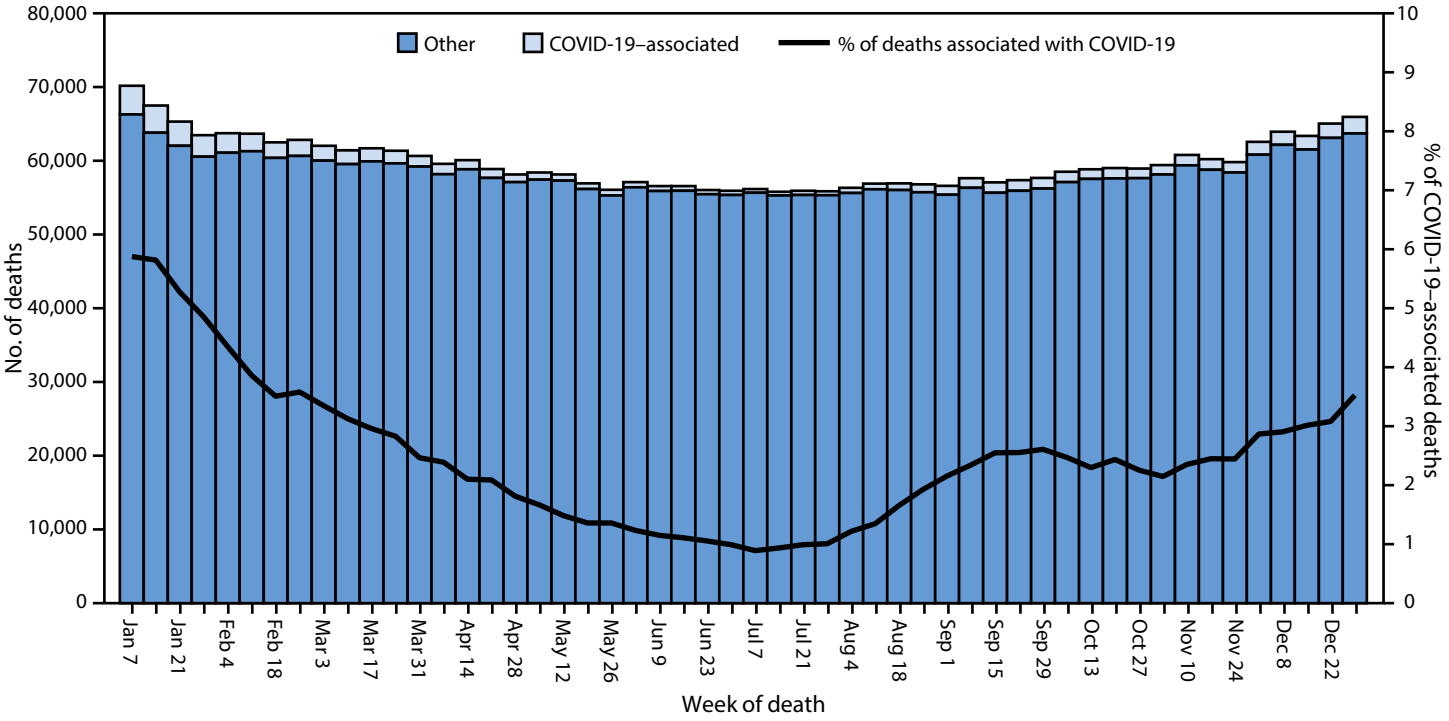
During 2023, COVID-19 was listed as the underlying or contributing cause of 76,446 deaths (18.2 per 100,000), a 68.9% decrease from 245,614 (58.7 per 100,000) in 2022 (Table). The COVID-19 death rate decreased from 2022 to 2023 for all age groups. As with deaths overall, the age-adjusted COVID-19–associated death rate per 100,000 among males (22.1) was higher than that among females (15.4). COVID-19–associated death rates decreased from 2022 to 2023 for all racial and ethnic groups (Table).

Discussion

The estimated age-adjusted death rate, 750.4 per 100,000 persons, was 6.1% lower in 2023 than in 2022 (798.8) (*1*). Death rates were highest among males, older adults, and Black persons. The highest weekly numbers of overall deaths and COVID-19 deaths occurred during early January and late December. The leading causes of death in 2023 were heart disease, cancer, and unintentional injury. COVID-19, the fourth leading cause of death in 2022 became the 10th leading cause in 2023. COVID-19 was the underlying cause for 1.6% of all deaths in 2023, decreasing from 5.7% (186,552 deaths) in 2022. Deaths from heart disease decreased in 2023 compared with 2022 (702,880 deaths), and deaths from cancer increased from 2022 (608,371).

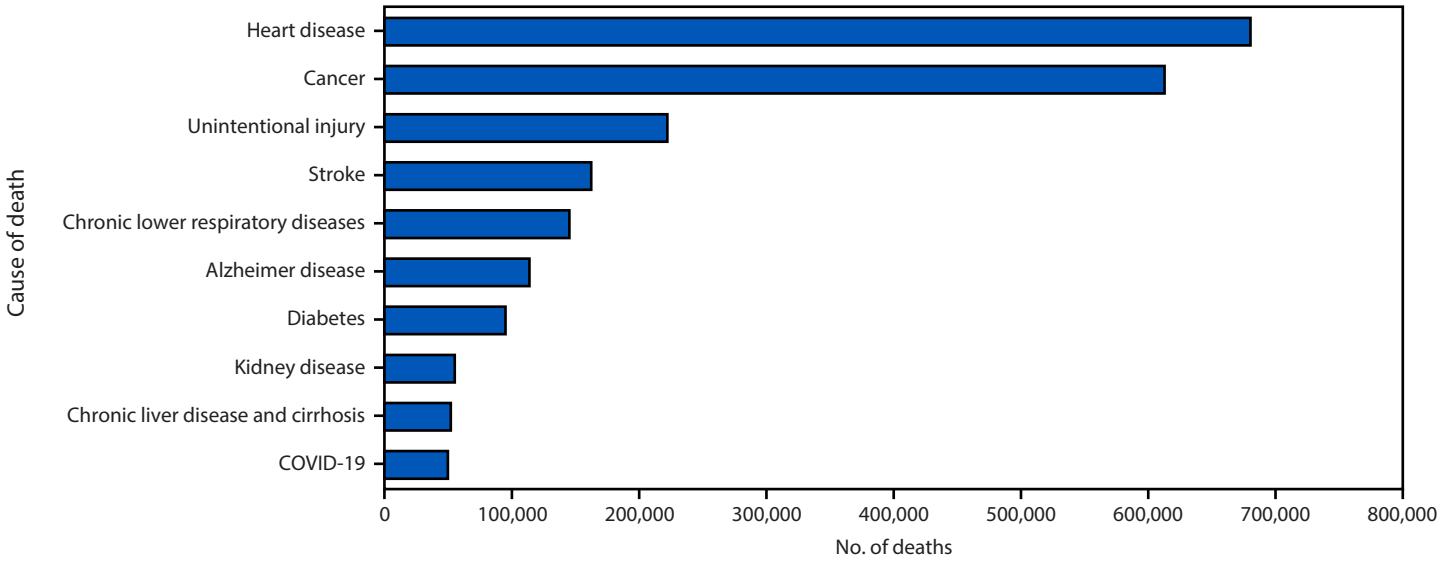
Overall death rates and COVID-19–associated death rates decreased from 2022 to 2023 for all demographic groups (but not significantly for ages 0–4 years). Although the overall and COVID-19 death rates decreased from 2022 to 2023 for persons aged ≥85 years, rates for this group remained higher than those for all other age groups. Overall and COVID-19–associated death rates decreased for all racial and ethnic groups. In 2023, White and AI/AN persons had the highest COVID-19–associated death rate (19.6 and 18.7, respectively), a shift from 2020–2022 when COVID-19 death rates were highest among AI/AN persons (*1*,*6*,*7*).

FIGURE 1. Provisional* number of COVID-19–associated deaths† and other deaths and percentage of deaths associated with COVID-19, by week of death — National Vital Statistics System, United States, 2023



* National Vital Statistics System provisional data for 2023 are incomplete. Data from December 2023 are less complete because of reporting lags. These data exclude deaths that occurred in the United States among residents of U.S. territories and foreign countries.
† Deaths with confirmed or presumed COVID-19 as an underlying or contributing cause of death, with *International Classification of Diseases, Tenth Revision* code U07.1.

FIGURE 2. Leading underlying causes of death* — National Vital Statistics System, United States, 2023



* National Vital Statistics System provisional data for 2023 are incomplete. These data exclude deaths that occurred in the United States among residents of U.S. territories and foreign countries.

Summary

What is already known about this topic?

Provisional death estimates provide an early indication of shifts in mortality trends and can guide public health policies and interventions intended to reduce mortality.

What is added by this report?

More than 3 million persons died in the United States in 2023. The overall age-adjusted death rate in 2023 was 6.1% lower than in 2022. The overall death rate was highest among non-Hispanic Black or African American persons. The number of deaths from COVID-19 was 68.9% lower than in 2022.

What are the implications for public health practice?

Timely and actionable data can guide public health policies and interventions for populations experiencing higher mortality.

Limitations

The findings in this report are subject to at least three limitations. First, data are provisional, and numbers and rates might change as additional information is received. For example, previously published provisional counts of deaths for 2022 were slightly lower than the final counts of deaths for 2022 (*1*,*8*). This finding is due to certain causes of deaths (e.g., unintentional injury deaths) that are known to be reported with a more substantial lag so that the final death count will likely be higher than reported currently (*9*). Described differences in rates and mortality trends might be underestimates. Second, timeliness of death certificate submission can vary by jurisdiction. As a result, the national distribution of deaths might be affected by the distribution of deaths reported from jurisdictions reporting later, which might differ from those in the United States overall. For example, late reporting from a jurisdiction with a large number of deaths in a particular demographic group could substantially increase the number and rate of deaths for the United States. Finally, potential for misclassification of certain categories of race (e.g., AI/AN or Asian) and Hispanic ethnicity reported on death certificates (*10*) exists; thus, death rates for some groups might be underestimated or overestimated.

Implications for Public Health Practice

This report provides an overview of provisional mortality in the United States during 2023. Provisional death estimates can give researchers and policymakers an early signal about shifts in mortality trends and provide actionable information sooner than do the final mortality data. These data can guide public health policies and interventions that are intended to reduce mortality.

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Health and Economic Benefits of Routine Childhood Immunizations in the Era of the Vaccines for Children Program — United States, 1994–2023

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Abstract

Since 1994, the U.S. Vaccines for Children (VFC) program has covered the cost of vaccines for children whose families might not otherwise be able to afford vaccines. This report assessed and quantified the health benefits and economic impact of routine U.S. childhood immunizations among both VFC-eligible and non–VFC-eligible children born during 1994–2023. Diphtheria and tetanus toxoids and acellular pertussis vaccine; *Haemophilus influenzae* type b conjugate vaccine; oral and inactivated poliovirus vaccines; measles, mumps, and rubella vaccine; hepatitis B vaccine; varicella vaccine; pneumococcal conjugate vaccine; hepatitis A vaccine; and rotavirus vaccine were included. Averted illnesses and deaths and associated costs over the lifetimes of 30 annual cohorts of children born during 1994–2023 were estimated using established economic models. Net savings were calculated from the payer and societal perspectives. Among approximately 117 million children born during 1994–2023, routine childhood vaccinations will have prevented approximately 508 million lifetime cases of illness, 32 million hospitalizations, and 1,129,000 deaths, at a net savings of $540 billion in direct costs and $2.7 trillion in societal costs. From both payer and societal perspectives, routine childhood vaccinations among children born during 1994–2023 resulted in substantial cost savings. Childhood immunizations continue to provide substantial health and economic benefits, while promoting health equity.

Introduction

Immunizations have contributed to substantial declines in morbidity and mortality associated with vaccine-preventable diseases worldwide. Broad availability of and access to vaccines is critical to averting disease and maximizing health benefits. In response to a U.S. measles resurgence during 1989–1991, the U.S. Congress established the Vaccines for Children (VFC) program in 1994 to provide vaccines at no cost to eligible children (*1*). Children can receive vaccines through VFC if they are Medicaid-eligible, uninsured, underinsured,* or American Indian or Alaska Native (*2*). In 2023, approximately 54% of children aged ≤18 years were eligible to receive VFC vaccines (CDC, unpublished data, 2023).

VFC has provided vaccines targeting nine diseases for eligible children aged ≤6 years since the program began in 1994: diphtheria, tetanus, and pertussis (DTP, [later, acellular pertussis, DTaP]) vaccine; *Haemophilus influenzae* type b (Hib) vaccine; polio (oral poliovirus vaccine [OPV] then inactivated [injectable] poliovirus vaccine [IPV]); measles, mumps, and rubella (MMR) vaccine; and hepatitis B (HepB) vaccine. Vaccines or immunizing agents targeting seven additional diseases were added to the routine immunization schedule for children aged ≤6 years† during 1996–2023: varicella vaccine (VAR; 1996); hepatitis A vaccine (HepA; 1996–1999 for high-risk areas and 2006 for all states); pneumococcal conjugate vaccine (PCV) (7-valent [PCV-7] in 2000, 13-valent [PCV-13] in 2010, 15-valent [PCV-15] in 2022, and 20-valent [PCV-20] in 2023); influenza (for children aged 6–23 months in 2004 and for those aged 6–59 months in 2006); rotavirus vaccine (Rota; 2006); COVID-19 vaccine (2023); and respiratory syncytial virus vaccine (RSV; 2023). This report summarizes the health benefits and economic effects of routine U.S. childhood immunization among all children (both VFC- and non–VFC-eligible) born during 1994–2023.

Methods

Vaccines Included in Analysis

Following previously established methods (*2*,*3*), one decision tree for each vaccine was used as the basis for the models, and the effects of routine childhood vaccination with nine vaccines (DTP/DTaP, Hib, OPV/IPV, MMR, HepB, VAR, HepA, PCV, and Rota) on 30 annual cohorts of children born during 1994–2023 were evaluated.§ Although influenza and COVID-19 vaccines are recommended for routine immunization, they were not included in this analysis, because the methods for assessing their costs and effects differ from those for other vaccines. In addition, recently recommended RSV vaccines were also not included, because implementation had just commenced in 2023, and some product supplies were constrained.

* Children categorized as underinsured because their health plans do not include coverage for recommended vaccinations are eligible to receive VFC vaccines only at Federally Qualified Health Centers, Rural Health Clinics, or under an approved deputization provider location agreement. https://www.cdc.gov/vaccines-for-children/hcp/program-eligibility/index.html

† https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html

§ Population estimates from 1994–2022 at age 0: https://www.census.gov/programs-surveys/popest.html. Data from 2022 were used to estimate the costs and benefits for 2023. Range = 3,570,131–4,147,947 children per birth cohort.

Data Sources

Immunization program costs, costs of disease outcomes, and parent travel and work time lost were estimated from birth through death (based on life expectancy[¶]) for the children in each birth cohort (*3*). Vaccination coverage with each of these vaccines in the United States during 1994–2022, estimated by the National Immunization Surveys (NIS) (*4*) and school vaccination surveys, were used (*5*). Data from 2022 were used to estimate the benefits and costs for 2023 because most of 2023 data were not available.

The age-specific annual incidences of diphtheria, tetanus, pertussis, Hib, poliomyelitis, measles, mumps, rubella, varicella, hepatitis A, rotavirus, and pneumococcus-related diseases, and the prevalence, complications, and perinatal transmission of hepatitis B in the United States in the prevaccine era were obtained from a previous analysis and used to estimate the morbidity and mortality of disease during that period (*3*). Disease morbidity and mortality after vaccination were estimated using surveillance data from the National Notifiable Diseases Surveillance System,[**] West Philadelphia Varicella Active Surveillance Project, and the Active Bacterial Core Surveillance.[††] For three vaccines (HepB, HepA, and Rota), the estimates for disease morbidity and mortality were model-based using vaccination coverage and efficacy (*3*).

Outcomes Estimated and Calculations

Net savings and benefit-cost ratios for all nine vaccines were calculated. Benefits of routine childhood immunization were quantified as the savings in direct and indirect costs from averting morbidity and mortality by vaccination. The immunization program costs are jointly covered by parents and private and public sectors, including VFC, and estimated using data from the CDC Vaccine Price List[§§] and from a previous analysis (*3*). These costs comprise the vaccines, administration, parent travel and work time lost, and adverse events associated with receipt of these vaccines. Net savings is the sum of the benefits from routine childhood immunization with the nine vaccines minus the sum of the immunization program costs, and benefit-cost ratio was calculated as the benefits divided by the immunization program costs. To account for the differential timing of benefits and costs, all future benefits and costs were discounted annually at 3%, as recommended by the Second Panel on Cost-Effectiveness in Health and Medicine (*6*).

The analyses were performed from two perspectives: payer (direct medical and nonmedical costs) and societal (direct and indirect costs). Direct medical costs include those associated with treating an initial infection, as well as the lifetime costs associated with complications and sequelae of these vaccine-preventable diseases. Direct nonmedical costs include those for travel, special education of children disabled by specific vaccine-preventable diseases, and disability-related supplies. Indirect costs include productivity losses attributable to premature mortality and permanent disability among cohort members, as well as opportunity costs associated with parents who miss work to care for their sick children or cohort members themselves who miss work because of vaccine-preventable illness. All costs were adjusted to the 2023 U.S. dollar. The general Consumer Price Index was used for productivity losses, opportunity and travel costs, and the medical care component of the Consumer Price Index was used for direct medical costs.[¶¶] This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.[***]

Results

Vaccination-Associated Prevention of Morbidity and Mortality

Among approximately 117 million children born during 1994–2023, routine childhood immunization was estimated to prevent 508 million lifetime cases of illness (averaging four illnesses per child) and 32 million hospitalizations (0.3 per child) and to avert 1,129,000 premature deaths from vaccine-preventable illnesses (Table 1). The cumulative number of illnesses prevented ranged from 5,000 for tetanus to approximately 100 million for measles and varicella. The highest estimated cumulative number of hospitalizations and deaths prevented were 13.2 million hospitalizations for measles vaccination and 752,800 deaths for diphtheria vaccination.

Economic Effect of Vaccination

Vaccination for the 1994–2023 birth cohorts will potentially avert $780 billion in direct costs and $2.9 trillion in societal costs by preventing illnesses and deaths (Table 2). After accounting for $240 billion in direct costs and $268 billion in societal costs of routine childhood immunization, the net savings for routine childhood immunization from the payer and societal perspectives were $540 billion and $2.7 trillion, respectively. The payer and societal benefit-cost ratios for routine childhood immunizations were 3.3 and 10.9, respectively.

Discussion

Routine childhood immunizations remain a highly cost-effective public health intervention, preventing thousands of lifetime

[¶] https://www.cdc.gov/nchs/nvss/life-expectancy.htm
[**] https://www.cdc.gov/nndss/index.html
[††] https://www.cdc.gov/abcs/index.html
[§§] Discounted by 14%–72% for the vaccines included in this analysis. https://www.cdc.gov/vaccines-for-children/php/awardees/current-cdc-vaccine-price-list.html
[¶¶] https://www.bls.gov/cpi/data.htm
[***] 45 C.F.R. part 46.102(l)(2), 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

TABLE 1. Estimated number of illnesses, hospitalizations, and deaths prevented by routine childhood immunization against selected vaccine-preventable diseases in 30 cohorts of children — United States, 1994–2023

Vaccine-preventable disease	Illnesses prevented (x 1,000)	Hospitalizations prevented (x 1,000)	Deaths prevented (x 1,000)
Diphtheria	7,528	7,528	752.8
Tetanus	5	5	0.7
Pertussis	80,738	3,646	28.4
Haemophilus influenzae type b	536	495	20.3
Polio	1,847	786	21.9
Measles	104,984	13,172	85.0
Mumps	63,355	2,020	0.3
Rubella	54,225	199	0.4
Congenital rubella syndrome	17	26	1.9
Hepatitis B	6,061	940	90.1
Varicella*	106,270	272	1.9
Hepatitis A*	4,048	78	1.5
Pneumococcus-related diseases*,†	47,804	1,969	123.2
Rotavirus*	30,265	819	0.4
Total	**507,683**	**31,955**	**1,128.8**

* Varicella vaccine for 1996–2023 cohorts, hepatitis A vaccine for 2006–2023, pneumococcal conjugate vaccine for 2001–2023, and rotavirus vaccine for 2007–2023.
† Includes invasive pneumococcal disease, otitis media, and pneumonia.

TABLE 2. Lifetime health and economic outcomes in 30 cohorts of children — United States, 1994–2023

Outcome	All children born 1994–2023
Total illnesses prevented (x 1,000)	**507,683**
Total hospitalizations prevented (x 1,000)	**31,955**
Total deaths prevented (x 1,000)	**1,129**
Direct cost of immunization (billion, $)	240
Societal cost of immunization (billion, $)	268
Benefits in direct costs (billion, $)	780
Benefits in societal costs (billion, $)	2,931
Direct net savings (billion, $)	540
Societal net savings (billion, $)	2,663
Payer benefit-cost ratio*	3.3
Societal benefit-cost ratio†	10.9

* Payer benefit-cost ratio = benefits in direct costs / direct cost of immunization.
† Societal benefit-cost ratio = benefits in societal costs / societal cost of immunization.

illnesses, hospitalizations, and deaths among children born during 1994–2023. Based on the 2022 CDC Market Share Report (CDC, unpublished data, 2022 [2023 data are not available]), VFC made a substantial contribution to these reductions by purchasing approximately one half of childhood vaccines at discounted prices.

Accurately estimating the proportion of benefits attributable to VFC is challenging because a child's eligibility for the VFC program can change over time. In addition, the percentage of vaccines purchased by VFC varies each year and by vaccine type. These variations complicate consistent measurement of the program's direct effect on public health outcomes. Coverage with many of the vaccines included in this analysis was near or above 90% during 1994–2022 (2023 NIS data were not available) (*4*,*5*). The VFC program reduces financial and logistical barriers for eligible children who otherwise might not have reasonable access to immunization, thereby promoting health equity and contributing substantially to these high coverage levels. Whereas the societal costs of routine childhood immunization over 30 cohorts of children are $268 billion, the resulting societal savings are $2.9 trillion. This calculation means that every $1 spent on childhood immunizations results in a savings of approximately $11. With discounted vaccine prices, every $1 spent on VFC program results in even further savings.

VFC funds are allocated to CDC by the Centers for Medicare & Medicaid Services, and Medicaid providers can receive payment from Medicaid for vaccine administration services provided to Medicaid-eligible children.††† CDC provides funding to 61 state, local, and territorial immunization programs to implement and oversee the VFC program and relies on participation from public and private health care providers to administer vaccines to eligible children.

During the COVID-19 pandemic, routine childhood vaccination coverage declined, in part resulting from reduced primary care service availability and increases in vaccine hesitancy (*7*). During the same period, the spread of vaccine-related misinformation and disinformation affected vaccine confidence (*8*) and threatened high vaccination coverage rates. Recent measles outbreaks resulting from internationally imported measles cases serve as a reminder that high vaccination coverage is critical for protection from highly transmissible vaccine-preventable diseases (*9*). VFC plays an important role in maintaining high childhood vaccination coverage by reducing barriers to access, especially in geographic areas and among populations that have historically had lower vaccination coverage, such as children living in rural areas (*4*). The VFC program is one of the nation's primary health platforms for promoting health equity, and VFC providers are critical to facilitating equitable vaccine access. Immunization programs might consider expanding their provider network by using nontraditional vaccine providers such as pharmacies in areas where access is deemed to be inadequate. Further, provider reminders, provider assessment and feedback, and client reminder-recall systems remain important methods to reduce missed opportunities for vaccination. VFC also serves as a critical component of U.S. preparedness by supporting important infrastructure needed for distributing medical countermeasures to children to halt transmission of vaccine preventable disease or mitigate severity of illness in outbreak settings.

††† Program for distribution of pediatric vaccines, Sec. 1928. [42 U.S.C. 1396s]. https://www.ssa.gov/OP_Home/ssact/title19/1928.htm

Summary

What is already known about this topic?

Broad access and availability of vaccines is critical for immunization programs to avert disease. Since 1994, the U.S. Vaccines for Children (VFC) program has covered the cost of vaccines for children whose families might not otherwise be able to afford them.

What is added by this report?

Among children born during 1994–2023, routine childhood vaccinations will have prevented approximately 508 million cases of illness, 32 million hospitalizations, and 1,129,000 deaths, resulting in direct savings of $540 billion and societal savings of $2.7 trillion.

What are the implications for public health practice?

During the VFC program era, routine childhood immunizations in the United States have been an important cost-saving public health strategy. Childhood immunizations continue to provide substantial health and economic benefits and promote health equity.

Limitations

The findings in this report are subject to at least four limitations. First, influenza, COVID-19, and RSV immunization were not included in this analysis, which might result in an underestimate of the benefits attributable to the immunization program. Second, actual vaccination coverage with some vaccines might be higher than estimates provided by NIS surveys (*10*), which might result in underestimating immunization costs. Third, federal, state, and local immunization program management expenditures and excise taxes[§§§] were not included, which might also result in underestimating immunization costs. Finally, for some diseases, factors other than immunization (e.g., hygiene and physical distancing measures) might have contributed to lower disease risks in recent decades, and reductions resulting from these contributions have not been incorporated into the model. If such reductions were substantial, the model would overestimate the vaccine-preventable incidence of these diseases. However, a sensitivity analysis from a previous study found that even with worst-case scenario assumptions, routine childhood immunization remained cost-saving (*3*). As noted, estimating more precise effects of vaccinations among children enrolled in the VFC program involves several complexities outside the scope of this report.

Implications for Public Health Practice

Supported by the VFC program, immunization has been a highly effective tool for improving the health of U.S. children. This analysis demonstrates the continued and substantial health benefits associated with vaccinating young children, rendering the investment in vaccines and immunizations services an important and cost-saving public health strategy.

[§§§] A $0.75 excise tax imposed on each component of (i.e., each disease prevented by) a vaccine is collected to fund the National Vaccine Injury Compensation Program. https://www.hrsa.gov/vaccine-compensation

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Notes from the Field

Prevalence of Previous Dengue Virus Infection Among Children and Adolescents Aged 7–16 Years — American Samoa, September–October 2023

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Dengue is a vectorborne disease caused by four dengue viruses (DENVs) and is transmitted through the bite of infected *Aedes* species mosquitoes. Dengue transmission in American Samoa is classified as frequent or continuous,* with 660 confirmed cases reported to CDC's national arboviral surveillance system during the 2016–2018 outbreak (*1*). Infection usually confers lifelong immunity to the infecting virus serotype but only offers temporary protection against other DENVs. Because a second infection with DENV is more likely to result in severe illness† than is a first or postsecondary infection, in 2021, the Advisory Committee on Immunization Practices recommended the Dengvaxia dengue vaccine (Sanofi Pasteur, Inc.) for persons aged 9–16 years with laboratory confirmation of previous DENV infection living in areas with frequent or continuous dengue transmission (*2*). Dengvaxia clinical trials demonstrated protection for persons with previous DENV infection but identified increased risk for severe dengue and hospitalization among persons without previous infection who were vaccinated (*2*).

Because most DENV infections are asymptomatic, subclinical, and rarely laboratory-confirmed (*3*), identification of previous DENV infection to determine vaccine eligibility requires a positive result from a serologic test meeting CDC-recommended performance standards.§ However, tests are more likely to result in incorrect positive (false positive) results and more likely to misclassify seronegative persons in low seroprevalence geographic areas than in high seroprevalence areas. To reduce the chances of mistakenly vaccinating children and adolescents with false positive test results, vaccine introduction is advised only in areas where ≥20% of the eligible children and adolescents have previously had dengue. The 20% seroprevalence corresponds to a positive predictive value of ≥90% for a test with minimum sensitivity of 75% and minimum specificity of 98% (*2*,*4*). Dengue seroprevalence among children and adolescents in American Samoa is unknown. To determine whether the minimum 20% threshold for vaccination implementation had been reached, a serosurvey was conducted in American Samoa during September–October 2023. This activity was reviewed by CDC, deemed not research, and conducted in accordance with applicable federal law and CDC policy.¶

Investigation and Outcomes

Study Design and Analysis

To guide decisions on dengue vaccine implementation, on August 8, 2023, the American Samoa Department of Health requested assistance from CDC to determine the prevalence of previous DENV infection among school-age children and adolescents through a school-based serosurvey. Seven of 36 public schools were randomly selected through a single-stage cluster sampling design stratified by school type.** All students in grades 3–10 enrolled in the selected schools were invited to participate. Students with a signed parental permission form were tested using the CTK Biotech OnSite dengue immunoglobulin G rapid test†† (sensitivity = 89.6%; specificity = 95.7%) (*5*). Seroprevalence estimates were computed using survey design weights and adjusting for test sensitivity and specificity.

Seroprevalence Findings

During September–October 2023, a total of 2,267 students were invited to participate in the serosurvey, and 887 (39%) received testing. The median participant age was 11 years (range = 7–16 years). More than one half (54%) of participants were female. Among tested students, 492 (56%) received positive

* Frequent or continuous dengue risk is defined as evidence of more than 10 dengue cases in ≥3 of the previous 10 years. https://www.cdc.gov/dengue/areas-with-risk/index.html

† Severe dengue is defined as dengue with any of the following clinical manifestations: severe plasma leakage leading to shock or fluid accumulation with respiratory distress; severe bleeding; or severe organ impairment such as hepatitis (elevated transaminases ≥1,000 IU/L), impaired consciousness, or heart impairment. https://www.cdc.gov/dengue/hcp/clinical-signs/index.html

§ CDC recommends prevaccination screening tests to have ≥75% sensitivity, ≥98% specificity, ≥90% positive predictive value, and ≥75% negative predictive value. In areas with frequent or continuous transmission, qualifying laboratory tests for vaccination include positive reverse transcription–polymerase chain reaction or nonstructural protein 1 test results. https://www.cdc.gov/dengue/hcp/vaccine/testing.html

¶ 45 C.F.R. part 46.102(l)(2), 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

** The schools comprised five elementary schools (kindergarten–8th grade) and two high schools (9th–12th grade).

†† The CTK Biotech test was conducted for public health purposes and not for determining individual vaccine eligibility. Testing for individual vaccine eligibility would require the two-test algorithm (https://www.cdc.gov/dengue/hcp/vaccine/testing.html) and require that it be performed in a laboratory meeting requirements to conduct and report results for clinical purpose, which was not available in American Samoa at the time the survey was conducted.

Summary

What is already known about this topic?

In 2021, CDC's Advisory Committee on Immunization Practices recommended dengue vaccination for children and adolescents aged 9–16 years with laboratory-confirmed previous dengue virus (DENV) infection who live in areas with frequent or continuous dengue transmission. To reduce false positive prevaccination screening results, dengue vaccination should be implemented only if ≥20% of age-eligible persons have previously been infected with DENV.

What is added by the report?

During 2023, a school-based dengue serosurvey in American Samoa found evidence of previous infection in 60% of persons aged 9–16 years.

What are the implications for public health practice?

DENV seroprevalence in American Samoa exceeds the minimum 20% threshold established for the introduction of recommended dengue vaccines to reduce the risk for hospitalization and severe dengue in seronegative children and adolescents. Dengue vaccines could be part of a broader strategy to reduce illness and death.

TABLE. Estimated dengue virus immunoglobulin G seroprevalence among children and adolescents aged 7–16 years — American Samoa, September–October 2023

Characteristic	No. of participants tested*	No. of participants with positive test results	Estimated IgG seroprevalence, % (95% CI)†
Total, aged 7–16 yrs	**887**	**492**	**59 (47–71)**
Age-eligible for vaccination, 9–16 yrs	**767**	**437**	**60 (48–72)**
Age, yrs			
7	**17**	9	84 (26–100)
8	**103**	46	46 (32–60)
9	**100**	52	59 (37–80)
10	**124**	71	53 (25–81)
11	**115**	72	67 (50–84)
12	**127**	66	53 (34–71)
13	**135**	85	72 (56–88)
14	**102**	56	58 (28–88)
15	**61**	32	55 (17–94)
16	**3**	3	100 (—)
Sex§			
Female	**475**	273	61 (49–74)
Male	**411**	219	56 (44–74)

Abbreviation: IgG = immunoglobulin G.

* Twenty-four participants received uninterpretable test results: males (14); and children and adolescents aged 7 years (three), 8 years (two), 9 years (two), 10 years (two), 11 years (six), 12 years (four), 13 years (three), 14 years (one), and 15 years (one).

† Seroprevalence was estimated using survey weights and adjusted for sensitivity and specificity.

§ One participant did not specify their sex.

results for dengue immunoglobulin G and 371 (42%) received negative results; results for 24 (3%) students were uninterpretable. The estimated seroprevalences among females and males were 61% and 56%, respectively. The estimated seroprevalence among all students aged 7–16 years was 59% (95% CI = 47%–71%) and was 60% (95% CI = 48%–72%) among those age-eligible for vaccination (i.e., those aged 9–16 years). Dengue seroprevalence was lowest among children aged 8 years (46%; 95% CI = 32%–60%) (Table).

Preliminary Conclusions and Actions

Dengue seroprevalence is approximately 60% among persons age-eligible (9–16 years) for dengue vaccination in American Samoa, exceeding the minimum threshold of 20% established for the introduction of recommended dengue vaccines to reduce the risk for severe dengue and hospitalization while minimizing the risk associated with vaccine administration to persons who have not been previously infected. Seroprevalence is high among all age groups, indicating widespread previous exposure to DENV and potential risk for future outbreaks as well as associated secondary cases among persons previously infected. In American Samoa, dengue vaccines could be part of a broader strategy for dengue control that would also include mosquito control at home, mosquito bite prevention measures, training of health care providers to recognize and treat dengue, and improving laboratory capacity to strengthen surveillance to effectively reduce illness and death.

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Erratum

Vol. 72, No. RR-6

In the Recommendation and Report "CDC Guidelines for the Prevention and Treatment of Anthrax, 2023," multiple errors occurred.

On page 32, in Table 7, and page 35, in Table 10, the imipenem/cilastatin dose should have read **1** g every 6 hours.

On page 33, in the Abbreviations under Table 8, the abbreviation for PCN-S should have read penicillin-**susceptible** strains.

On page 37, in Table 12, the clarithromycin dose should have read **7.5** mg/kg.

On page 37, in Table 12, and page 38, in Table 13, the age range for the last two doses of moxifloxacin listed should have read **≥12** to <18 years.

On page 39, in Table 13, and page 41, in Table 14, the first dose of AIGIV listed should have read **<10** kg.

On page 42, in Table 15; page 43, in Table 16; and page 45, in Table 17, the moxifloxacin dose in all columns should have read **10** mg/kg.

On page 42, in Table 15, the amoxicillin dose should have read **25** mg/kg in all columns, and the linezolid dose in the 0 to <1 week columns should have read every **12** hours.

On page 45, in Table 17, the omadacycline dose in the last three columns should have read 5.5 mg/kg loading dose **IV** × 1, then 3.85 mg/kg **every 24 hours IV**.

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