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Advisory Committee on Immunization Practices Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger — United States, 2023

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At its October 2022 meeting, the Advisory Committee on Immunization Practices* (ACIP) approved the Recommended Child and Adolescent Immunization Schedule for Ages 18 Years or Younger, United States, 2023. The 2023 child and adolescent immunization schedule, available on the CDC immunization schedule website (https://www.cdc.gov/vaccines/schedules), summarizes ACIP recommendations, including several changes from the 2022 immunization schedule† on the cover page, tables, notes, and appendix. Health care providers are advised to use the tables, notes, and appendix together to determine recommended vaccinations for patient populations. This immunization schedule is recommended by ACIP (https://www.cdc.gov/vaccines/acip) and approved by CDC (https://www.cdc.gov), the American Academy of Pediatrics (https://www.aap.org), the American Academy of Family Physicians (https://www.aafp.org), the American College of Obstetricians and Gynecologists (http://www.acog.org), the American College of Nurse-Midwives (https://www.midwife.org), the American Academy of Physician Associates (https://www.aapa.org), and the National Association of Pediatric Nurse Practitioners (https://www.napnap.org).

ACIP's recommendations for the use of each vaccine are developed after in-depth reviews of vaccine-related data, including the epidemiology and societal impacts of the vaccine-preventable disease, vaccine efficacy and effectiveness, vaccine safety, quality of evidence, feasibility of program implementation, and economic analyses of immunization policy (*1*). The child and adolescent immunization schedule is published annually to consolidate and summarize updates to ACIP recommendations on vaccination of children and adolescents and

Continuing Education examination available at https://www.cdc.gov/mmwr/mmwr_continuingEducation.html

* Recommendations for routine use of vaccines in children and adolescents are developed by ACIP, a federal advisory committee chartered to provide expert external advice and guidance to the CDC director on use of vaccines and related agents for the control of vaccine-preventable diseases in the civilian population of the United States. Recommendations for routine use of vaccines in children and adolescents are harmonized to the greatest extent possible with recommendations made by the American Academy of Pediatrics, the American Academy of Family Physicians, the American College of Obstetricians and Gynecologists, the American College of Nurse-Midwives, the American Academy of Physician Associates, and the National Association of Pediatric Nurse Practitioners. ACIP recommendations approved by the CDC director become agency guidelines on the date published in the *Morbidity and Mortality Weekly Report*. Additional information about ACIP is available at https://www.cdc.gov/vaccines/acip.

† Past immunization schedules are available at https://www.cdc.gov/vaccines/schedules/hcp/schedule-related-resources.html#accordion-2-collapse-3.

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to assist health care providers in implementing current ACIP recommendations. The use of vaccine trade names in this report and in the child and adolescent immunization schedule is for identification purposes only and does not imply endorsement by ACIP or CDC.

For further guidance on the use of each vaccine, including any changes that might occur after annual publication of the 2023 child and adolescent immunization schedule, health care providers are referred to the respective ACIP vaccine recommendations at https://www.cdc.gov/vaccines/hcp/acip-recs. If errors or omissions are discovered within the schedule, CDC will post revised versions on the CDC immunization schedule website.[§] Printable versions of the 2023 child and adolescent immunization schedule and instructions for ordering hard copies of the schedule are available on the immunization schedule website (https://www.cdc.gov/vaccines/schedules/).

[§] CDC encourages organizations to use syndication as a more reliable method for displaying the most current and accurate immunization schedules on an organization's website rather than copying these schedules to their websites. Use of content syndication requires a one-time step that ensures an organization's website displays current schedules as soon as they are published or revised; instructions for syndication code are available on CDC's website https://www.cdc.gov/vaccines/schedules/resource-library/syndicate.html. CDC also offers technical assistance for implementing this form of content syndication (requests can be e-mailed to ncirdwebteam@cdc.gov).

Changes in the 2023 Child and Adolescent Immunization Schedule

Vaccine-specific changes in the 2023 immunization schedule for children and adolescents aged ≤18 years include new or updated ACIP recommendations for influenza vaccine (*2*), pneumococcal conjugate vaccine (*3*), measles, mumps, and rubella vaccine (MMR) (*4*), and COVID-19 vaccine (https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/covid-19.html), which have been added to the Tables and to the Notes sections. Changes also include clarification of the recommendations for dengue vaccine, hepatitis A vaccine (HepA), hepatitis B vaccine (HepB), human papillomavirus vaccine (HPV), meningococcal serogroups A, C, W, Y vaccine (MenACWY), meningococcal serogroup B vaccine (MenB), inactivated poliovirus vaccine (IPV), and varicella vaccine.

Cover page

- COVID-19 vaccines, 15-valent pneumococcal conjugate vaccine (PCV15), and a newly licensed MMR (Priorix) have all been added to the table of vaccine abbreviations and trade names.

Table 1 (Routine Immunization Schedule)

- **COVID-19 row:** A new row has been added with the columns for age 6 months–18 years highlighted in yellow to indicate the recommended age for COVID-19

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vaccination. The overlying text "2- or 3-dose primary series and booster (See Notes)" has also been added.
- **Pneumococcal conjugate row:** PCV15 has been added.
- **IPV row:** The overlying text "See Notes" has been added to the column for persons aged 17–18 years prompting health care providers to review the Notes section for additional information for persons aged 18 years.

Table 2 (Catch-up Immunization Schedule)

- **Pneumococcal conjugate row:** Language for the minimum interval between doses 3 and 4 has been revised to clarify when a fourth dose is indicated. The text now reads "This dose is only necessary for children aged 12–59 months regardless of risk, or aged 60–71 months with any risk, who received 3 doses before age 12 months."

Table 3 (Immunization by Medical Indication Schedule)

- **COVID-19 row:** A new row was added to summarize COVID-19 vaccination recommendations by medical conditions or other indications. The overlying text "See Notes" has been added to both HIV infection and immunocompromised status (excluding HIV infection) columns prompting providers to review specific recommendations for these populations.

Vaccine Notes

The notes for each vaccine are presented in alphabetical order. Edits have been made throughout the Notes section to harmonize language between the child and adolescent immunization schedule and the adult immunization schedule to the greatest extent possible.

- **Additional information:** The text for injury compensation was revised to include the Countermeasures Injury Compensation Program for COVID-19 vaccines.
- **COVID-19:** A new section was added to provide additional details on the use of COVID-19 vaccines. The routine vaccination section describes the recommendations for primary series in the general population, and the special situations section describes the recommendations for primary series in persons who are moderately or severely immunocompromised. For booster dose vaccination in all populations, and guidance for Janssen (Johnson & Johnson) COVID-19 vaccine recipients, hyperlinks are included referring health care providers to the latest guidance. In addition, hyperlinks to the current COVID-19 vaccination schedules, use of COVID-19 preexposure prophylaxis in persons who are moderately or severely immunocompromised, as well as Emergency Use Authorization indications for COVID-19 vaccines, have been added.
- **Dengue:** A new bullet was added to clarify that dengue vaccine should not be administered to children traveling to or visiting endemic dengue areas.
- **HepB**: The language in the routine vaccination section was revised to highlight the recommendations for infants born to mothers who have received positive test results for hepatitis B surface antigen (HBsAg), or whose HBsAg status is unknown. In addition, the catch-up vaccination section was updated to include Heplisav-B and PreHevbrio vaccines for persons aged 18 years.
- **Influenza:** The note has been updated to reflect the recommendations for the 2022–23 influenza season. Language was added to the "Special situations" section to clarify that live attenuated influenza vaccine should not be administered to close contacts of immunosuppressed persons who require a protected environment. In addition, the language for persons with egg allergy with symptoms other than hives was moved from the appendix to the "Special situations" section.
- **MMR:** The "Special situations" section was updated to include recommendations for additional MMR doses in a mumps outbreak setting.
- **MenACWY:** Language clarifying that the newly licensed Menveo one-vial (all liquid) formulation should not be administered before age 10 years was added.
- **MenB:** The "Special situations" section was updated to include the recommendations for situations in which the second or third dose of Trumenba is administered earlier or later than the recommended minimum interval. If the second dose is administered ≥6 months after the first dose, then the third dose is not needed. If the third dose is administered earlier than 4 months after the second dose, a fourth dose should be administered ≥4 months after the third dose.
- **Pneumococcal:** The routine vaccination, catch-up vaccination, and "Special situations" sections have been updated with the recommendations for use of PCV15. In addition, language was added stating that 13-valent pneumococcal conjugate vaccine (PCV13) and PCV15 can be used interchangeably in both healthy children and those with any risk for invasive pneumococcal disease. In addition, a hyperlink to the CDC app that can be used to determine a patient's pneumococcal vaccination needs has been included.
- **Poliovirus:** A new "Special situations" section was created to describe the use of IPV in persons aged 18 years who are at increased risk for exposure to polioviruses.

Appendix (Contraindications and Precautions)

- The column header was changed from "Contraindications" to "Contraindicated or Not recommended."
- **Influenza (egg-based) row:** In the precautions for egg-based inactivated and live attenuated vaccines, the language for persons with egg allergy with symptoms other than hives has been moved to the Notes section.
- **Dengue row:** Language was added stating that lack of laboratory confirmation of previous dengue virus infection is a contraindication.
- **HepB row:** Language was added to the contraindicated or not recommended column stating that Heplisav-B and PreHevbrio are not recommended during pregnancy; other HepB products should be used if vaccination is indicated. A footnote providing information on the pregnancy exposure registries for persons who were inadvertently vaccinated with Heplisav-B or PreHevbrio while pregnant was added.
- **HPV row:** Language was added to the contraindicated or not recommended column stating that HPV is not recommended during pregnancy.
- **MMR row:** Measles, mumps, rubella, and varicella virus vaccine (MMRV) was added. In addition, language was added to the precautions stating that a personal or family history of seizure of any etiology is a precaution for using MMRV.
- **Varicella row:** Language was added stating that if MMRV is used, the precautions for MMR/MMRV should be reviewed.

Additional Information

The Recommended Child and Adolescent Immunization Schedule, United States, 2023 is available at https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html. The full ACIP recommendations for each vaccine are also available at https://www.cdc.gov/vaccines/hcp/acip-recs. All vaccines identified in Tables 1, 2, and 3 (except DTaP, rotavirus, and PCV13) also appear in the Recommended Adult Immunization Schedule for Ages 19 Years or Older, United States, 2023, available at https://www.cdc.gov/vaccines/schedules/hcp/imz/adult.html. The notes and appendix for vaccines that appear in both the child and adolescent immunization schedule and the adult immunization schedule have been harmonized to the greatest extent possible.

Acknowledgments

Rosters of current and past members of the Advisory Committee on Immunization Practices are available at https://www.cdc.gov/vaccines/acip/members/index.html.

ACIP Combined Immunization Schedule Work Group

Kevin Ault (Chair). Members: Henry Bernstein, Carolyn Bridges, Uzo Chukwuma, Sybil Cineas, Sarah Coles, Katherine Debiec, Marci Drees, John Epling, Susan Farrall, Mary-Margaret Fill, Holly Fontenot, Sandra Fryhofer, Kathleen Harriman, Robert Hopkins, Molly Howell, Paul Hunter, Karen Ketner, David Kim, Jane Kim, Marie-Michelle Leger, Susan Lett, Veronica McNally, Sarah McQueen, Amy B. Middleman, Pia Pannaraj, Diane Peterson, Chad Rittle, William Schaffner, Ken Schmader, Rhoda Sperling, Patricia Stinchfield, Peter Szilagyi, and L.J. Tan. Contributors: A. Patricia Wodi (CDC co-Lead), Neil Murthy (CDC co-Lead); CDC contributors: Tara Anderson, Jennifer Collins, Erin Conners, Laura Cooley, Samuel Crowe, Lisa Grohskopf, Elisha Hall, Susan Hariri, Holly Hill, Suzanne Johnson-DeLeon, Sarah Kidd, Miwako Kobayashi, Andrew Kroger, Elisabeth Krow-Lucal, Tatiana Lanzieri, Mona Marin, Lauri Markowitz, Lucy McNamara, Noele Nelson, Sara Oliver, Lakshmi Panagiotakopoulos, Gabriela Paz-Bailey, Hilda Razzaghi, Janell Routh, Sarah Schillie, Tami Skoff, Jacqueline Tate, Mark Weng, Donna Williams, Akiko Wilson, and JoEllen Wolicki.

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All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Veronica McNally reports that she is the president of the Franny Strong Foundation. Kevin Ault reports having received consulting fees from PathoVax, serving as a volunteer on the medical advisory board of Family Fighting Flu, and as a committee member of the American College of Obstetricians and Gynecologists. No other potential conflicts of interest were disclosed.

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Advisory Committee on Immunization Practices Recommended Immunization Schedule for Adults Aged 19 Years or Older — United States, 2023

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At its October 2022 meeting, the Advisory Committee on Immunization Practices* (ACIP) approved the Recommended Adult Immunization Schedule for Ages 19 Years or Older, United States, 2023. The 2023 adult immunization schedule summarizes ACIP recommendations, including several changes to the cover page, tables, notes, and appendix from the 2022 immunization schedule.† This schedule can be found on the CDC immunization schedule website (https://www.cdc.gov/vaccines/schedules). Health care providers are advised to use the cover page, tables, notes, and appendix together to determine recommended vaccinations for patient populations. This adult immunization schedule is recommended by ACIP (https://www.cdc.gov/vaccines/acip) and approved by CDC (https://www.cdc.gov), the American College of Physicians (https://www.acponline.org), the American Academy of Family Physicians (https://www.aafp.org), the American College of Obstetricians and Gynecologists (https://www.acog.org), the American College of Nurse-Midwives (https://www.midwife.org), the American Academy of Physician Associates (https://www.aapa.org), the American Pharmacists Association (https://www.pharmacist.com), and the Society for Healthcare Epidemiology of America (https://shea-online.org).

ACIP's recommendations for the use of each vaccine are developed after in-depth reviews of vaccine-related data, including disease epidemiology and societal impacts, vaccine efficacy and effectiveness, vaccine safety, quality of evidence, feasibility of program implementation, and economic analyses of immunization policy (*1*). The adult immunization schedule is published annually to consolidate and summarize updates to ACIP recommendations on vaccination of adults and to assist health care providers in implementing current ACIP recommendations. The use of vaccine trade names in this report and in the adult immunization schedule is for identification purposes only and does not imply endorsement by ACIP or CDC.

For further guidance on the use of each vaccine, including any changes that might occur after annual publication of the adult immunization schedule, health care providers are referred to the respective ACIP vaccine recommendations at https://www.cdc.gov/vaccines/hcp/acip-recs. If errors or omissions are discovered within the schedule, CDC will post revised versions on the CDC immunization schedule website.§ Printable versions of the 2023 adult immunization schedule and instructions for ordering hard copies of the schedule are available on the immunization schedule website (https://www.cdc.gov/vaccines/schedules).

Changes in the 2023 Adult Immunization Schedule

Vaccine-specific changes in the 2023 immunization schedule for adults aged ≥19 years include new or updated ACIP recommendations for influenza vaccines (*2*) and pneumococcal vaccines (*3*). Additional information was added for the measles, mumps, and rubella vaccine (MMR), meningococcal vaccine, and recombinant zoster vaccine (RZV) sections. The hepatitis B vaccine (HepB) section was rearranged and revised to improve clarity in the language, and minor edits were made to the tetanus, diphtheria, and acellular pertussis vaccination (Tdap) notes to improve readability. In addition, COVID-19 vaccines have been added to the Tables and to the Notes sections summarizing ACIP recommendations. A new poliovirus vaccination section was also added to the Notes section to describe the use of inactivated poliovirus vaccine (IPV) in adults who are at increased risk for exposure to polioviruses. Changes were also made to the appendix section to improve clarity in the language.

* Recommendations for routine use of vaccines in adults are developed by ACIP, a federal advisory committee chartered to provide expert external advice and guidance to the CDC director on use of vaccines and related agents for the control of vaccine-preventable diseases in the civilian population of the United States. Recommendations for routine use of vaccines in adults are harmonized to the greatest extent possible with recommendations made by the American Academy of Pediatrics, the American Academy of Family Physicians, and the American College of Obstetricians and Gynecologists. ACIP recommendations approved by the CDC director become agency guidelines on the date published in the *Morbidity and Mortality Weekly Report*. Additional information about ACIP is available at https://www.cdc.gov/vaccines/acip/.

† Past immunization schedules are available at https://www.cdc.gov/vaccines/schedules/hcp/schedule-related-resources.html#accordion-2-collapse-3.

§ CDC encourages organizations to use syndication as a more reliable method for displaying the most current and accurate immunization schedules on an organization's website rather than copying these schedules to their websites. Use of content syndication requires a one-time step that ensures an organization's website displays current schedules as soon as they are published or revised; instructions for the syndication code are available on CDC's website (https://www.cdc.gov/vaccines/schedules/resource-library/syndicate.html). CDC also offers technical assistance for implementing this form of content syndication (requests can be e-mailed to ncirdwebteam@cdc.gov).

Cover page

- The American Pharmacists Association has been added as a partner organization approving the adult immunization schedule.
- A newly recommended HepB vaccine (PreHevbrio) and a newly recommended MMR vaccine (Priorix) have been added to the table of vaccine abbreviations and trade names.
- COVID-19 vaccines have been added to the table of vaccine abbreviations and trade names. ACIP has developed new abbreviations for the COVID-19 vaccine products. These abbreviations contain information on the vaccine's valency (i.e., monovalent versus bivalent, indicated by "1v" and "2v," respectively) and vaccine platform (mRNA versus acellular protein subunit, or "aPS").
- The pneumococcal conjugate vaccines PCV15 and PCV20 have been combined into one row in the table of vaccine abbreviations and trade names.
- The language in the injury claims section has been modified to indicate which vaccines are covered by the National Vaccine Injury Compensation Program and which vaccines are covered by the Countermeasures Injury Compensation Program.

Table 1 (Routine Immunization Schedule)

- **COVID-19 row:** The COVID-19 vaccine row is a new addition to the tables this year. The color of this row is yellow, indicating that COVID-19 vaccination is now routinely recommended for all adults. The text overlay states, "2- or 3-dose primary series and booster (See Notes)."
- **MMR row**: Overlaying text has been added to the column for persons aged ≥65 years referring providers to the notes for vaccination considerations for health care personnel in this age group.
- **Hepatitis A row**: The overlaying text has been updated to "2, 3, or 4 doses depending on vaccine," to account for the possibility of an accelerated Twinrix series requiring 4 doses.

Table 2 (Immunization by Medical Indication Schedule)

- **COVID-19 row**: The COVID-19 vaccine row is a new addition to the tables this year. The color of this row is yellow, indicating that COVID-19 vaccination is now routinely recommended for adults with any of the medical conditions or other indications listed. The text overlay for the immunocompromised and HIV infection columns states, "See Notes," referring providers to the notes for specific recommendations for this population.
- **Hepatitis A row**: The overlaying text has been updated to "2, 3, or 4 doses depending on vaccine," to account for the possibility of an accelerated Twinrix series requiring 4 doses.

Vaccine Notes

The notes for each vaccine are presented in alphabetical order. Edits have been made throughout the Notes section to harmonize language between the child and adolescent and the adult immunization schedules to the greatest extent possible.

- **COVID-19**: A new section was added to provide additional details for use of COVID-19 vaccines. The "Routine vaccination" section describes the primary series recommendations for the general population. The "Special situations" section describes the primary series recommendations for persons who are moderately or severely immunocompromised. Hyperlinks have been provided referring health care providers to the latest guidance for booster dose recommendations in both populations, and to the recommendation for persons who received the Janssen (Johnson & Johnson) COVID-19 vaccine. Additionally, hyperlinks to the current COVID-19 vaccination schedules, use of COVID-19 preexposure prophylaxis in persons who are moderately or severely immunocompromised, as well as Emergency Use Authorization indications for COVID-19 vaccines, have been added.
- **HepB**: In the "Routine vaccination" section, PreHevbrio was added to the description of the 3-dose series, and information on the 4-dose series for persons on hemodialysis was moved to the "Special situations" section. HepB vaccination continues to be universally recommended for all adults aged 19–59 years. Language has been added stating that persons aged ≥60 years with known risk factors for hepatitis B virus infection should complete a HepB vaccination series, whereas persons aged ≥60 years without known risk factors for hepatitis B virus infection may complete a HepB vaccination series.
- **Influenza**: Information was added to the routine vaccination section for persons aged ≥65 years stating that any one of quadrivalent high-dose inactivated influenza vaccine, quadrivalent recombinant influenza vaccine, or quadrivalent adjuvanted inactivated influenza vaccine is preferred for this age group. A hyperlink to the 2022–23 influenza recommendations and a bullet for the 2023–24 influenza recommendations were added. In the "Special situations" section, guidance for close contacts of severely immunocompromised patients who require a protected

environment was added. In addition, the text describing guidance for persons with egg allergy who have experienced any symptom other than hives was moved from the appendix to the "Special situations" section.

- **MMR**: In the "Special situations" section, a hyperlink was provided that describes the recommendation for additional doses of MMR vaccine (including the third dose of MMR vaccine) in the context of a mumps outbreak setting.
- **Meningococcal**: In the "Special situations" section for meningococcal serogroup B vaccine, guidance was added stating that if the third dose of Trumenba is administered earlier than 4 months after the second dose, a fourth dose should be administered ≥4 months after the third dose.
- **Pneumococcal**: The section has been substantially updated to reflect ACIP's new recommendations for the use of PCV15 and PCV20 in persons who previously received pneumococcal vaccines. In addition, a hyperlink to the CDC app that can be used to determine a patient's pneumococcal vaccination needs has been included.
- **Poliovirus**: A new section was added summarizing poliovirus vaccination recommendations for adults. Although routine vaccination of adults residing in the United States is not necessary, the "Special situations" section describes the use of IPV in adults who are at increased risk for exposure to poliovirus.
- **Tdap**: Minor changes were made to the "Special situations" section to improve clarity in the language.
- **Zoster**: The "Routine vaccination" section was revised to clarify that serologic evidence of prior varicella is not necessary for zoster vaccination and to provide guidance for situations in which serologic evidence of varicella susceptibility becomes available. The "Special situations" section was updated to provide guidance for persons with immunocompromising conditions who do not have a documented history of varicella, varicella vaccination, or herpes zoster. In addition, minor changes were made to the immunocompromising conditions bullet to clarify that this includes persons with HIV regardless of CD4 count.

Appendix (Contraindications and Precautions)

- The header of the "Contraindications" column was changed to "Contraindicated or not recommended."
- **Influenza (egg-based) row**: The information for persons with history of egg allergy was moved from the precautions column to the influenza vaccination notes section.
- **HepB row**: The language regarding the use of Heplisav-B and PreHevbrio in pregnant persons was modified. The language now states that "Heplisav-B and PreHevbrio are not recommended because of lack of safety data in pregnant persons. Use other hepatitis B vaccines if HepB is indicated." A footnote providing information on the pregnancy exposure registries for persons who were inadvertently vaccinated with Heplisav-B and PreHevbrio while pregnant was added.
- **Human papillomavirus row**: The language regarding the use of human papillomavirus (HPV) vaccination among pregnant persons was modified. The language now states, "pregnancy: HPV vaccination not recommended."

Additional Information

The Recommended Adult Immunization Schedule, United States, 2023, is available at https://www.cdc.gov/vaccines/schedules/hcp/adult.html and in the *Annals of Internal Medicine* (https://www.acpjournals.org/doi/10.7326/M23-0041). The full ACIP recommendations for each vaccine are also available at https://www.cdc.gov/vaccines/hcp/acip-recs/index.html. All vaccines identified in Tables 1 and 2 (except PCV20 and RZV) also appear in the Recommended Immunization Schedule for Children and Adolescents, United States, 2023 (https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html). The notes and appendices for vaccines that appear in both the adult immunization schedule and the child and adolescent immunization schedule have been harmonized to the greatest extent possible.

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COVID-19 Incidence and Mortality Among Unvaccinated and Vaccinated Persons Aged ≥12 Years by Receipt of Bivalent Booster Doses and Time Since Vaccination — 24 U.S. Jurisdictions, October 3, 2021–December 24, 2022

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On September 1, 2022, CDC recommended an updated (bivalent) COVID-19 vaccine booster to help restore waning protection conferred by previous vaccination and broaden protection against emerging variants for persons aged ≥12 years (subsequently extended to persons aged ≥6 months).* To assess the impact of original (monovalent) COVID-19 vaccines and bivalent boosters, case and mortality rate ratios (RRs) were estimated comparing unvaccinated and vaccinated persons aged ≥12 years by overall receipt of and by time since booster vaccination (monovalent or bivalent) during Delta variant and Omicron sublineage (BA.1, BA.2, early BA.4/BA.5, and late BA.4/BA.5) predominance.† During the late BA.4/BA.5 period, unvaccinated persons had higher COVID-19 mortality and infection rates than persons receiving bivalent doses (mortality RR = 14.1 and infection RR = 2.8) and to a lesser extent persons vaccinated with only monovalent doses (mortality RR = 5.4 and infection RR = 2.5). Among older adults, mortality rates among unvaccinated persons were significantly higher than among those who had received a bivalent booster (65–79 years; RR = 23.7 and ≥80 years; 10.3) or a monovalent booster (65–79 years; 8.3 and ≥80 years; 4.2). In a second analysis stratified by time since booster vaccination, there was a progressive decline from the Delta period (RR = 50.7) to the early BA.4/BA.5 period (7.4) in relative COVID-19 mortality rates among unvaccinated persons compared with persons receiving who had received a monovalent booster within 2 weeks–2 months. During the early BA.4/BA.5 period, declines in relative mortality rates were observed at 6–8 (RR = 4.6), 9–11 (4.5), and ≥12 (2.5) months after receiving a monovalent booster. In contrast, bivalent boosters received during the preceding 2 weeks–2 months improved protection against death (RR = 15.2) during the late BA.4/BA.5 period. In both analyses, when compared with unvaccinated persons, persons who had received bivalent boosters were provided additional protection against death over monovalent doses or monovalent boosters. Restored protection was highest in older adults. All persons should stay up to date with COVID-19 vaccination, including receipt of a bivalent booster by eligible persons, to reduce the risk for severe COVID-19.

Previous reports on COVID-19 vaccine impact indicated that protection against infection and, to a lesser degree, severe illness, declined with waning of vaccine-induced immunity and emergence of the SARS-CoV-2 Delta and Omicron variants§ (*1–4*). After Omicron (BA.1) became predominant in the United States in late December 2021, Omicron sublineages BA.2, BA.4, and BA.5 circulated at high prevalence; BA.4 and BA.5-related variants constituted 78% of circulating lineages by December 24, 2022. Food and Drug Administration (FDA)–authorized bivalent boosters, which include an additional Omicron BA.4/BA.5 spike component, have been shown to enhance protection against infection and medically attended illness (*5–7*).

Weekly counts of COVID-19 cases (October 3, 2021–December 24, 2022) and associated deaths (October 3, 2021–December 3, 2022) by primary series vaccination and

* https://www.cdc.gov/coronavirus/2019-ncov/vaccines/stay-up-to-date.html

† National weighted estimates of weekly proportions of infections attributed to SARS-CoV-2 variants are based on CDC analyses (https://covid.cdc.gov/covid-data-tracker/#variant-proportions). Analysis periods were categorized based on variant predominance (defined as those accounting for >50% of sequenced lineages): Delta, October 3–December 18, 2021; Omicron BA.1, December 19, 2021–March 19, 2022; Omicron BA.2, March 20–June 25, 2022; early Omicron BA.4/BA.5, June 26–September 17, 2022; and late Omicron BA.4/BA.5 (only period in which bivalent boosters were recommended), September 18–December 24, 2022. A subset analysis was performed for the Omicron BA.5-, BA.4-, and BA.2-related variant period (November 6–December 24, 2022).

§ https://covid.cdc.gov/covid-data-tracker/#covidnet-hospitalizations-vaccination

booster status, including bivalent boosters (the week starting September 18, 2022), were reported from 24 jurisdictions[¶] that routinely link case surveillance data to immunization registries (vaccinations) and vital registration databases (deaths). Accounting for case and death reporting lags (2 weeks and 5 weeks, respectively) permitted more complete reporting, data linkage, and mortality ascertainment. Standardized definitions were used for COVID-19 cases[**] and COVID-19–associated deaths[††] by vaccination status[§§] with specimen collection dates used as reference dates; vaccinated persons who did not complete a primary COVID-19 vaccination series were excluded. Analysis periods were determined based on U.S. variant proportion estimates. Rate denominators were calculated from vaccine administration data, with numbers of unvaccinated persons estimated by subtracting numbers of persons vaccinated with at least a primary series and persons with an incomplete primary series from 2019 U.S. intercensal population estimates.[¶¶] A continuity correction assumed that ≥5% of each age group and jurisdiction would always be unvaccinated (i.e., ≤95% vaccination coverage).[***] Average weekly incidence and mortality were calculated during each period and stratified by age group (12–17, 18–49, 50–64, 65–79 and ≥80 years) and vaccination status; overall rates were age-standardized using the 2000 U.S. Census Bureau standard population.[†††] Two sets of analyses of incidence and mortality rates overall (24 jurisdictions) and by time since last monovalent or bivalent booster vaccination (23 jurisdictions) were conducted. Overall and strata-specific RRs were calculated by dividing rates among unvaccinated persons by rates among vaccinated persons; after detrending the underlying linear changes in rates, 95% CIs were calculated from the remaining variation in observed weekly rates[§§§] (*8*,*9*). SAS (version 9.4; SAS Institute) and R (version 4.1.2; R Foundation) were used to conduct all analyses. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[¶¶¶]

Among persons aged ≥12 years, a total of 21,296,326 COVID-19 cases and 115,078 associated deaths were reported during October 3, 2021–December 24, 2022, and October 3, 2021–December 3, 2022, respectively, from 24 U.S. jurisdictions (Table). Average weekly age-standardized incidence and mortality (cases and deaths per 100,000 population aged ≥12 years) increased substantially during the Omicron BA.1 period and to a lesser extent during the early BA.4/BA.5 period (Figure 1). During all periods, average weekly age-standardized incidence and mortality were consistently higher among unvaccinated persons (ranges = 216.1–1,256.0 and 1.6–15.8, respectively) than among monovalent-only vaccine recipients (ranges = 86.4–487.7 and 0.3–1.4, respectively); average weekly incidence and mortality during the late BA.4/BA.5 period were lowest among bivalent booster recipients (78.5 and 0.1, respectively).

Overall, age-standardized case RRs (unvaccinated persons compared with monovalent-only vaccine recipients) declined from 4.0 during the Delta period to 2.6 during the Omicron BA.1 and 1.8 during the Omicron BA.2 periods, before increasing to 2.7 in the early BA.4/BA.5 period. Overall case RRs (unvaccinated persons compared with bivalent booster recipients) were slightly higher (2.8) than were those for monovalent-only vaccine recipients (2.5) during the late

[¶] The 24 jurisdictions included in this analysis represent 52% of the U.S. population: Alabama, Arizona, Arkansas, Colorado, District of Columbia, Georgia, Idaho, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Nebraska, New Jersey, New Mexico, New York, North Carolina, Tennessee, Texas, Utah, Washington, and West Virginia. A subset of 23 jurisdictions (50% of the US population) was included in the time since last booster vaccination analysis; New York did not provide mortality data.

[**] A COVID-19 case (confirmed or probable) was defined as the detection of SARS-CoV-2 RNA or antigen in a respiratory specimen collected per the Council of State and Territorial Epidemiologists' update to the standardized surveillance case definition and national notification for COVID-19 (https://cdn.ymaws.com/www.cste.org/resource/resmgr/ps/ps2022/22-ID-01_COVID19.pdf). Reinfections occurring after 90 days were counted as new cases, per current guidance.

[††] A COVID-19–associated death occurred in a person with a documented COVID-19 diagnosis who died and whose report local health authorities reviewed to make that determination (e.g., using vital records, public health investigation, or other data sources). Per national guidance, this group should include persons whose death certificate lists COVID-19 or SARS-CoV-2 as an underlying cause or a significant condition contributing to death (https://preparedness.cste.org/wp-content/uploads/2022/12/CSTE-Revised-Classification-of-COVID-19-associated-Deaths.Final_.11.22.22.pdf). Rates of COVID-19 deaths by vaccination status are reported based on when specimens were tested for COVID-19, not the date the patient died.

[§§] COVID-19 cases among unvaccinated persons and persons vaccinated with a primary series with or without a monovalent or bivalent booster dose were defined as previously described (https://www.cdc.gov/coronavirus/2019-ncov/php/hd-breakthrough.html). COVID-19 patients who had received a primary series or a monovalent booster were combined in the "vaccinated with monovalent vaccines only" category. Cases were excluded among persons who received ≥1 FDA-authorized vaccine dose but did not complete a primary series ≥14 days before the positive specimen collection date.

[¶¶] https://www.census.gov/programs-surveys/popest/data/tables.2019.html

[***] A continuity correction was applied to denominators by capping the percentage of population coverage at 95%. To do this, it was assumed that ≥5% of each age group would always be unvaccinated in each jurisdiction. Adding this correction ensures that there is always a reasonable denominator for the unvaccinated population and prevents incidence and death rates from growing unrealistically large because of potential overestimates of vaccination coverage.

[†††] Age-standardization was performed using the direct method with the year 2000 projected U.S. population, per the 1998 directive on adjusting mortality data from the Secretary of the U.S. Department of Health and Human Services (https://www.cdc.gov/nchs/data/statnt/statnt20.pdf).

[§§§] 95% CIs were calculated after detrending underlying linear changes in weekly rates using piecewise linear regression. Each 95% CI represents the remaining variation in observed weekly rates and resulting RRs. The number of observations leading to each 95% CI reflects the number of weeks per period: Delta (11), Omicron BA.1 (13), Omicron BA.2 (14), early Omicron BA.4/BA.5 (12), and late Omicron BA.4/BA.5 (14).

[¶¶¶] 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.0 Sect.552a; 44 U.S.C. Sect. 3501 et seq.

TABLE. Average weekly incidence,* mortality rates,† and rate ratios for unvaccinated compared with vaccinated persons, by age group, variant period,§ and receipt of bivalent booster doses — 24 U.S. jurisdictions,¶ October 2021–December 2022**

Dates (predominant variant)	Age group, yrs											
	12–17		18–49		50–64		65–79		≥80		All ages ≥12 yrs (age-standardized)	
	No.	Incidence	No.	Incidence	No.	Incidence	No.	Incidence	No.	Incidence	No.	Incidence
Cases*												
Oct 3–Dec 18, 2021 (Delta)												
Unvaccinated	238,129	384.9	1,101,981	443.9	320,532	473.5	135,567	729.8	36,528	457.9	**1,832,737**	**475.8**
Vaccinated	43,715	71.4	587,110	137.6	270,337	113.3	146,740	82.2	48,377	93.9	**1,096,279**	**118.3**
RR (95% CI)††	—	5.4 (2.7–10.7)	—	3.2 (1.9–5.3)	—	4.2 (3.2–5.5)	—	8.9 (7.1–11.1)	—	4.9 (4.0–6.0)	—	**4.0 (2.9–5.6)**
Dec 19, 2021–Mar 19, 2022 (Omicron BA.1)												
Unvaccinated	572,012	870.9	3,170,926	1,241.3	834,743	1,261.0	337,174	1,704.0	101,276	1,182.6	**5,016,131**	**1,256.0**
Vaccinated	426,833	507.2	3,202,802	572.9	1,230,476	405.0	581,903	258.2	168,564	259.6	**5,610,578**	**487.7**
RR (95% CI)††	—	1.7 (1.0–2.9)	—	2.2 (1.1–4.5)	—	3.1 (1.5–6.4)	—	6.6 (3.6–12.1)	—	4.6 (2.7–7.7)	—	**2.6 (1.6–4.1)**
Mar 20–Jun 25, 2022 (Omicron BA.2)												
Unvaccinated	65,272	98.7	546,933	212.5	170,798	252.4	90,598	442.0	33,135	375.6	**906,736**	**240.2**
Vaccinated	78,139	80.6	904,179	144.8	427,853	127.8	275,413	111.1	95,296	133.3	**1,780,880**	**130.8**
RR (95% CI)††	—	1.2 (0.9–1.6)	—	1.5 (1.3–1.6)	—	2.0 (1.8–2.2)	—	4.0 (3.6–4.4)	—	2.8 (2.5–3.1)	—	**1.8 (1.7–2.0)**
Jun 26–Sep 17, 2022 (early Omicron BA.4/BA.5)												
Unvaccinated	106,120	193.5	761,559	356.7	241,386	429.1	138,059	812.4	49,447	685.1	**1,296,571**	**417.3**
Vaccinated	69,144	81.7	863,788	160.0	471,681	162.9	350,412	162.8	128,081	205.9	**1,883,106**	**154.5**
RR (95% CI)††	—	2.4 (1.2–4.5)	—	2.2 (2.1–2.4)	—	2.6 (2.5–2.8)	—	5.0 (4.7–5.3)	—	3.3 (3.2–3.5)	—	**2.7 (2.6–2.8)**
Sep 18–Dec 24, 2022 (late Omicron BA.4/BA.5)												
Unvaccinated	46,384	74.0	377,142	155.3	146,444	228.4	100,317	511.1	46,026	554.4	**716,313**	**216.1**
Monovalent vaccine only	39,360	41.2	481,552	80.2	298,532	97.5	230,382	110.4	107,169	174.4	**1,156,995**	**86.4**
RR (95% CI)††	—	1.8 (1.2–2.8)	—	1.9 (1.5–2.5)	—	2.3 (1.9–2.9)	—	4.6 (3.8–5.6)	—	3.2 (2.6–4.0)	—	**2.5 (2.2–2.9)**
Bivalent booster	1,112	25.9	30,424	79.6	29,589	85.2	45,139	88.4	21,253	139.6	**127,517**	**78.5**
Bivalent booster RR	—	2.9 (1.8–4.4)	—	2.0 (1.5–2.5)	—	2.7 (2.2–3.3)	—	5.8 (4.8–6.9)	—	4.0 (3.2–5.0)	—	**2.8 (2.4–3.1)**
Deaths†												
Oct 3–Dec 18, 2021 (Delta)												
Unvaccinated	23	0.04	3,072	1.3	7,202	11.7	9,470	55.0	5,533	77.6	**25,300**	**12.2**
Vaccinated	2	0.004	232	0.1	1,111	0.5	3,279	2.1	4,041	9.3	**8,665**	**0.7**
RR (95% CI)††	—	10.8 (0.2–578.5)	—	20.9 (13.0–33.5)	—	21.4 (16.0–28.6)	—	25.8 (20.6–32.4)	—	8.3 (6.4–10.9)	—	**16.2 (14.1–18.7)**
Dec 19, 2021–Mar 19, 2022 (Omicron BA.1)												
Unvaccinated	25	0.04	2,495	1.0	6,917	11.3	12,836	70.5	10,220	131.0	**32,493**	**15.8**
Vaccinated	7	0.01	635	0.1	2,828	1.1	7,748	4.0	8,994	16.3	**20,212**	**1.4**
RR (95% CI)††	—	4.3 (0.5–41.2)	—	7.8 (5.0–12.1)	—	10.5 (7.6–14.4)	—	17.8 (13.2–24.0)	—	8.0 (5.5–11.7)	—	**11.5 (9.4–14.1)**

See table footnotes on the next page.

BA.4/BA.5 period. Average, age-standardized mortality RRs in monovalent-only vaccine recipients decreased from the Delta (16.2) to BA.1 (11.5) period, then stabilized during the BA.2 (5.3), early BA.4/BA.5 (5.3), and late BA.4/BA.5 (5.4) periods. Overall mortality rates among unvaccinated persons were 14.1 times the rates among bivalent vaccine recipients; mortality rates among monovalent-only vaccine recipients were 2.6 times the rates among bivalent vaccine recipients during the late BA.4/BA.5 period. Compared with unvaccinated persons, protection among bivalent booster recipients aged 65–79 years (RR = 23.7), and ≥80 years (10.3) was significantly higher than was protection among monovalent booster recipients aged 65–79 years (8.3) and ≥80 years (4.2).

In stratified comparisons of unvaccinated persons and vaccinated persons who had received a monovalent booster dose 2 weeks–2 months earlier, progressive declines in case RRs were more pronounced between the Delta (7.0) and BA.1 (3.4), BA.2 (2.4), early BA.4/BA.5 (2.8), and late BA.4/BA.5 (2.8) periods; the case RR at 2 weeks–2 months after a bivalent booster (2.8) was the same during the late BA.4/BA.5 period

TABLE. (*Continued*) Average weekly incidence,* mortality rates,† and rate ratios for unvaccinated compared with vaccinated persons, by age group, variant period,§ and receipt of bivalent booster doses — 24 U.S. jurisdictions,¶ October 2021–December 2022**

Dates (predominant variant)	Age group, yrs											
	12–17		18–49		50–64		65–79		≥80		All ages ≥12 yrs (age-standardized)	
	No.	Incidence	No.	Incidence	No.	Incidence	No.	Incidence	No.	Incidence	No.	Incidence
Mar 20–Jun 25, 2022 (Omicron BA.2)												
Unvaccinated	9	0.01	245	0.1	514	0.8	1,144	6.1	1,418	17.5	**3,330**	**1.6**
Vaccinated	2	0.002	133	0.02	501	0.2	1,503	0.7	2,700	4.4	**4,839**	**0.3**
RR (95% CI)††	—	6.2 (0.04–935.3)	—	4.0 (1.6–10.0)	—	4.7 (3.5–6.4)	—	8.7 (6.6–11.5)	—	4.0 (3.4–4.6)	—	**5.3 (4.6–6.0)**
Jun 26–Sep 17, 2022 (early Omicron BA.4/BA.5)												
Unvaccinated	12	0.02	332	0.2	790	1.5	1,725	11.1	2,154	32.4	**5,013**	**2.9**
Vaccinated	1	0.001	223	0.05	760	0.3	2,665	1.4	4,039	7.6	**7,688**	**0.5**
RR (95% CI)††	—	17.4 (0.03–9,462.7)	—	3.4 (1.9–5.9)	—	5.0 (3.7–6.6)	—	7.8 (6.9–8.9)	—	4.3 (3.6–5.0)	—	**5.3 (4.8–5.9)**
Sep 18–Dec 3, 2022 (late Omicron BA.4/BA.5)												
Unvaccinated	3	0.01	165	0.1	387	0.8	1,076	7.6	1,410	23.4	**3,041**	**2.0**
Monovalent vaccine only	0	0	81	0.02	397	0.2	1,369	0.9	2,358	5.5	**4,205**	**0.4**
RR (95% CI)††	—	—	—	4.5 (2.3–9.1)	—	4.4 (2.6–7.4)	—	8.3 (6.4–10.7)	—	4.2 (3.7–4.9)	—	**5.4 (4.8–6.1)**
Bivalent booster	0	0	1	0.005	12	0.1	91	0.3	188	2.3	**292**	**0.1**
Bivalent booster RR (95% CI)††	—	—	—	18.8 (0.8–467.9)	—	12.8 (2.7–61.5)	—	23.7 (12.6–44.7)	—	10.3 (7.0–15.2)	—	**14.1 (10.1–19.6)**

Abbreviation: RR = rate ratio.

* Cases per 100,000 persons aged ≥12 years. COVID-19 cases among unvaccinated persons and persons vaccinated with a primary series with or without a monovalent or bivalent booster dose were defined as previously described (https://www.cdc.gov/coronavirus/2019-ncov/php/hd-breakthrough.html). Cases with primary series or a monovalent booster were combined in the "vaccinated only with monovalent vaccines" category. Cases were excluded among persons who received ≥1 Food and Drug Administration–authorized vaccine dose but did not complete a primary series ≥14 days before the positive specimen collection date.

† Deaths per 100,000 persons aged ≥12 years. A COVID-19–associated death occurred in a person with a documented COVID-19 diagnosis who died, and whose report local health authorities reviewed to make that determination (e.g., using vital records, public health investigation, or other data sources). Per national guidance, this group includes persons whose death certificate lists COVID-19 or SARS-CoV-2 as an underlying cause of death or a significant condition contributing to death. COVID-19 mortality by vaccination status is reported based on COVID-19 test date, not the date the patient died.

§ Analysis periods were categorized based on variant predominance (defined as accounting for >50% of sequenced isolates): Delta, October 3–December 18, 2021; Omicron BA.1, December 19, 2021–March 19, 2022; Omicron BA.2, March 20–June 25, 2022; early Omicron BA.4/BA.5, June 26–September 17, 2022; and late Omicron BA.4/BA.5 (only period in which bivalent boosters were recommended), September 18–December 24, 2022.

¶ These 24 jurisdictions represent 52% of the overall U.S. population and were included in this analysis: Alabama, Arizona, Arkansas, Colorado, District of Columbia, Georgia, Idaho, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Nebraska, New Jersey, New Mexico, New York, North Carolina, Tennessee, Texas, Utah, Washington, and West Virginia; New York did not provide mortality data.

** Date range for average weekly incidence is October 3, 2021–December 24, 2022; date range for mortality rates is October 3, 2021–December 3, 2022.

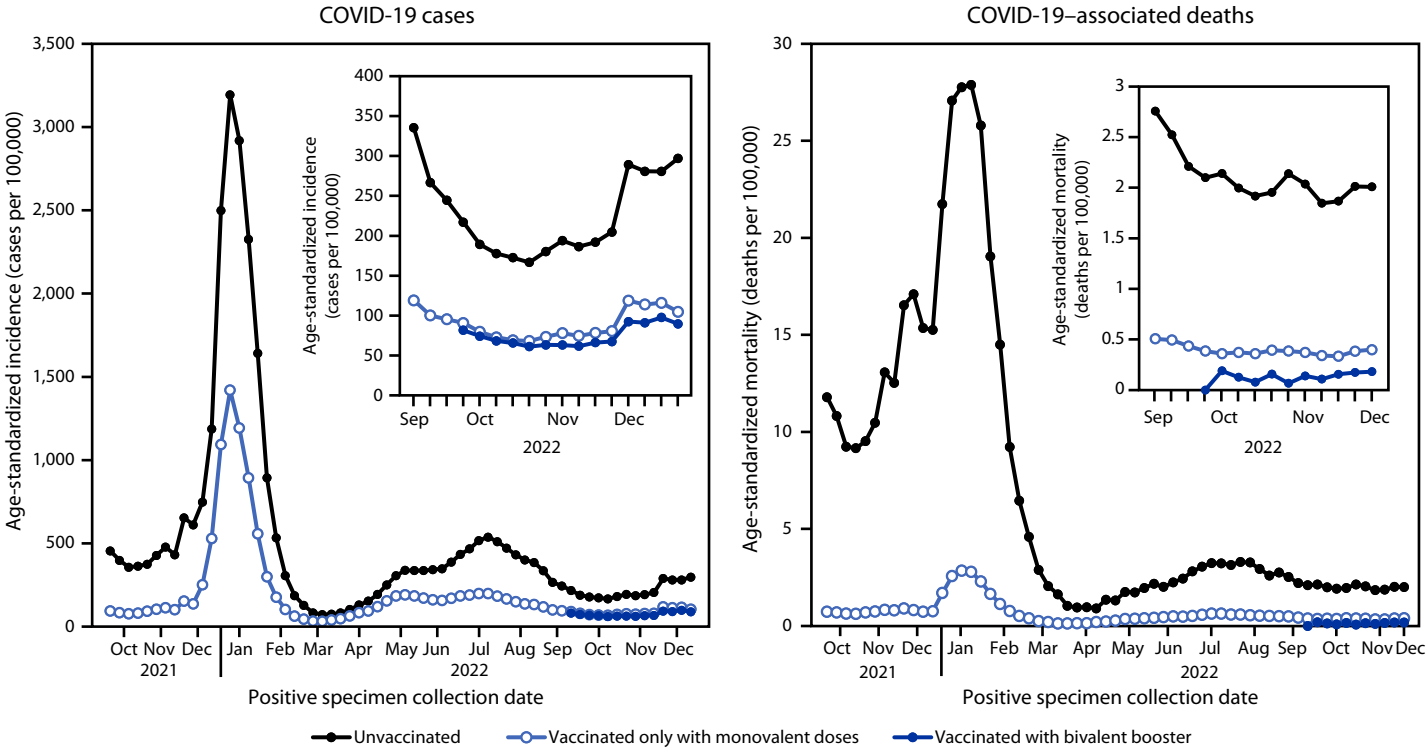
†† 95% CIs were calculated after detrending underlying linear changes in weekly rates using piecewise linear regression. Each 95% CI represents the remaining variation in observed weekly rates and resulting RRs. The number of observations informing each 95% CI reflects the number of weeks per period: Delta (11), Omicron BA.1 (13), Omicron BA.2 (14), early Omicron BA.4/BA.5 (12), and late Omicron BA.4/BA.5 (14).

(Figure 2) (Supplementary Table, https://stacks.cdc.gov/view/cdc/124201).**** A similar reduction in the case RR was observed for both the monovalent booster at 3–5 months (2.0) and the bivalent booster at 3 months (1.7) after vaccination during the late BA.4/BA.5 period. Mortality RRs for unvaccinated persons compared with persons who received a monovalent booster dose 2 weeks–2 months earlier declined from 50.7 during the Delta period to 21.4 during the BA.1 period, 7.9 during the BA.2 period, and 7.4 during the early BA.4/BA.5 period, representing a reduction in crude vaccine effectiveness (VE) from 98% (Delta) to 87% (BA.4/BA.5).†††† During the early BA.4/BA.5 period, mortality RRs remained stable 3–5 months after receiving a monovalent booster dose (7.2) but declined to 4.6 at 6–8 months, 4.5 at 9–11 months, and 2.5 at ≥12 months. In contrast, bivalent boosters received in the preceding 2 weeks–2 months during the late BA.4/BA.5 period provided enhanced protection against death (mortality RR = 15.2 in unvaccinated persons versus bivalent booster recipients), representing a crude VE of 93%. A subset analysis of the Omicron BA.5, BA.4, and BA.2-related variant period (November 6–December 24, 2022) yielded similar results.

**** The median interval in the 2 weeks–2 months since vaccination period was longer for persons who received monovalent boosters during early (60 days) and late (70 days) BA.4/BA.5 periods than for those who received bivalent boosters (47 days). The median interval among persons who received a monovalent booster 3–5 months earlier was 131 and 144 days during early and late BA.4/BA.5 periods, respectively; among those who received bivalent boosters 3–5 months earlier, the median interval was 95 days.

†††† To interpret rate ratio changes, age-standardized crude vaccine effectiveness was estimated as (1 – [incidence in vaccinated / incidence in unvaccinated]) x 100%.

FIGURE 1. Age-standardized weekly COVID-19 incidence* and COVID-19–associated mortality rates,† by vaccination status and receipt of a bivalent booster dose§ — 24 U.S. jurisdictions,¶ October 2021–December 2022**



* Cases per 100,000 persons aged ≥12 years. COVID-19 cases among unvaccinated persons and persons vaccinated with a primary series with or without a monovalent or bivalent booster dose were defined as previously described (https://www.cdc.gov/coronavirus/2019-ncov/php/hd-breakthrough.html). Cases with primary series or a monovalent booster were combined in the "vaccinated only with monovalent vaccines" category. Cases were excluded among persons who received ≥1 Food and Drug Administration–authorized vaccine dose but did not complete a primary series ≥14 days before the positive specimen collection date.

† Deaths per 100,000 persons aged ≥12 years. A COVID-19–associated death occurred in a person with a documented COVID-19 diagnosis who died, and whose report local health authorities reviewed to make that determination (e.g., using vital records, public health investigation, or other data sources). Per national guidance, this group should include persons whose death certificate lists COVID-19 or SARS-CoV-2 as an underlying cause or a significant condition contributing to death. Rates of COVID-19 deaths by vaccination status are reported based on when the patient was tested for COVID-19, not the date the patient died.

§ Bivalent boosters were recommended during September 1–December 24, 2022. Based on case definitions, a case after vaccination occurred in a person ≥14 days postvaccination.

¶ These 24 jurisdictions represent 52% of the overall U.S. population and were included in this analysis: Alabama, Arizona, Arkansas, Colorado, District of Columbia, Georgia, Idaho, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Nebraska, New Jersey, New Mexico, New York, North Carolina, Tennessee, Texas, Utah, Washington, and West Virginia; New York did not provide mortality data.

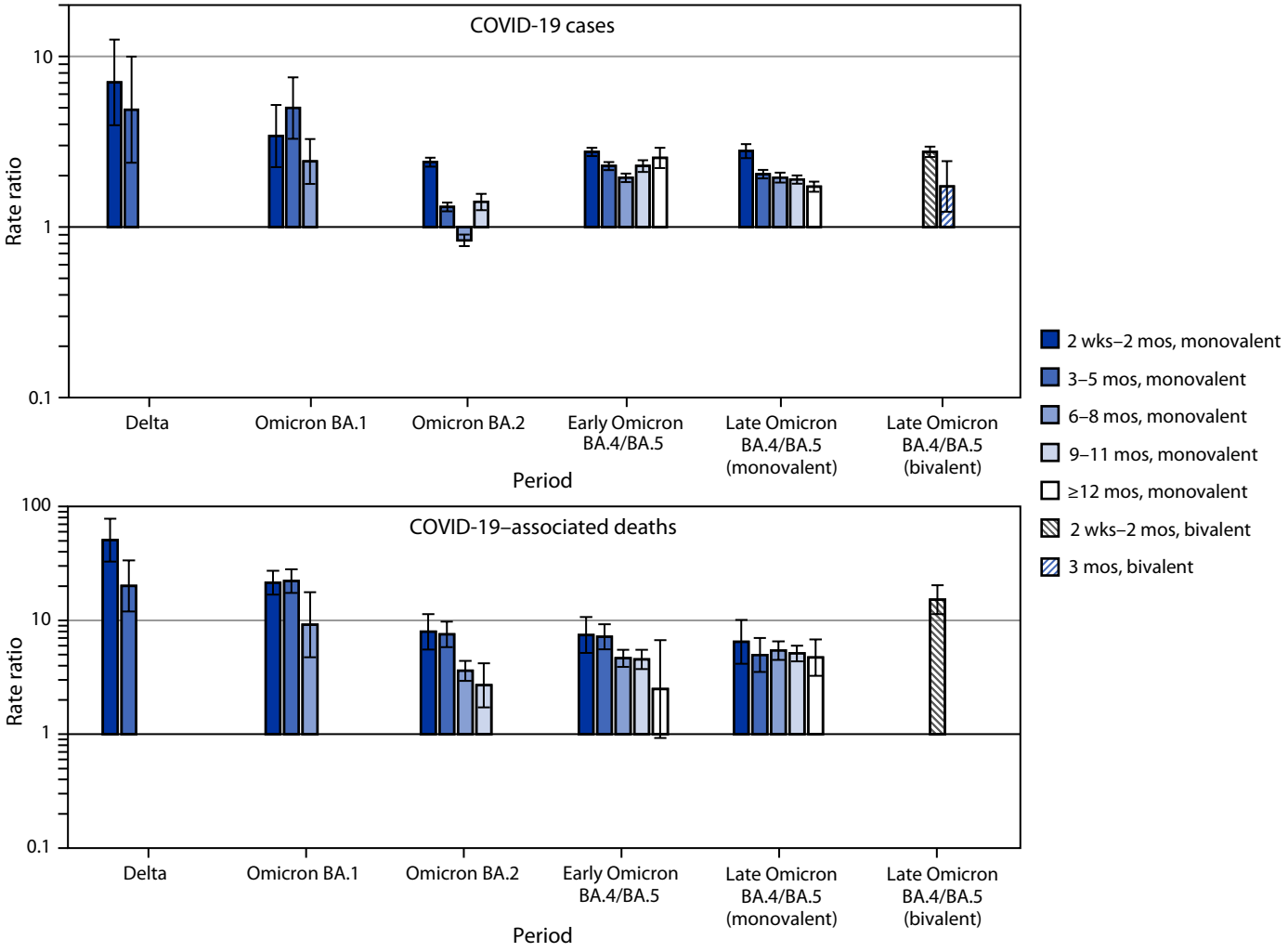
** Date range for age-standardized weekly COVID-19 incidence is October 3, 2021–December 24, 2022; date range for COVID-19–associated mortality rates is October 3, 2021–December 3, 2022.

Discussion

This multijurisdictional report of COVID-19 case and mortality rates included two sets of analyses with different comparisons by vaccination status. In the first, overall rates among unvaccinated persons were compared to rates in persons with only monovalent doses or bivalent boosters. Receipt of bivalent booster added protection against infection and death for circulating Omicron BA.4/BA.5 sublineages. When stratifying by time since vaccination for the second analysis, comparisons during the late BA.4/BA.5 period of monovalent and bivalent boosters found that bivalent boosters restored protection against mortality and provided similar protection against infection at 2 weeks through 2 months. Although long-term protection could not yet be assessed, evidence of waning protection against infection 3 months after bivalent booster dose receipt was observed. This study supports previous findings of protection afforded by bivalent vaccines against infection and medically attended illness during BA.4/BA.5 predominance (*5*–*7*) and provides additional evidence of enhanced protection against COVID-19–associated mortality. To date, however, bivalent booster coverage has been low (17.5% among persons aged ≥12 years).[§§§§]

[§§§§] https://covid.cdc.gov/covid-data-tracker/#vaccinations_vacc-total-admin-rate-total

FIGURE 2. Age-standardized average weekly case* and mortality† rate ratios with 95% CIs§ in unvaccinated persons compared with booster dose recipients, by variant period¶ and time since receipt of last booster dose — 23 U.S. jurisdictions,†† October 2021–December 2022§§**



* Cases per 100,000 persons aged ≥12 years. COVID-19 cases among unvaccinated persons and persons vaccinated with a primary series with or without a monovalent or bivalent booster dose were defined as previously described (https://www.cdc.gov/coronavirus/2019-ncov/php/hd-breakthrough.html). Cases were excluded in persons who only completed a primary series or who received ≥1 Food and Drug Administration–authorized vaccine dose but did not complete a primary series ≥14 days prior to the positive specimen collection date.

† A COVID-19–associated death occurred in a person with a documented COVID-19 diagnosis who died, and whose report local health authorities reviewed to make that determination (e.g., using vital records, public health investigation, or other data sources). Per national guidance, this group should include persons whose death certificate lists COVID-19 or SARS-CoV-2 as an underlying cause or a significant condition contributing to death. Rates of COVID-19 deaths by vaccination status are reported based on when the patient was tested for COVID-19, not the date the patient died.

§ 95% CIs were calculated after detrending underlying linear changes in weekly rates using piecewise linear regression. Each 95% CI represents the remaining variation in observed weekly rates and resulting rate ratios. The number of observations leading to each 95% CI reflects the number of weeks per period: Delta (11), Omicron BA.1 (13), Omicron BA.2 (14), early Omicron BA.4/BA.5 (12), and late Omicron BA.4/BA.5 (14).

¶ Analysis periods were categorized based on variant predominance (defined as accounting for >50% of sequenced lineages): Delta, October 3–December 18, 2021; Omicron BA.1, December 19, 2021–March 19, 2022; Omicron BA.2, March 20–June 25, 2022; early Omicron BA.4/BA.5, June 26–September 17, 2022; and late Omicron BA.4/BA.5 (only period where bivalent boosters were recommended), September 18–December 24, 2022.

** Time since last monovalent booster categories was restricted to outcomes occurring during eligible weeks based on the timing of the first booster recommendation for adults aged ≥65 years and adults aged ≥18 years in high-risk groups on September 24, 2021: 2 weeks–2 months (starting October 3, 2021); 3–5 months (starting November 13, 2021); 6–8 months (starting February 13, 2022); 9–11 months (starting May 15, 2022); ≥12 months (starting August 14, 2022). For persons aged 12–17 years, boosters were recommended on January 5, 2022; data are included the week starting January 16, 2022. Bivalent boosters were included for the period starting September 18, 2022, and for categories of 2 weeks–2 months and 3 months after receipt of a booster for cases and 2 weeks–2 months after receipt of a booster for deaths. Unvaccinated persons are compared to vaccinated persons for the same time frame in each category. The median interval in the 2 weeks–2 months since vaccination period was longer for persons with monovalent boosters during early (60 days) and late (70 days) BA.4/BA.5 periods than for those who received bivalent boosters (47 days). The median interval among persons who received a monovalent booster 3–5 months earlier was 131 and 191 days, respectively, during early and late BA.4/BA.5 periods; among those who received bivalent boosters 3 months earlier, the median interval was 95 days.

†† These 23 jurisdictions represent 50% of the overall U.S. population and were included in this analysis: Alabama, Arizona, Arkansas, Colorado, District of Columbia, Georgia, Idaho, Indiana, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Nebraska, New Jersey, New Mexico, New York, North Carolina, Tennessee, Texas, Utah, Washington, and West Virginia; New York did not provide mortality data.

§§ Date range for age-standardized average weekly case rate ratio is October 3, 2021–December 24, 2022; date range for mortality rate ratio is October 3, 2021–December 3, 2022.

Summary

What is already known about this topic?

COVID-19 vaccine effectiveness decreased with waning of vaccine-derived immunity and emerging Omicron sublineages. An updated (bivalent) booster dose enhances protection against infection and medically attended illness, but protection against death has not been evaluated.

What is added by this report?

Bivalent booster recipients in 24 U.S. jurisdictions had slightly higher protection against infection and significantly higher protection against death than was observed for monovalent booster recipients or unvaccinated persons, especially among older adults.

What are the implications for public health practice?

Bivalent COVID-19 booster doses protected against infection and death during BA.4/BA.5 circulation. All eligible persons should get 1 bivalent booster dose ≥2 months after their COVID-19 primary series or last monovalent booster dose.

During the early BA.4/BA.5 period, waning protection against COVID-19–associated death was observed ≥6 months after receipt of monovalent boosters, although decreases were not always statistically significant. Findings were similar to those reported in a 2021 study on waning immunity from primary COVID-19 vaccination during the Delta period (*4*). Patterns of waning protection against COVID-19–associated death after receiving a monovalent booster were less apparent during the late BA.4/BA.5 period; this might be related to smaller sample sizes and potential boosts to immunity over time resulting from recent infections or receipt of boosters that were not matched to existing vaccination records. Well-controlled VE studies conducted during the BA.4/BA.5 period have shown waning protection of monovalent doses against hospitalization starting at 4 months, with incremental benefits of bivalent boosters with increasing time since the last monovalent dose¶¶¶¶ (*6*,*7*).

The findings in this report are subject to at least six limitations. First, authorizations for monovalent and bivalent boosters were not concurrent; the median time after vaccination was longer for persons who received monovalent boosters than for those who received bivalent boosters, which limits direct comparability. Second, distinguishing monovalent boosters from additional primary doses administered to immunocompromised persons was not possible, which could result in reduced RRs because of lower VE in this population. Third, this ecologic study could not adjust for important confounders that might contribute to rate differences, such as possible variations in infection-derived immunity, co-morbidities, and testing or prevention behaviors by age and vaccination status (*1*). Increased at-home test use has affected trends in case incidence more than trends in mortality over time (*1*); however, increases have been noted in COVID-19–associated deaths without laboratory-confirmation,***** which were not included in data reported by vaccination status, possibly reducing recent RRs. Fourth, national variant prevalence estimates were used, but variant prevalence differs by region. Fifth, misclassification of bivalent or monovalent boosters could influence RRs (*10*). Cases in bivalent booster recipients might have been preferentially identified because accounting for bivalent doses reported as first and second doses was possible, whereas distinguishing unlinked monovalent boosters from first or second doses was not possible. Finally, these data represent approximately one half of the U.S. population, and therefore, might not be generalizable.

This report presents evidence of the enhanced protection provided by bivalent COVID-19 boosters compared to monovalent vaccines against infection and death during the BA.4/BA.5 period and are consistent with other VE studies. Continued monitoring of the impact of emerging variants on VE against severe COVID-19 outcomes is needed. For the best protection against severe COVID-19, all persons should stay up to date with recommended COVID-19 vaccination, including receipt of a bivalent booster by eligible persons.

¶¶¶¶ https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2022-09-01/04-covid-link-gelles-508.pdf

***** https://www.cdc.gov/coronavirus/2019-ncov/science/data-review/hospitals.html

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Vital Signs: Health Disparities in Hemodialysis-Associated *Staphylococcus aureus* Bloodstream Infections — United States, 2017–2020

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Abstract

On February 6, 2023, this report was posted as an MMWR *Early Release on the* MMWR *website (https://www.cdc.gov/mmwr).*

Introduction: Racial and ethnic minorities are disproportionately affected by end-stage kidney disease (ESKD). ESKD patients on dialysis are at increased risk for *Staphylococcus aureus* bloodstream infections, but racial, ethnic, and socioeconomic disparities associated with this outcome are not well described.

Methods: Surveillance data from the 2020 National Healthcare Safety Network (NHSN) and the 2017–2020 Emerging Infections Program (EIP) were used to describe bloodstream infections among patients on hemodialysis (hemodialysis patients) and were linked to population-based data sources (CDC/Agency for Toxic Substances and Disease Registry [ATSDR] Social Vulnerability Index [SVI], United States Renal Data System [USRDS], and U.S. Census Bureau) to examine associations with race, ethnicity, and social determinants of health.

Results: In 2020, 4,840 dialysis facilities reported 14,822 bloodstream infections to NHSN; 34.2% were attributable to *S. aureus*. Among seven EIP sites, the *S. aureus* bloodstream infection rate during 2017–2020 was 100 times higher among hemodialysis patients (4,248 of 100,000 person-years) than among adults not on hemodialysis (42 of 100,000 person-years). Unadjusted *S. aureus* bloodstream infection rates were highest among non-Hispanic Black or African American (Black) and Hispanic or Latino (Hispanic) hemodialysis patients. Vascular access via central venous catheter was strongly associated with *S. aureus* bloodstream infections (NHSN: adjusted rate ratio [aRR] = 6.2; 95% CI = 5.7–6.7 versus fistula; EIP: aRR = 4.3; 95% CI = 3.9–4.8 versus fistula or graft). Adjusting for EIP site of residence, sex, and vascular access type, *S. aureus* bloodstream infection risk in EIP was highest in Hispanic patients (aRR = 1.4; 95% CI = 1.2–1.7 versus non-Hispanic White [White] patients), and patients aged 18–49 years (aRR = 1.7; 95% CI = 1.5–1.9 versus patients aged ≥65 years). Areas with higher poverty levels, crowding, and lower education levels accounted for disproportionately higher proportions of hemodialysis-associated *S. aureus* bloodstream infections.

Conclusions and implications for public health practice: Disparities exist in hemodialysis-associated *S. aureus* infections. Health care providers and public health professionals should prioritize prevention and optimized treatment of ESKD, identify and address barriers to lower-risk vascular access placement, and implement established best practices to prevent bloodstream infections.

Introduction

More than 800,000 persons in the United States live with ESKD, 70% of whom are treated with dialysis (89% hemodialysis and 11% peritoneal dialysis); 30% have a functioning kidney transplant (*1*). Race, ethnicity, and social determinants of health* affect development of ESKD (*1–4*). ESKD prevalence is fourfold higher among Black persons and more than twofold higher among Hispanic than among White persons (*1*), disparities which are thought to be attributable at least in part to underlying conditions such as hypertension and diabetes mellitus (*1–3*). Furthermore, disparities in pre-ESKD nephrology care and receipt of ESKD therapies exist for these same groups, as well as those with lower income and insurance coverage (*1,5–9*). Black persons constitute 33% of all U.S. patients receiving dialysis (*1*), but only 12% of the U.S. population (*10*).

Infections are a leading cause of morbidity and mortality in hemodialysis patients (*1*). *S. aureus* is the most commonly isolated pathogen among bloodstream infections in hemodialysis patients reported to NHSN; 40% of those infections are methicillin resistant (MRSA)† (*11*). Higher rates of invasive *S. aureus* infections have been observed in dialysis patients compared with nondialysis patients (*12*).

Type of hemodialysis access is a well-established risk factor for infections; risk is highest for central venous catheters (CVCs), lower for grafts, and lowest for fistulas (*11*). Although elevated rates have been reported for both invasive MRSA infections among Black dialysis patients (*13*) and hospitalizations for

* https://www.cdc.gov/healthequity/whatis/

† https://www.cdc.gov/dialysis/pdfs/BSI-NHSN-2014to2019-508.pdf

dialysis-related infections among adult Black patients and older Hispanic patients (aged >60 years) (*14*), the association among hemodialysis-related infections, race and ethnicity, and social determinants of health is largely undescribed. To identify groups experiencing high numbers and risk of infections and to determine which preventive interventions should be prioritized, this study used a national facility-level reporting system and a laboratory- and population-based surveillance network to understand markers of disparities in the risk for *S. aureus* bloodstream infections in hemodialysis patients. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[§]

Methods

NHSN. *S. aureus* bloodstream infection was defined as a new positive blood culture test result reported from outpatient dialysis facilities during 2020. Dialysis facilities report bloodstream infections and vascular access in place at the time of event as well as monthly denominator data (patient-months summed from patients who received treatment during the first 2 working days of each month) by vascular access type.[¶] Bloodstream infections and patient-months were categorized by type of vascular access: CVC, fistula, and graft or other. Facility-specific characteristics were reported through 2020 annual survey data. CDC/ATSDR SVI data from 2018 were linked to the facility at the county level (*15*).

A total of 7,097 dialysis facilities were included in this analysis. Incidences for *S. aureus* bloodstream infections were created by pooling events as the numerator and patient-months as the denominator for each vascular access type as reported by each facility. A statistical model[**] was used to assess potential associations between the main outcome of facility *S. aureus* bloodstream infection incidence with patient vascular access type and selected dialysis facility characteristics, including those related to infection control practices (45 variables), and SVI data (20 variables) (*15*).[††] All analyses were conducted using SAS software (version 9.4; SAS Institute).

EIP. *S. aureus* bloodstream infection data among adult hemodialysis patients (aged ≥18 years) from CDC's EIP surveillance in selected counties from seven sites (selected counties within each state) during 2017–2020 were analyzed; data on race and ethnicity were included.[§§] Sites, case definitions, and methodology have been described previously (*12*). EIP site staff members geocoded patient addresses to U.S. Census Bureau tracts, which were then linked to selected socioeconomic status (SES) factors for these tracts (i.e., measures of poverty, crowding, and education).[¶¶]

Unadjusted *S. aureus* bloodstream infection rates were calculated for hemodialysis patients and the general population (adults not on hemodialysis) for the surveillance area. EIP *S. aureus* bloodstream infection data were used as the numerator for calculating rates. The denominators for *S. aureus* bloodstream infection rates among hemodialysis patients were obtained as follows: for each year of data, aggregated county-level denominator data on the number of hemodialysis patients (number of hemodialysis patients as of December 31 of the preceding calendar year) were obtained from USRDS. USRDS provided the data stratified by sex, age group (18–49, 50–64, and ≥65 years), race and ethnicity, and vascular access type (analyzed as CVC versus fistula or graft) for each year. The denominator for calculating *S. aureus* bloodstream infection rates among the general population was obtained by subtracting the hemodialysis population from the total population of the surveillance area. Population totals for the entire surveillance catchment area (i.e., including persons not receiving dialysis) were obtained from U.S. Census Bureau data.[***]

[§] 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.

[¶] https://www.cdc.gov/nhsn/dialysis/event/index.html

[**] *S. aureus* bloodstream infection incidence was modeled using forward stagewise negative binomial regression. Akaike and Bayesian information criteria and Wald and likelihood ratio chi-square tests were used to evaluate model fit. The best candidate model was validated using bootstrap resampling methods and independently assessed by two separate analysts. Univariate analyses were also performed using the model.

[††] The SVI data set included 15 individual vulnerability subthemes, four summary themes, and one overall vulnerability index score. The method of SVI scoring involves ranking U.S. counties and assigning each one a percentile, ranging from 0 to 100, where a higher value represents greater vulnerability. SVI variables were assessed as quartiles, and all other continuous variables were assessed as deciles, quintiles, quartiles, tertiles, and at the median.

[§§] Race and ethnicity were categorized as Black, Hispanic, White, and other (which includes patients with more than one race recorded). Missing race (255, 9.1%) and ethnicity (310, 11.0%) information were imputed using the respective proportions of Black, Hispanic, and White persons in the U.S. Census Bureau tract population where the patient lived and the distribution of race and ethnicity among dialysis patients with known race and ethnicity by age group, sex, and county; 10 imputed data sets were created. Descriptive results involving race and ethnicity report the mean aggregated across all 10 imputation data sets; for multivariable modeling, the SAS MIANALYZE procedure was used to incorporate results from modeling the 10 imputation data sets.

[¶¶] Measures of SES included the following: 1) percentage of population living below the poverty level, 2) percentage of households with crowding (more than one occupant per room), 3) percentage of adults aged ≥25 years with less than a high school education, using 2015–2019 (for 2017–2019 cases) or 2016–2020 (for 2020 cases) 5-year U.S. Census Bureau American Community Survey data (https://www.census.gov/programs-surveys/acs). U.S. Census Bureau tracts under surveillance were grouped by quartile for each measure of SES factors, and the number of *S. aureus* bloodstream infections occurring in tracts within each quartile of SES factors was described.

[***] USRDS data were requested from and provided by USRDS (https://usrds.org). U.S. Census Bureau data were obtained from National Center for Health Statistics bridged-race vintage postcensal files. https://www.cdc.gov/nchs/nvss/bridged_race.htm

Unadjusted *S. aureus* bloodstream infection rates among hemodialysis patients were stratified by the characteristics described in the USRDS data. To handle overdispersion, negative binomial regression was performed to determine aRRs for age, race and ethnicity, sex, vascular access type, and EIP site.

Results

NHSN. During 2020, 4,840 dialysis facilities (68.2% of 7,097 reporting to NHSN) reported 14,822 bloodstream infections; *S. aureus* was isolated from 5,070 (34.2%), yielding a rate of 0.1 *S. aureus* bloodstream infections per 100 patient-months. Among reported *S. aureus* bloodstream infections, 2,602 (51.3%) were identified as methicillin-sensitive and 1,923 (37.9%) as MRSA; 545 (10.7%) had no susceptibility test results reported.

Although several statistically significant differences in facility characteristics were found in univariate analyses, the best candidate model for facility *S. aureus* bloodstream infection incidence indicated that *S. aureus* bloodstream infection risk was most strongly associated with patient vascular access type: compared with fistula access, CVC and graft or other had approximately six times (aRR = 6.2; 95% CI = 5.7–6.7) and approximately two times (aRR = 2.2; 95% CI = 2.0–2.4) higher risk, respectively (Table 1). Facility characteristics with statistically significant associations with *S. aureus* bloodstream infection incidence included any hospital affiliation (aRR = 1.5; 95% CI = 1.3–1.8), not being part of a chain of dialysis centers (aRR = 1.4; 95% CI = 1.2–1.7), not having a written antibiotic use policy (aRR = 1.3; 95% CI = 1.1–1.4), and location of the facility in an area with a higher proportion of persons aged ≥65 years (aRR = 1.4; 95% CI = 1.2–1.6; between highest quartile compared with lowest quartile) (Table 1).

EIP. During 2017–2020, 2,800 *S. aureus* bloodstream infections among hemodialysis patients were reported in the EIP surveillance areas. The overall annual *S. aureus* bloodstream infection rate was 100 times higher in hemodialysis patients (4,248 of 100,000 person-years) than among adults not on hemodialysis (42 of 100,000 person-years). U.S. Census Bureau tracts with lower SES factors accounted for disproportionately higher proportions of hemodialysis-associated *S. aureus* bloodstream infections (Figure 1). For example, 42.1% of *S. aureus* bloodstream infections among patients on hemodialysis occurred in tracts in the highest quartile of population proportion living below the poverty level, versus 10.4% in tracts in the lowest poverty quartile; similar distributions of *S. aureus* bloodstream infections according to crowding and educational levels also occurred. The overall population for the surveillance area was distributed relatively equally across tract-based quartiles for each of the SES factors examined.

TABLE 1. Independent factors associated with dialysis-associated *Staphylococcus aureus* bloodstream infection incidence* — National Healthcare Safety Network, United States, 2020

Characteristic	Likelihood ratio test†		aRR (95% CI)	p-value
	Chi-square	p-value		
Vascular access type§				
Central venous catheter	2,090.2	<0.001	6.2 (5.7–6.7)	<0.001
Graft or other			2.2 (2.0–2.4)	<0.001
Fistula			Ref	—
Location/Hospital affiliation¶				
Hospital**	113.0	<0.001	1.5 (1.3–1.8)	<0.001
Freestanding			Ref	—
Member of group or chain of dialysis centers¶				
No	111.7	<0.001	1.4 (1.2–1.7)	<0.001
Yes			Ref	—
Written antibiotic use policy¶				
No	35.1	<0.001	1.3 (1.1–1.4)	<0.001
Yes			Ref	—
Quartile of % of persons aged ≥65 yrs††				
Quartile 4: 75–100 (highest)	54.3	<0.001	1.4 (1.2–1.6)	<0.001
Quartile 3: 50–74			1.3 (1.2–1.5)	<0.001
Quartile 2: 25–49			1.3 (1.2–1.4)	<0.001
Quartile 1: 0–24 (lowest)			Ref	—

Abbreviations: aRR = adjusted rate ratio; ATSDR = Agency for Toxic Substances and Disease Registry; NHSN = National Healthcare Safety Network; Ref = referent group; SVI = Social Vulnerability Index.

* Negative binomial regression was used to fit this multivariate model.

† Likelihood ratio test evaluates whether a factor is statistically significantly associated with *Staphylococcus aureus* bloodstream infection incidence. Additionally, Akaike and Bayesian information criteria and Wald and likelihood ratio chi-square tests were used to evaluate model fit. The best candidate model was validated using bootstrap resampling methods and independently assessed by two separate analysts.

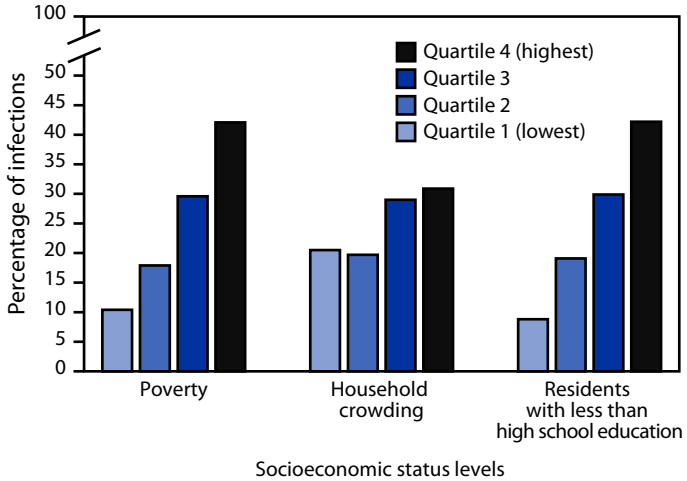
§ Source of data was NHSN event surveillance.

¶ Source of data was NHSN Outpatient Dialysis Center Practices Survey. https://www.cdc.gov/nhsn/forms/57.500_outpatientdialysissurv_blank.pdf

** Location could be a hospital or a freestanding location owned by a hospital.

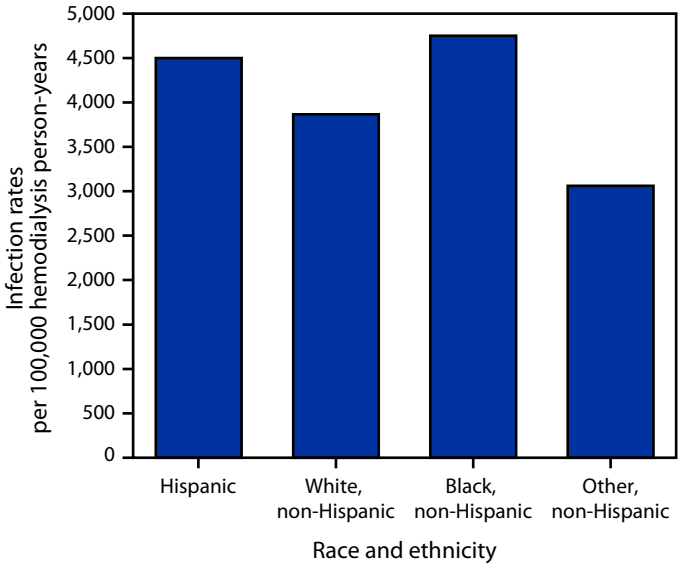
†† Source of data was CDC/ATSDR SVI.

FIGURE 1. Percentage distribution of *Staphylococcus aureus* hemodialysis bloodstream infections among adult hemodialysis patients, by socioeconomic status levels of U.S. Census Bureau tracts of residence — Emerging Infections Program, United States, 2017–2020



Unadjusted rates of *S. aureus* bloodstream infection were higher among Black and Hispanic hemodialysis patients (Figure 2) (Table 2). Other variables with higher rates included male sex, younger age groups, CVC access, and specific surveillance sites. The highest rates occurred among Black patients aged 18–49 years; 65% of bloodstream infections in this age, race, and ethnicity subgroup involved CVCs, which represented the highest prevalence of CVC use among the age, race, and ethnicity groups with bloodstream infections (range = 29%–65%). Multivariable analyses demonstrated that Hispanic ethnicity (aRR = 1.4; 95% CI = 1.2–1.7), male sex (aRR = 1.2; 95% CI = 1.1–1.4), younger age groups (patients aged 18–49 years [aRR = 1.7; 95 CI = 1.5–1.9] and patients aged 50–64 years [aRR = 1.2; 95% CI = 1.1–1.4] compared with patients aged ≥65 years), and specific sites were independent factors associated with higher bloodstream infection rates. However, CVC access had the strongest effect of all factors assessed. Black patients did not have significantly elevated risk when accounting for access type, age, sex, and EIP site. The proportion of hemodialysis patients who received a CVC was higher among White patients (23.1%) and Black patients (20.8%) than among Hispanic patients (13.9%).

FIGURE 2. *Staphylococcus aureus* bloodstream infection rates* per 100,000 hemodialysis person-years, by race and ethnicity† — Emerging Infections Program, United States, 2017–2020



* Unadjusted rates presented.
† Race and ethnicity were categorized as non-Hispanic Black or African American (Black), Hispanic or Latino (Hispanic), non-Hispanic White, and non-Hispanic other (includes patients with more than one race recorded).

Discussion

Although hemodialysis bloodstream infections have decreased since 2014 with the widespread implementation of evidence-based prevention strategies in dialysis facilities (e.g., staff and patient education, CVC care practices, observations of infection prevention practices, and surveillance for infections), *S. aureus* bloodstream infections remain an important cause of morbidity in hemodialysis patients, with rates 100 times higher in hemodialysis patients than among adults not on hemodialysis during 2017–2020. Although vascular access type was the factor most strongly associated with *S. aureus* bloodstream infections, disparities by race, ethnicity, and SES were also observed.

Although it is well established that race, ethnicity, and social determinants of health affect the development of ESKD and treatment options (*1*–*3*), how they relate to dialysis-related infection risk has not been as well described. In this study, the higher unadjusted *S. aureus* bloodstream infection rates observed in Black and Hispanic patients support the higher infection risk described in other published reports (*13*,*14*). However, whereas higher crude rates were observed in Black patients in the current study, race was not a statistically significant factor in multivariable analyses, suggesting the higher unadjusted rate might be mediated by other factors; in contrast, Hispanic ethnicity was independently associated with a 40% higher risk for *S. aureus* bloodstream infection. Although the effect of insurance status and lower SES could not be analyzed in the multivariable model in this report, disproportionately higher numbers of hemodialysis patients with *S. aureus* bloodstream infections lived in U.S. Census Bureau tracts with higher poverty, more household crowding, and lower education levels. These findings suggest that Black and Hispanic dialysis patients have higher rates of *S. aureus* bloodstream infections, and that lower SES might also be related to development of *S. aureus* bloodstream infections.

Although CVC vascular access, a known major risk factor for hemodialysis bloodstream infections (*11*) was most strongly associated with *S. aureus* bloodstream infections independent of race, ethnicity, and SES, potentially important associations between race and ethnicity and vascular access type used should also be considered. For example, recent national data suggest that initiation of hemodialysis with a CVC does not vary substantially by race, ethnicity, or SES (*1*), although other studies have shown associations among Black race, Hispanic ethnicity, poverty, insurance status, and shorter duration of pre-ESKD care with lower initiation with fistula (*16*–*18*). In the current study, despite having a 40% higher risk for *S. aureus* bloodstream infections, EIP Hispanic hemodialysis patients had a lower proportion of CVC use, which along with recent national data (*1*), suggest that CVC use is unlikely to be the only factor mediating this increased *S. aureus* bloodstream infection risk. Duration of CVC use might also be important; one study found that Black and Hispanic incident hemodialysis

TABLE 2. *Staphylococcus aureus* bloodstream infections associated with hemodialysis — Emerging Infections Program,* United States, 2017–2020

Characteristic	Univariate analysis			Multivariable analysis	
	No. of *S. aureus* bloodstream infections	No. of patient-years	Unadjusted rate†	aRR§ (95% CI)	p-value
Age groups, yrs¶					
18–49	736	11,848	6,212	1.7 (1.5–1.9)	<0.001
50–64	993	22,312	4,451	1.2 (1.1–1.4)	<0.001
≥65	1,071	31,758	3,372	Ref	—
Sex					
Female	1,112**	28,239	3,938	Ref	—
Male	1,685	37,679	4,472	1.2 (1.1–1.4)	<0.001
EIP site					
California	822	23,478	3,501	1.1 (0.9–1.4)	0.19
Connecticut	182	4,404	4,133	1.2 (1.0–1.5)	0.12
Georgia	393	6,218	6,320	2.0 (1.6–2.5)	<0.001
Maryland	741	15,022	4,933	1.4 (1.1–1.7)	0.003
New York	242	5,024	4,817	1.3 (1.0–1.6)	0.05
Tennessee	183	4,190	4,368	1.2 (1.0–1.5)	0.12
Minnesota	237	7,582	3,126	Ref	—
Race and ethnicity††					
Black, non-Hispanic	1,509	31,762	4,751	1.1 (0.9–1.2)	0.40
Hispanic	321	7,122	4,500	1.4 (1.2–1.7)	<0.001
White, non-Hispanic	687	17,764	3,866	Ref	—
Other, non-Hispanic	284	9,270	3,061	1.0 (0.8–1.2)	0.92
Vascular access types§§					
Central venous catheter	1,444	11,963	12,071	4.3 (3.9–4.8)	<0.001
Fistula or graft	1,303	48,631	2,679	Ref	—
Total	**2,800**	**65,918**	**4,248**	—	—

Abbreviations: aRR = adjusted rate ratio; EIP = Emerging Infections Program; Ref = referent group; *S. aureus* = *Staphylococcus aureus*.

* EIP data for January 1, 2017–December 31, 2020.

† Per 100,000 hemodialysis person-years.

§ Adjusted for age, race and ethnicity, sex, vascular access type, and EIP site as appropriate.

¶ The median age of patients with hemodialysis *S. aureus* bacterial infection was 60 years (IQR = 49–70 years); the median age of those aged 18–49 years was 41 years.

** Sex was unknown for three patients.

†† Race and ethnicity were categorized as non-Hispanic Black or African American (Black), Hispanic or Latino (Hispanic), non-Hispanic White, and non-Hispanic other (includes patients with more than one race recorded). Race and ethnicity case counts are averaged over 10 imputations to account for missing values of race and ethnicity. The total sums to >2,800 because of rounding.

§§ Fifty-three cases had unknown vascular access type. The denominator includes 5,324 hemodialysis patient-years with unknown vascular access type.

patients aged ≥65 years have longer use of CVC access compared with White patients, with Black patients spending on average approximately 40 more days on CVC, and Hispanic patients and those of other races spending 20–30 more days (*19*). Other mediating factors might include how patients with CVCs are educated about CVC care or what resources are available for such care. Although more data are needed to better define these factors, further reducing rates of CVC use among those at most risk is an important step in reducing *S. aureus* bloodstream infections.

The complex relationships among age, race and ethnicity, social determinants of health, and hemodialysis-associated infection risk warrant additional study. In particular, strengthening hemodialysis bloodstream infection surveillance to more comprehensively assess social determinants of health would improve understanding of risk and address some of the limitations of this report, which is subject to at least two. First, analyses of 2020 NHSN facility–reported bloodstream infection data relied on linkage with ecologic 2018 SVI data that were not patient-specific and could not be summarized below the county level. This limited the strength of conclusions that could be drawn from small but statistically significant associations of bloodstream infection rates with facility characteristics such as location in areas with higher percentages of older adults. Similarly, it is unclear whether the associations observed between bloodstream infection rates and dialysis facility affiliation or having a written antibiotic use policy are related to facility organizational structure and staffing, reporting practices, or other infection control policies. Second, and in contrast to NHSN analyses, EIP data were available on patient age, race, and ethnicity, but bloodstream infection rates by SES factors could not be calculated because U.S. Census Bureau tract–level denominator data were unavailable. Instead, the number of bloodstream infections by tract quartiles for different SES factors were calculated. These and other differences between NHSN and EIP surveillance design, including

differing case ascertainment methodologies, reflect different primary surveillance purposes that have led to relatively lower bloodstream infection case estimates in NHSN (*20*). Overall, improved surveillance through closer linkage of existing relevant data sources and more granular surveillance data capture (e.g., patient-level information about access type, race and ethnicity, and SES), especially through automated reporting, would provide additional insight to address health disparities through specific public health interventions without increasing reporting responsibilities for health care providers.

Because disparities can affect ESKD development, access to treatment options, and risk of hemodialysis bloodstream infections, a comprehensive approach to preventive care that recognizes racial, ethnic, and socioeconomic disparities is needed. This approach could include continued efforts to prevent and improve management of underlying conditions such as diabetes and hypertension, improved access to care for prevention and early recognition and treatment of chronic kidney disease, and increased availability of optimal treatments for ESKD, particularly in areas of lower SES. In addition, the use of cultural- and language-appropriate patient education might help patients in the care of dialysis access and infection prevention, which might be especially relevant for Hispanic patients given the higher *S. aureus* bloodstream infection risk observed in Hispanic persons (*3*). Given the importance of CVC use as a risk factor, further investigation of the determinants of CVC use and duration including possible disparities by population subgroups is needed and could further minimize CVC use and address possible barriers to lower-risk access types. Regardless, education and implementation of established best practices to prevent bloodstream infections[†††] are critical to protecting the entire hemodialysis patient community, including those most at risk.

[†††] https://www.cdc.gov/dialysis/prevention-tools/core-interventions.html

Summary

What is already known about this topic?

Racial and ethnic minorities are disproportionately affected by end-stage kidney disease (ESKD), and patients on dialysis are at increased risk for *Staphylococcus aureus* bloodstream infections. Hemodialysis access type is a well-established risk factor for bloodstream infections, with central venous catheters having the highest associated risk.

What is added by this report?

Although vascular access type was the major risk factor for hemodialysis-associated *S. aureus* bloodstream infections, race, ethnicity, and socioeconomic factors also affected infection rates and distribution, with Hispanic or Latino ethnicity as an independent risk factor.

What are the implications for public health practice?

Health care providers should prioritize prevention and optimized treatment of ESKD, identify and address barriers to lower-risk vascular access placement, and implement established best practices to prevent bloodstream infections.

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Notes from the Field

Recent Changes in Suicide Rates, by Race and Ethnicity and Age Group — United States, 2021

Deborah M. Stone, ScD[1]; Karin A. Mack, PhD[1]; Judith Qualters, PhD[1]

Suicide is a serious public health problem in the United States. After 2 consecutive years of declines in suicide (47,511 in 2019 and 45,979 in 2020), 2021 data indicate an increase in suicide to 48,183, nearly returning to the 2018 peak (48,344) with an age-adjusted rate of 14.1 suicides per 100,000 population (versus 14.2 in 2018).* To understand how this increase is distributed across racial and ethnic groups, CDC analyzed changes in racial and ethnic age-adjusted and age-specific suicide rates during 2018–2021.

Suicides were identified from the National Vital Statistics System multiple cause-of-death mortality files for 2018–2021. Age-adjusted rates and 95% CIs were calculated using the direct method and the 2000 U.S. standard population. Hispanic or Latino (Hispanic) persons could be of any race, and racial groups excluded persons of Hispanic ethnicity. Persons with unknown ethnicity were excluded from race and ethnicity groups but were included in the overall total. Differences in rates from 2018 to 2021 were compared using z-tests when deaths were ≥100; p-values <0.05 were considered statistically significant. When deaths were <100, differences in rates were considered significant if CIs based on a gamma distribution did not overlap. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.†

Age-adjusted 2021 suicide rates were highest among non-Hispanic American Indian or Alaska Native (AI/AN) persons (28.1 per 100,000) overall; this group also experienced the highest relative percentage change during 2018–2021 (from 22.3 to 28.1 per 100,000; a 26% increase) (Table). Age-adjusted rates also increased significantly among non-Hispanic Black or African American (Black) persons (from 7.3 to 8.7; a 19.2% increase) and for Hispanic persons (from 7.4 to 7.9; a 6.8% increase) during 2018–2021. Non-Hispanic White (White) persons were the only group to show an overall age-adjusted rate decline compared with that in 2018 (from 18.1 to 17.4; a 3.9% decline).

Suicide rates among persons aged 10–24 years increased significantly during 2018–2021 among Black persons (from 8.2 to 11.2; a 36.6% increase). Among those aged 25–44 years, rates increased significantly overall (5%) and among AI/AN (33.7%), Black (22.9%), Hispanic (19.4%), and non-Hispanic multiracial (20.6%) persons during the examined period. Rates among persons aged 45–64 years decreased significantly overall (–12.4%) and among non-Hispanic Asian (Asian) (–15.9%), Hispanic (–9.3%), and White persons (–11.5%). No significant changes were noted among persons aged ≥65 years.

These analyses demonstrate disparities in suicide rates among populations based on race and ethnicity and age group in the context of overall suicide rates nearly returning to their 2018 peak after 2 years of declines. Significant increases among young Black persons aged 10–24 years and across multiple racial and ethnic populations aged 25–44 years raise particular concern. Suicide is a complex problem related to multiple risk factors such as relationship, job or school, and financial problems, as well as mental illness, substance use, social isolation, historical trauma, barriers to health care, and easy access to lethal means of suicide among persons at risk (*1*). Moreover, suicide rates might be stable or even decline during a disaster, only to rise afterwards as the longer-term sequalae ensue for individual persons and within families and communities (*2*). As the nation continues to respond to the short- and long-term impacts of the COVID-19 pandemic, remaining vigilant in prevention efforts is critical, especially among disproportionately affected populations where longer-term impacts might compound preexisting inequities in suicide risk.

The findings in this report are subject to at least three limitations. First, children aged <10 years were excluded from age group category analyses because self-harm intent can be difficult to ascertain in young children (*3*). Second, age-specific rates for some racial groups could not be reported because of small numbers. Finally, racial and ethnic group designation might involve misclassification (*4*).

Research indicates that suicide is preventable through a comprehensive public health approach (*1*) that relies on data to drive decision-making, multisectoral partnerships to expand reach, and implementation and evaluation of multiple culturally relevant prevention strategies. CDC's Suicide Prevention Resource for Action (*1*) supports states and communities to prioritize interventions with the best available evidence that can save lives. For persons in crisis, help is available through the U.S. Substance Abuse and Mental Health Services Administration's 988 Suicide & Crisis Lifeline (https://www.988lifeline.org or by texting or calling 988).

* https://wonder.cdc.gov/mcd-icd10-expanded.html (Accessed January 11, 2023).
† 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.

TABLE. Annual number of suicides and rates of suicide* (suicides per 100,000 population), by race and ethnicity and age group — National Vital Statistics System, United States, 2018–2021

Race and ethnicity†/Year	Total no. of deaths	Rate (95% CI)				
			Age group, yrs			
		Age-adjusted§	10–24	25–44	45–64	≥65
American Indian or Alaska Native						
2018	545	22.3 (20.4–24.2)	31.1 (26.4–35.8)	39.5 (34.7–44.3)	15.8 (12.8–19.4)	—¶
2019	546	22.5 (20.5–24.4)	29.9 (25.2–34.5)	39.3 (34.6–44.0)	16.4 (13.3–20.0)	8.0 (5.1–11.8)
2020	588	23.9 (21.9–25.9)	33.0 (28.2–37.9)	41.6 (36.7–46.4)	17.7 (14.3–21.1)	7.2 (4.6–10.9)
2021	692	28.1 (26.0–30.2)	36.3 (31.2–41.3)	52.8 (47.3–58.2)	16.4 (13.3–20.1)	10.7 (7.4–14.8)
Relative rate change, %** 2018–2021	NA	26.0††	16.7	33.7††	3.8	NA
Asian						
2018	1,315	6.7 (6.4–7.1)	8.5 (7.5–9.4)	7.2 (6.6–7.9)	8.2 (7.4–9.1)	8.0 (6.8–9.1)
2019	1,342	6.7 (6.3–7.1)	7.7 (6.8–8.6)	7.8 (7.1–8.5)	8.2 (7.3–9.0)	8.1 (7.0–9.3)
2020	1,302	6.4 (6.1–6.8)	7.4 (6.5–8.3)	7.4 (6.7–8.1)	7.6 (6.8–8.4)	8.3 (7.2–9.4)
2021	1,379	6.8 (6.4–7.1)	9.4 (8.4–10.4)	7.9 (7.2–8.6)	6.9 (6.1–7.6)	7.8 (6.7–8.8)
Relative rate change, %** 2018–2021	NA	1.5	10.6	9.7	–15.9††	–2.5
Black or African American						
2018	3,022	7.3 (7.0–7.5)	8.2 (7.6–8.8)	11.8 (11.2–12.4)	7.0 (6.5–7.5)	4.4 (3.8–5.0)
2019	3,115	7.5 (7.2–7.7)	8.5 (7.9–9.1)	12.1 (11.4–12.7)	7.1 (6.6–7.7)	4.4 (3.8–4.9)
2020	3,286	7.8 (7.5–8.1)	9.9 (9.3–10.6)	12.7 (12.1–13.3)	6.6 (6.1–7.1)	4.3 (3.7–4.9)
2021	3,692	8.7 (8.4–9.0)	11.2 (10.5–11.9)	14.5 (13.8–15.2)	6.8 (6.3–7.3)	4.4 (3.9–5.0)
Relative rate change, %** 2018–2021	NA	19.2††	36.6††	22.9††	–2.9	0
Hispanic or Latino						
2018	4,313	7.4 (7.2–7.7)	7.3 (6.9–7.8)	10.3 (9.8–10.8)	8.6 (8.1–9.1)	7.4 (6.6–8.3)
2019	4,331	7.3 (7.0–7.5)	7.5 (7.1–8.0)	10.3 (9.8–10.7)	8.5 (8.0–9.1)	5.9 (5.2–6.6)
2020	4,571	7.5 (7.3–7.8)	7.9 (7.4–8.3)	11.3 (10.8–11.8)	7.5 (7.1–8.0)	6.9 (6.1–7.6)
2021	4,907	7.9 (7.7–8.1)	7.9 (7.4–8.3)	12.3 (11.8–12.8)	7.8 (7.3–8.3)	6.9 (6.2–7.7)
Relative rate change, %** 2018–2021	NA	6.8††	8.2	19.4††	–9.3††	–6.8
Native Hawaiian or other Pacific Islander						
2018	73	11.9 (9.3–15.0)	—¶	21.7 (15.6–29.4)	—¶	—¶
2019	90	14.4 (11.5–17.7)	16.6 (10.3–25.3)	25.9 (19.2–34.2)	—¶	—¶
2020	79	12.5 (9.9–15.6)	18.9 (12.1–28.1)	18.9 (13.3–26.0)	—¶	—¶
2021	82	12.6 (10.0–15.7)	16.2 (10.0–24.8)	22.7 (16.6–30.4)	—¶	—¶
Relative rate change, %** 2018–2021	NA	5.9	NA	4.6	NA	NA
White						
2018	38,415	18.1 (17.9–18.3)	12.9 (12.5–13.2)	23.3 (22.9–23.7)	26.1 (25.6–26.5)	20.7 (20.2–21.1)
2019	37,428	17.7 (17.5–17.9)	12.0 (11.6–12.4)	23.0 (22.6–23.5)	25.3 (24.9–25.7)	20.4 (20.0–20.8)
2020	35,442	16.9 (16.7–17.0)	12.0 (11.6–12.3)	22.7 (22.2–23.1)	22.6 (22.2–23.0)	19.7 (19.2–20.1)
2021	36,681	17.4 (17.3–17.6)	12.4 (12.0–12.8)	23.3 (22.9–23.7)	23.1 (22.7–23.5)	20.9 (20.4–21.3)
Relative rate change, %** 2018–2021	NA	–3.9††	–3.9	0	–11.5††	1.0

See table footnotes on the next page.

TABLE. (*Continued*) Annual number of suicides and rates of suicide* (suicide deaths per 100,000 population), by race and ethnicity and age group — National Vital Statistics System, United States, 2018–2021

Race and ethnicity†/Year	Total no. of deaths	Rate (95% CI)				
			Age group, yrs			
		Age-adjusted§	10–24	25–44	45–64	≥65
Multiracial						
2018	514	9.0 (8.1–9.8)	7.2 (6.1–8.3)	13.1 (11.3–14.9)	11.4 (9.2–13.6)	7.2 (4.8–10.3)
2019	527	8.8 (8.0–9.6)	7.2 (6.1–8.3)	13.5 (11.8–15.2)	11.6 (9.4–13.7)	4.7 (2.8–7.2)
2020	599	9.6 (8.7–10.4)	8.0 (6.8–9.1)	15.4 (13.6–17.2)	11.3 (9.2–13.4)	5.7 (3.7–8.4)
2021	631	9.7 (8.9–10.5)	8.2 (7.0–9.3)	15.8 (14.0–17.6)	10.0 (8.1–12.1)	7.4 (5.1–10.2)
Relative rate change, %** 2018–2021	NA	7.8	13.9	20.6††	−12.3	2.8
Total§§						
2018	**48,344**	**14.2 (14.1–14.4)**	**10.7 (10.4–10.9)**	**17.9 (17.6–18.1)**	**20.1 (19.8–20.4)**	**17.4 (17.0–17.7)**
2019	**47,511**	**13.9 (13.8–14.1)**	**10.2 (10.0–10.5)**	**17.8 (17.5–18.1)**	**19.5 (19.2–19.8)**	**17.0 (16.6–17.3)**
2020	**45,979**	**13.5 (13.4–13.6)**	**10.5 (10.2–10.7)**	**17.9 (17.6–18.2)**	**17.4 (17.1–17.7)**	**16.4 (16.1–16.8)**
2021	**48,183**	**14.1 (14.0–14.2)**	**11.0 (10.8–11.3)**	**18.8 (18.5–19.1)**	**17.6 (17.3–17.9)**	**17.3 (16.9–17.6)**
Relative rate change, % 2018–2021**	**NA**	**−0.7**	**2.8**	**5.0††**	**−12.4††**	**−0.6**

Abbreviation: NA = not applicable.

* Suicide deaths were identified by using *International Classification of Diseases, Tenth Revision* underlying cause-of-death codes U03, X60–X84, and Y87.0.

† Data for Hispanic or Latino (Hispanic) origin should be interpreted with caution; studies comparing Hispanic origin on death certificates and on U.S. Census Bureau surveys have shown inconsistent reporting on Hispanic ethnicity. Potential racial misclassification might lead to underestimates for certain categories, primarily American Indian, Alaska Native, Asian, and other Pacific Islander decedents. Single-race estimates are presented and might not be comparable to earlier years produced by bridging multiple races to a single race choice. Hispanic ethnicity includes persons of any race. Racial groups exclude persons of Hispanic ethnicity. Persons with unknown ethnicity are excluded from race and ethnicity groups but are included in the overall total.

§ Age-adjusted rates (suicides per 100,000 population) were calculated using the direct method and the 2000 U.S. Census Bureau standard population.

¶ Rates are flagged as unreliable or suppressed when the rate is calculated with a numerator of <20, or the data meet the criteria for confidentiality constraints (<10 deaths).

** Relative change was calculated using the following equation: (2021 rate − 2018 rate) / 2018 rate x 100 (for significant difference during 2018–2021, p<0.05. Z-tests were used if the number of deaths was ≥100; nonoverlapping CIs based on the gamma method were used if the number of deaths was ≤100). Data were accessed on CDC WONDER on January 11, 2023.

†† Statistically significant at p<0.05.

§§ Includes decedents of unknown ethnicity.

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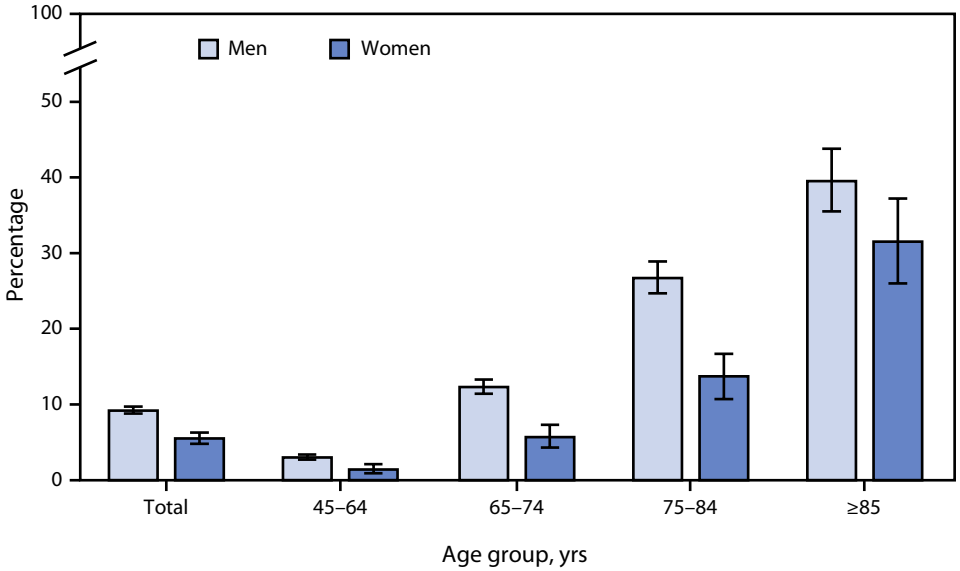
QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Adults Aged ≥45 Years Who Use a Hearing Aid,† by Sex and Age Group — National Health Interview Survey, United States, 2021§



* With 95% CIs indicated by error bars.
† Based on a positive response to the question, "Do you use a hearing aid?"
§ Estimates are based on household interviews of a sample of the civilian, noninstitutionalized U.S. population.

In 2021, among adults aged ≥45 years, men were more likely to use a hearing aid than were women (9.2% versus 5.5%). This pattern was found in all age groups: 3.0% of men versus 1.4% of women among those aged 45–64 years, 12.3% versus 5.7% among those aged 65–74 years, 26.7% versus 13.7% among those aged 75–84 years, and 39.5% versus 31.5% among those aged ≥85 years. Among both men and women, the percentage who use a hearing aid increased with age.

Sources: National Center for Health Statistics, National Health Interview Survey, 2021 (https://www.cdc.gov/nchs/nhis.htm); NCHS data brief, no. 414, 2021. https://www.cdc.gov/nchs/products/databriefs/db414.htm

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