Centers for Disease Control and Prevention
MMWR
Morbidity and Mortality Weekly Report
Weekly / Vol. 72 / No. 14
April 7, 2023

Seasonality of Respiratory Syncytial Virus — United States, 2017–2023

Sarah Hamid, PhD[1,2]; Amber Winn, MPH[2]; Rishika Parikh, MPH[2,3]; Jefferson M. Jones, MD[2]; Meredith McMorrow, MD[2]; Mila M. Prill, MSPH[2]; Benjamin J. Silk, PhD[2]; Heather M. Scobie, PhD[2]; Aron J. Hall, DVM[2]

In the United States, respiratory syncytial virus (RSV) infections cause an estimated 58,000–80,000 hospitalizations among children aged <5 years (*1*,*2*) and 60,000–160,000 hospitalizations among adults aged ≥65 years each year (*3*–*5*). U.S. RSV epidemics typically follow seasonal patterns, peaking in December or January (*6*,*7*), but the COVID-19 pandemic disrupted RSV seasonality during 2020–2022 (*8*). To describe U.S. RSV seasonality during prepandemic and pandemic periods, polymerase chain reaction (PCR) test results reported to the National Respiratory and Enteric Virus Surveillance System (NREVSS)[*] during July 2017–February 2023 were analyzed. Seasonal RSV epidemics were defined as the weeks during which the percentage of PCR test results that were positive for RSV was ≥3% (*9*). Nationally, prepandemic seasons (2017–2020) began in October, peaked in December, and ended in April. During 2020–21, the typical winter RSV epidemic did not occur. The 2021–22 season began in May, peaked in July, and ended in January. The 2022–23 season started (June) and peaked (November) later than the 2021–22 season, but earlier than prepandemic seasons. In both prepandemic and pandemic periods, epidemics began earlier in Florida and the Southeast and later in regions further north and west. With several RSV prevention products in development,[†] ongoing monitoring of RSV circulation can guide the timing of RSV immunoprophylaxis and of clinical trials and postlicensure effectiveness studies. Although the timing of the 2022–23 season suggests that seasonal patterns are returning toward those observed in prepandemic years, clinicians should be aware that off-season RSV circulation might continue.

Each week, participating clinical and public health laboratories voluntarily report to NREVSS aggregate numbers of RSV PCR tests performed and numbers of positive test results. Although antigen tests are sometimes performed, this analysis was restricted to PCR tests because they accounted for >90% of tests reported (*9*). Surveillance years were defined based on troughs in RSV circulation. During 2017–2020 (the prepandemic period), surveillance years began in early July (epidemiologic week 27) and ended the following year in late June (week 26). Because the typical winter RSV epidemic was absent during 2020–21, and the 2021–22 epidemic began in the spring, the 2021–22 and 2022–23 surveillance years (pandemic period) were defined as early March (week 9) to late February (week 8) of the following year.[§] Several methods for characterizing RSV seasonality were explored (Supplementary Table 1, https://stacks.cdc.gov/view/cdc/126381) (Supplementary Table 2, https://stacks.cdc.gov/view/cdc/126380). A 3% test positivity threshold was chosen

---

[*] https://www.cdc.gov/surveillance/nrevss/index.html

[†] https://www.path.org/resources/rsv-vaccine-and-mab-snapshot

[§] Defining surveillance year start and end dates based on troughs in RSV activity ensures that seasonal epidemics are encompassed in a 12-month period and that calculated proportions of annual detections that occur in the epidemic period are comparable over time (i.e., that the denominator for the proportion is the 12-month period between troughs in RSV circulation).

INSIDE

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

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

because it prospectively identified a high proportion of annual RSV detections during epidemic periods of moderate duration. The epidemic onset and offset (or end) weeks were defined, respectively, as the first and last of 2 consecutive weeks when the percentage of PCR tests positive for RSV was ≥3%. The epidemic duration was the inclusive number of weeks between onset and offset. The peak was defined as the week with the highest percentage of PCR tests positive for RSV.

Epidemic onset, offset, peak, and duration were identified for each season at the national level and by U.S. Department of Health and Human Services (HHS) region.¶ Because patterns of weekly RSV circulation in Alaska, Florida, and Hawaii are different from those in other states within their assigned regions (HHS Regions 10, 4, and 9, respectively), these states were excluded from regional analyses. State-level seasonality for Florida is reported; however, an insufficient number of laboratories in Alaska and Hawaii consistently reported PCR data to present state-level seasonality in those states. The analysis included data from laboratories that consistently conducted PCR testing.** This activity was conducted consistent with applicable federal law and CDC policy.††

During the period with weeks ending July 8, 2017–February 25, 2023, five distinct RSV epidemics occurred: three before the COVID-19 pandemic (2017–18, 2018–19, and 2019–20) and two during the pandemic (2021–22 and 2022–23). Using the 3% epidemic threshold, no seasonal RSV epidemic was observed to occur during the 2020–21 surveillance year (Figure 1). The number of tests performed increased substantially during the pandemic (Table).

Nationally, RSV epidemics during the 3 surveillance years preceding the COVID-19 pandemic (2017–2020) began in October, peaked in December, and lasted a median of 27 weeks before the offset during March–April (Table). In contrast, the 2021–22 epidemic began 21 weeks earlier (May), peaked in July, and lasted 33 weeks until January 2022, although the peak percentage of RSV-positive PCR results (15%) was comparable with that during prepandemic seasons (Figure 1). During the 2022–23 surveillance year, onset occurred in June, the proportion of positive PCR results peaked in November, and the peak was higher (19%) than that during prepandemic seasons (range = 13%–16%). The epidemic lasted 32 weeks until the offset occurred in January.

In both the prepandemic and pandemic periods, RSV epidemics began earliest in Florida and the Southeast and later in regions further north and west (Figure 2). During the Florida prepandemic seasons, the median onset occurred in August, the peak occurred in November, and the epidemic continued until March (median duration = 30 weeks).

¶ https://www.hhs.gov/about/agencies/iea/regional-offices/index.html

** Consistent reporting was defined by the following criteria: 1) reported RSV PCR testing results for ≥30 weeks during the 12-month surveillance year and 2) reported an average of 10 or more RSV-positive PCR tests per week during the surveillance year.

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

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

Suggested citation: [Author names; first three, then et al., if more than six.] [Report title]. MMWR Morb Mortal Wkly Rep 2023;72:[inclusive page numbers].

(Table). (Supplementary Figure, https://stacks.cdc.gov/view/cdc/126382). In the 10 HHS regions (excluding Alaska, Florida, and Hawaii), the median onset ranged from September in Region 4 to December in Region 8. The median epidemic peaks ranged from November in Region 6 to February in Regions 8 and 9. Median offsets ranged from March in Region 5 to May in Region 7; offsets occurred 2–6 weeks earlier during the 2019–20 surveillance year (i.e., when the COVID-19 pandemic began) compared with the preceding 2 surveillance years. The shortest epidemic periods occurred in Region 10 (median = 21 weeks), and the longest occurred in Region 4 (median = 27 weeks).

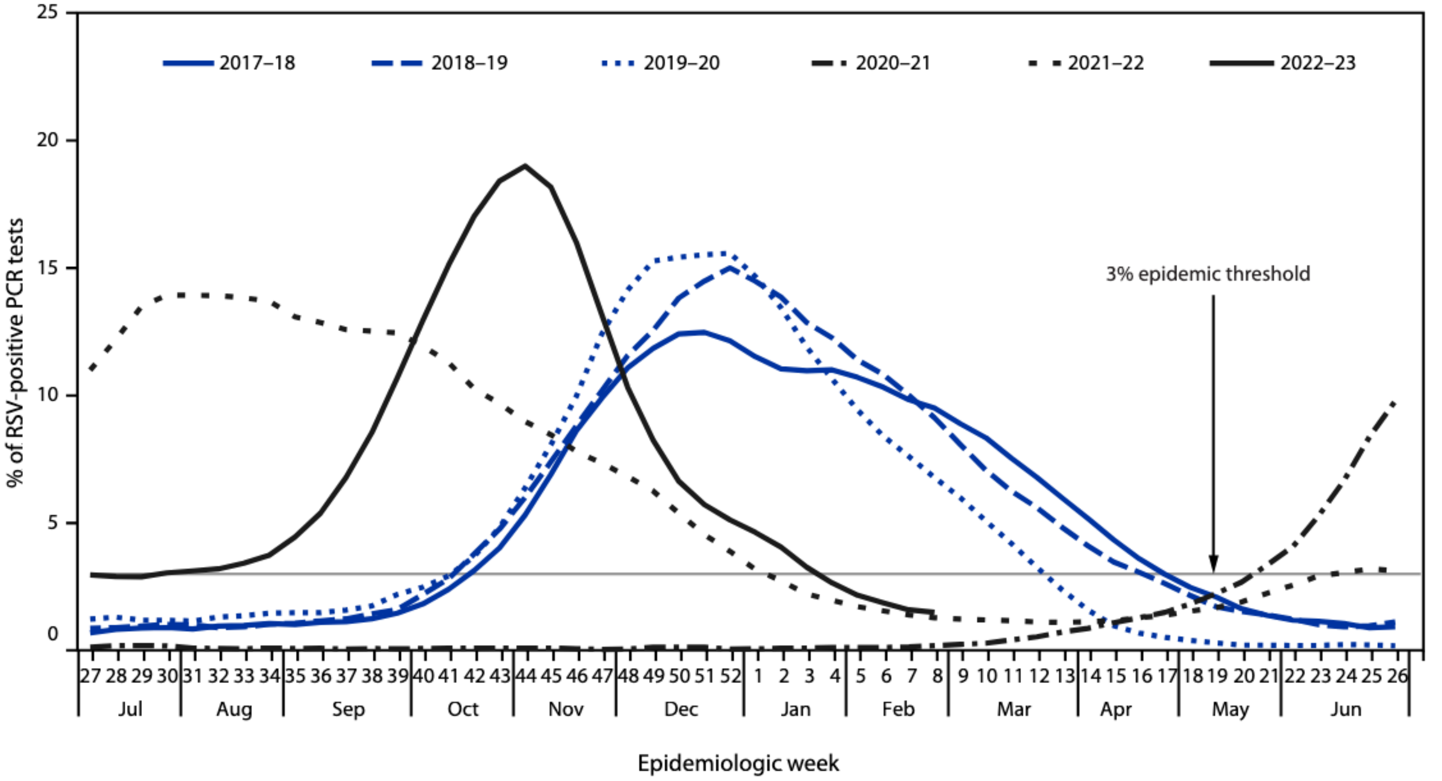
During the 2021–22 (pandemic) surveillance year, epidemic onsets across the 10 HHS regions and Florida occurred a median of 20 weeks earlier (range = 13–25 weeks) than the median onsets during the prepandemic period (range = March [Florida] to August [Region 10]). Epidemic peaks also occurred earlier than they did during the prepandemic years, ranging from July in Region 6 to December in Region 10. Offsets ranged from November (Region 4) to February (Region 9), which is when prepandemic peaks typically occurred. During the 2021–22 surveillance year, the epidemic durations were a median of 6 weeks longer than the median durations of prepandemic RSV epidemics (range = 21 weeks [Region 2] to 38 weeks [Florida]).

During the 2022–23 season, early epidemic onsets (April–June) were observed in Florida and HHS Regions 3, 4, and 6, but the percentage of RSV-positive PCR test results levelled off before increasing again in September (Figure 1) (Table). In other regions, epidemics began between August and October. Seasons peaked from October in Region 4 to November in regions further north and west (Regions 2, 8, 9, and 10). Epidemics ended between December and February.

Discussion

In the United States, disruption of the seasonal circulation of RSV was observed during the COVID-19 pandemic as nonpharmaceutical interventions (e.g., school closures and masking) reduced respiratory virus transmission and led to an accumulation of susceptible persons resulting in large epidemics with atypical seasonality (*10*). After the implementation of nonpharmaceutical interventions in March 2020, the 2019–20

FIGURE 1. Percentage* of polymerase chain reaction test results positive for respiratory syncytial virus, by epidemiologic week — National Respiratory and Enteric Virus Surveillance System, United States, July 2017–February 2023



Abbreviations: PCR = polymerase chain reaction; RSV = respiratory syncytial virus.

* Three-week centered moving averages of percentage of RSV-positive PCR test results nationally. The threshold for a seasonal epidemic was set at 3% RSV-positive PCR test results (not based on a moving average).

TABLE. Summary of respiratory syncytial virus seasons, by U.S. Department of Health and Human Services Region* and in Florida — National Respiratory and Enteric Virus Surveillance System, July 2017–February 2023[†]

HHS region (headquarters) or state, RSV season	No. of laboratories reporting	No. of tests performed	Onset epidemiologic week[§] (mo)	Peak epidemiologic week[¶] (mo)	Offset epidemiologic week** (mo)	Epidemic duration, no. of wks[††]	% of annual detections in epidemic period[§§]
National							
2017–18	**130**	**810,977**	**42 (Oct)**	**51 (Dec)**	**16 (Apr)**	**27**	**96**
2018–19	**138**	**816,512**	**41 (Oct)**	**51 (Dec)**	**16 (Apr)**	**28**	**95**
2019–20	**166**	**999,493**	**42 (Oct)**	**51 (Dec)**	**12 (Mar)**	**23**	**95**
2021–22	**196**	**1,849,047**	**21 (May)**	**30 (Jul)**	**1 (Jan)**	**33**	**92**
2022–23	**221**	**3,160,659**	**24 (Jun)**	**44 (Nov)**	**3 (Jan)**	**32**	**92**
Region 1 (Boston)							
2017–18	9	38,902	44 (Nov)	52 (Dec)	17 (Apr)	26	97
2018–19	10	39,951	45 (Nov)	52 (Dec)	15 (Apr)	23	94
2019–20	12	53,441	44 (Nov)	52 (Dec)	12 (Mar)	21	96
2021–22	11	70,122	25 (Jun)	36 (Sep)	51 (Dec)	27	90
2022–23	10	184,128	35 (Sep)	44 (Nov)	50 (Dec)	16	81
Region 2 (New York City)							
2017–18	8	52,010	43 (Oct)	1 (Jan)	13 (Mar)	23	93
2018–19	9	62,066	44 (Nov)	51 (Dec)	13 (Mar)	22	89
2019–20	13	100,384	43 (Oct)	49 (Dec)	10 (Mar)	20	90
2021–22	9	186,986	30 (Jul)	39 (Oct)	50 (Dec)	21	78
2022–23	11	286,733	38 (Sep)	45 (Nov)	51 (Dec)	14	74
Region 3 (Philadelphia)							
2017–18	11	55,660	42 (Oct)	52 (Dec)	14 (Apr)	25	94
2018–19	9	46,260	43 (Oct)	49 (Dec)	13 (Mar)	23	93
2019–20	13	63,745	43 (Oct)	1 (Jan)	9 (Feb)	19	90
2021–22	16	85,062	24 (Jun)	34 (Aug)	52 (Jan)	29	92
2022–23	13	142,867	23 (Jun)	42 (Oct)	3 (Jan)	33	95
Region 4 (Atlanta)							
2017–18	9	55,316	40 (Oct)	51 (Dec)	14 (Apr)	27	92
2018–19	9	59,747	38 (Sep)	52 (Dec)	13 (Mar)	28	92
2019–20	11	60,429	38 (Sep)	48 (Nov)	9 (Feb)	24	92
2021–22	11	130,818	14 (Apr)	30 (Jul)	47 (Nov)	34	86
2022–23	13	267,547	21 (May)	40 (Oct)	50 (Dec)	30	89
Region 5 (Chicago)							
2017–18	33	201,222	44 (Nov)	50 (Dec)	17 (Apr)	26	95
2018–19	35	185,950	41 (Oct)	1 (Jan)	12 (Mar)	24	92
2019–20	51	273,402	42 (Oct)	51 (Dec)	11 (Mar)	22	93
2021–22	68	462,017	24 (Jun)	33 (Aug)	49 (Dec)	26	86
2022–23	81	725,015	32 (Aug)	44 (Nov)	2 (Jan)	23	90
Region 6 (Dallas)							
2017–18	16	128,254	40 (Oct)	48 (Dec)	17 (Apr)	30	97
2018–19	16	123,577	40 (Oct)	47 (Nov)	13 (Mar)	26	94
2019–20	17	131,460	40 (Oct)	48 (Nov)	11 (Mar)	24	95
2021–22	22	300,954	20 (May)	28 (Jul)	1 (Jan)	34	96
2022–23	21	355,621	17 (Apr)	41 (Oct)	3 (Jan)	39	95
Region 7 (Kansas City)							
2017–18	8	24,443	46 (Nov)	7 (Feb)	20 (May)	27	97
2018–19	9	32,138	46 (Nov)	52 (Dec)	18 (May)	25	97
2019–20	9	36,150	43 (Oct)	51 (Dec)	13 (Mar)	23	97
2021–22	14	120,813	21 (May)	33 (Aug)	51 (Dec)	31	91
2022–23	29	247,426	36 (Sep)	44 (Nov)	2 (Jan)	19	88
Region 8 (Denver)							
2017–18	9	55,535	48 (Dec)	7 (Feb)	17 (Apr)	22	96
2018–19	9	57,877	48 (Dec)	5 (Feb)	18 (May)	23	97
2019–20	11	64,399	46 (Nov)	4 (Jan)	14 (Apr)	21	97
2021–22	10	119,298	26 (Jul)	39 (Oct)	1 (Jan)	28	92
2022–23	9	115,584	39 (Oct)	45 (Nov)	5 (Feb)	19	90
Region 9 (San Francisco)							
2017–18	11	121,569	47 (Nov)	6 (Feb)	16 (Apr)	22	97
2018–19	8	108,118	48 (Dec)	6 (Feb)	17 (Apr)	22	97
2019–20	8	108,085	47 (Nov)	1 (Jan)	13 (Mar)	19	96
2021–22	9	163,200	29 (Jul)	49 (Dec)	6 (Feb)	30	98
2022–23	9	473,657	37 (Sep)	45 (Nov)	4 (Jan)	20	91

See table footnotes on the next page.

TABLE. (*Continued*) Summary of respiratory syncytial virus seasons, by U.S. Department of Health and Human Services Region* and in Florida — National Respiratory and Enteric Virus Surveillance System, July 2017–February 2023[†]

HHS region (headquarters) or state, RSV season	No. of laboratories reporting	No. of tests performed	Onset epidemiologic week[§] (mo)	Peak epidemiologic week[¶] (mo)	Offset epidemiologic week** (mo)	Epidemic duration, no. of wks[††]	% of annual detections in epidemic period[§§]
Region 10 (Seattle)							
2017–18	8	56,212	47 (Nov)	4 (Jan)	15 (Apr)	21	96
2018–19	15	74,851	47 (Nov)	6 (Feb)	17 (Apr)	23	95
2019–20	13	74,837	46 (Nov)	52 (Dec)	12 (Mar)	19	95
2021–22	18	154,248	34 (Aug)	50 (Dec)	5 (Feb)	24	94
2022–23	20	228,081	39 (Oct)	45 (Nov)	5 (Feb)	19	90
Florida							
2017–18	6	20,224	32 (Aug)	46 (Nov)	9 (Mar)	30	87
2018–19	7	24,390	29 (Jul)	45 (Nov)	13 (Mar)	37	91
2019–20	5	28,626	33 (Aug)	48 (Nov)	7 (Feb)	27	88
2021–22	5	43,340	12 (Mar)	23 (Jun)	49 (Dec)	38	90
2022–23	2	68,801	18 (May)	40 (Oct)	3 (Jan)	38	90

Abbreviations: HHS = U.S. Department of Health and Human Services; PCR = polymerase chain reaction; RSV = respiratory syncytial virus.

* https://www.hhs.gov/about/agencies/iea/regional-offices/index.html. Patterns of weekly RSV circulation in Alaska, Florida, and Hawaii are distinct from other states within their assigned regions (HHS regions 10, 4, and 9, respectively); therefore, these states were excluded from regional analyses. State-level seasonality for Florida is reported; however, there are an insufficient number of laboratories consistently reporting RSV PCR data to present state-level seasonality in Alaska and Hawaii.

[†] Because the typical seasonal RSV epidemic was notably absent during the 2020–21 surveillance year, data from this surveillance year are not shown. Surveillance years were defined based on troughs in RSV circulation. During 2017–2020, surveillance years began in epidemiologic week 27 (early July) and ended the following year in epidemiologic week 26 (late June). During the COVID-19 pandemic (2021–22 and 2022–23), surveillance years began in epidemiologic week 9 (early March) and ended the following year in epidemiologic week 8 (late February).

[§] The epidemic onset was defined as the first of 2 consecutive weeks when the percentage of PCR tests positive for RSV was ≥3%.

[¶] The epidemic peak was defined as the week with the highest percentage of PCR tests positive for RSV.

** The epidemic offset was defined as the last of 2 consecutive weeks when the percentage of PCR tests positive for RSV was ≥3%.

[††] The epidemic duration was the inclusive number of weeks between onset and offset.

[§§] Annual percentage of detections in the epidemic period was defined as the proportion of all detections during a surveillance year that occurred during the epidemic period.

RSV epidemic ended earlier than the previous two epidemics. During 2020, RSV circulated at historically low levels. In 2021, RSV circulation began earlier (in late spring), when nonpharmaceutical interventions eased, and continued longer than it did during prepandemic years, although the percentage of RSV-positive PCR tests at the peak was comparable to those during prepandemic years. The 2022–23 epidemic began later than the 2021–22 epidemic but earlier than prepandemic epidemics, suggesting a reversion toward prepandemic seasonality with winter peaks. The peak percentage of positive RSV test results was higher than those in previous years, suggesting higher intensity of circulation. Across both prepandemic and pandemic years, RSV circulation began in Florida and the Southeast and later in regions to the north and west. The consistency of this pattern could help predict the timing of future epidemics in specific regions.

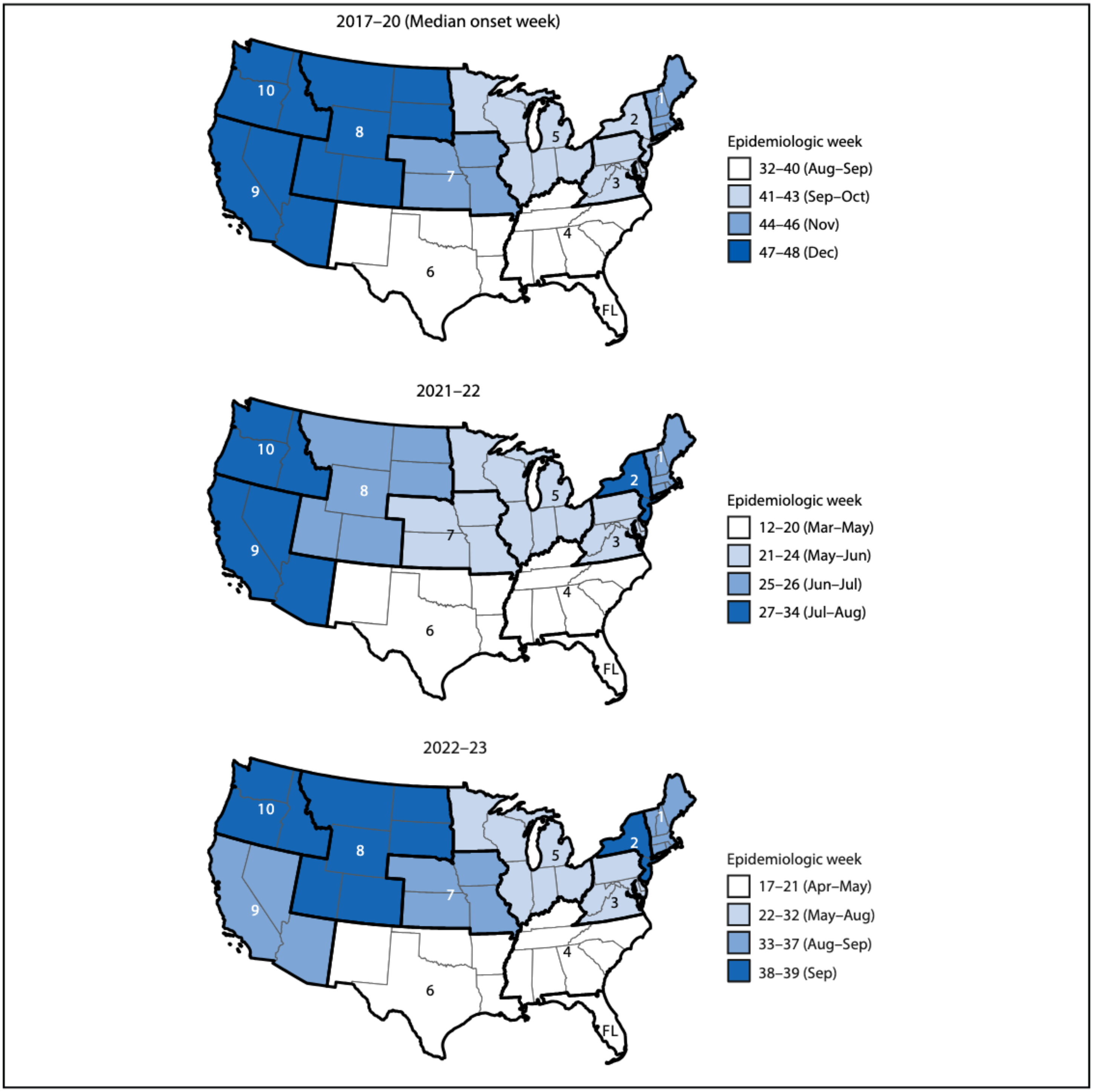
The findings in this report are subject to at least four limitations. First, reporting to NREVSS is voluntary, and analysis is limited to laboratories that consistently report, which might not represent local and state circulation. Second, differences in testing across regions and changes in testing practices and diagnostics over time, including increased panel testing during the COVID-19 pandemic, could have affected the baseline percentage of positive test results and trends, and thus the onset, offset, and duration of epidemics. Third, there is no standard method for characterizing seasonality; seasonal attributes vary depending on the method used. An earlier description of RSV seasonality in the United States used a more sensitive method (retrospective slope 10[§§]) that can only be applied retrospectively and results in longer epidemic durations (*6*,*9*). However, the 3% RSV-positive PCR threshold used in the current analysis can be applied in near real time and identified epidemic periods that included a high concentration of detections (*9*). Finally, this analysis describes regional and national trends; locally available data and region-specific thresholds might better reflect circulation patterns within specific jurisdictions.

Although the peak in RSV circulation during November 2022 suggests that seasonal patterns are returning to those observed in prepandemic years, it is uncertain whether this reversion will continue in the upcoming surveillance year. To monitor RSV circulation, CDC has conducted year-round surveillance using a variety of approaches including active, population-based surveillance for RSV-associated hospitalizations

---

[§§] Retrospective slope 10 is a method for retrospectively characterizing RSV seasons that captures a high percentage of PCR detections. It uses a centered 5-week moving average of RSV detections normalized to a season peak of 1,000 detections. The season onset is defined as the second of 2 consecutive weeks when the slope, or normalized 5-week moving average of RSV detections between subsequent weeks, exceeds 10. The season offset is the last week when the standardized (normalized) detections exceed the standardized detections at onset.

FIGURE 2. Respiratory syncytial virus epidemic onsets[*] in U.S. Department of Health and Human Services Regions 1–10[†] and in Florida — National Respiratory and Enteric Virus Surveillance System, United States, July 2017–February 2023[§]



Abbreviations: FL = Florida; RSV = respiratory syncytial virus.

[*] The epidemic onset was defined as the first of 2 consecutive weeks of a surveillance year when the percentage of PCR tests positive for RSV was ≥3%. Median epidemic onset weeks were calculated for the three RSV epidemics that occurred before the COVID-19 pandemic (2017–18, 2018–19, and 2019–20).

[†] https://www.hhs.gov/about/agencies/iea/regional-offices/index.html. Patterns of weekly RSV circulation in Alaska, Florida, and Hawaii are distinct from other states within their assigned regions; therefore, these states were excluded from regional analyses. State-level seasonality for Florida is reported; however, there are an insufficient number of laboratories consistently reporting polymerase chain reaction testing data to present state-level seasonality in Alaska and Hawaii.

[§] Surveillance years were defined based on troughs in RSV circulation. During 2017–2020, surveillance years began in epidemiologic week 27 (early July) and ended the following year in epidemiologic week 26 (late June). The aberrant 2020–21 surveillance year was defined as week 27 through week 8 (late February) inclusive. During the COVID-19 pandemic (2021–22 and 2022–23), surveillance years began in epidemiologic week 9 (early March) and ended the following year in epidemiologic week 8.

Summary

What is already known about this topic?

In the United States, the timing of seasonal respiratory syncytial virus (RSV) epidemics (October–April) was disrupted during the COVID-19 pandemic.

What is added by this report?

RSV circulation was historically low during 2020–21 and began earlier and continued longer during 2021–22 than during prepandemic seasons. The 2022–23 season started later than the 2021–22 season but earlier than prepandemic seasons, suggesting a return toward prepandemic seasonality.

What are the implications for public health practice?

Ongoing monitoring of RSV seasonality can guide the timing of immunoprophylaxis and evaluation of new immunization products. Although an eventual return to prepandemic RSV seasonality is expected, clinicians should be aware that off-season RSV circulation might continue.

and outpatient visits.¶¶ Clinicians should be aware that atypical RSV epidemics might continue and consider testing patients for multiple respiratory pathogens when indicated. With new prevention products nearing licensure, including vaccines for older adults, maternal vaccines, and long-acting RSV immunoprophylaxis for infants and children, policy makers should consider RSV seasonality when making recommendations about the timing of studies and administration of new immunization and other RSV prevention products.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflicts of interest were disclosed.

References

1. Hall CB, Weinberg GA, Iwane MK, et al. The burden of respiratory syncytial virus infection in young children. N Engl J Med 2009;360:588–98. PMID:19196675 https://doi.org/10.1056/NEJMoa0804877
2. McLaughlin JM, Khan F, Schmitt HJ, et al. Respiratory syncytial virus-associated hospitalization rates among US infants: a systematic review and meta-analysis. J Infect Dis 2022;225:1100–11. PMID:33346360 https://doi.org/10.1093/infdis/jiaa752
3. McLaughlin JM, Khan F, Begier E, Swerdlow DL, Jodar L, Falsey AR. Rates of medically attended RSV among US adults: a systematic review and meta-analysis. Open Forum Infect Dis 2022;9:ofac300. PMID:35873302 https://doi.org/10.1093/ofid/ofac300
4. Zheng Z, Warren JL, Shapiro ED, Pitzer VE, Weinberger DM. Estimated incidence of respiratory hospitalizations attributable to RSV infections across age and socioeconomic groups. Pneumonia 2022;14:6. PMID:36280891 https://doi.org/10.1186/s41479-022-00098-x
5. Havers FP, Whitaker M, Pham H, et al. 2209. RSV-associated hospitalizations in adults aged ≥18 years and the impact of the COVID-19 pandemic in the United States, October 2018–February 2022. Open Forum Infect Dis 2022;9(Suppl 2):ofac492.1828. https://doi.org/10.1093/ofid/ofac492.1828
6. Rose EB, Wheatley A, Langley G, Gerber S, Haynes A. Respiratory syncytial virus seasonality—United States, 2014–2017. MMWR Morb Mortal Wkly Rep 2018;67:71–6. PMID:29346336 https://doi.org/10.15585/mmwr.mm6702a4
7. Haynes AK, Prill MM, Iwane MK, Gerber SI; CDC. Respiratory syncytial virus—United States, July 2012–June 2014. MMWR Morb Mortal Wkly Rep 2014;63:1133–6. PMID:25474034
8. Olsen SJ, Winn AK, Budd AP, et al. Changes in influenza and other respiratory virus activity during the COVID-19 pandemic—United States, 2020–2021. MMWR Morb Mortal Wkly Rep 2021;70:1013–9. PMID:34292924 https://doi.org/10.15585/mmwr.mm7029a1
9. Midgley CM, Haynes AK, Baumgardner JL, et al. Determining the seasonality of respiratory syncytial virus in the United States: the impact of increased molecular testing. J Infect Dis 2017;216:345–55. PMID:28859428 https://doi.org/10.1093/infdis/jix275
10. Baker RE, Park SW, Yang W, Vecchi GA, Metcalf CJE, Grenfell BT. The impact of COVID-19 nonpharmaceutical interventions on the future dynamics of endemic infections. Proc Natl Acad Sci U S A 2020;117:30547–53. PMID:33168723 https://doi.org/10.1073/pnas.2013182117

¶¶ The Respiratory Syncytial Virus Hospitalization Surveillance Network conducts active, population-based surveillance for laboratory-confirmed RSV-associated hospitalizations (https://www.cdc.gov/rsv/research/rsv-net/dashboard.html). The New Vaccine Surveillance Network conducts active, population-based surveillance for RSV-associated acute respiratory illness among children in outpatient, emergency department, and hospital settings at seven U.S. medical centers. https://www.cdc.gov/surveillance/nvsn/index.html

Corresponding author: Sarah Hamid, tsl4@cdc.gov.

---

[1]Epidemic Intelligence Service, CDC; [2]Coronavirus and Other Respiratory Viruses Division, National Center for Immunizations and Respiratory Diseases, CDC; [3]Goldbelt C6, Chesapeake, Virginia.

Widespread Community Transmission of Hepatitis A Virus Following an Outbreak at a Local Restaurant — Virginia, September 2021–September 2022

Meagan J. Helmick, PhD[1]; Cynthia B. Morrow, MD[2]; J. Hope White, MPH[2]; Paige Bordwine, MPH[1]

Hepatitis A is a vaccine-preventable liver infection caused by the hepatitis A virus (HAV); it is transmitted through ingestion of food or drink that has been contaminated by small amounts of infected stool, or through direct contact, including sexual contact, with a person who is infected (*1*). After years of historically low rates of hepatitis A in the United States, the incidence began increasing in 2016, with outbreaks characterized by person-to-person HAV transmission among persons who use drugs, persons experiencing homelessness, and men who have sex with men (*2,3*). As of September 2022, 13 states were experiencing outbreaks, including Virginia (*3*). In September 2021, the Roanoke City and Alleghany Health Districts (RCAHD) in southwestern Virginia investigated an outbreak of hepatitis A. The outbreak, which resulted in 51 cases, 31 hospitalizations, and three deaths, was associated with a food handler who was infected. After the outbreak, the community experienced ongoing person-to-person transmission of HAV, predominantly among persons who use injection drugs. As of September 30, 2022,* an additional 98 cases had been reported to RCAHD. The initial outbreak and community transmission have exceeded US$3 million in estimated direct costs (*4,5*). This report describes the initial outbreak and the ongoing community transmission of HAV. Increasing vaccination coverage among persons with risk factors for hepatitis A infection is important, including among those who use drugs. Strengthening community partnerships between public health officials and organizations that employ persons with risk factors for acquisition of HAV could help to prevent infections and outbreaks.

Initial Outbreak Investigation (September–November 2021)

RCAHD serves a population of approximately 280,000 persons. The districts have previously experienced a low hepatitis A incidence, with only six cases reported during January 1, 2019–December 31, 2020, and none through August 2021. In mid-September 2021, however, five hepatitis A cases were reported during a single week. Initial case investigations identified a local restaurant chain as a common source of exposure. Further investigation identified the index patient as an unvaccinated food handler who had risk factors for hepatitis A and who had worked at three locations of the same restaurant chain; however, this person delayed seeking medical attention for more than 2 weeks after symptom onset and did not disclose being employed as a food handler at that time. Based on the index patient's symptom onset date and last day worked, the exposure period for patrons who ate at any of the three restaurants was determined to be August 10–26, 2021. When the outbreak investigation was closed on November 20, 2021, 51 restaurant-associated cases had been identified (Figure).† The median patient age was 64 years (range = 30–86 years) (Table).

Sustained Community Transmission (Ongoing)

In October 2021, RCAHD began to receive reports of hepatitis A cases that were not directly associated with the index patient or restaurant outbreak. By the end of 2021, 13 additional cases were reported to RCAHD. Sustained community transmission continued into 2022, with 98 total cases reported through September 2022, including 64 hospitalizations (Figure). An identical genotype IB sequence was identified in eight of the nine specimens submitted from the restaurant outbreak and from all five sequenced community case specimens.

Although a clear temporal association between the restaurant outbreak and two of the community cases was demonstrated, limited contact information for most of the persons with community-acquired cases hampered the ability to conclusively identify an epidemiologic link between the restaurant outbreak and sustained person-to-person community transmission. Among the 98 cases, only 40 (40.8%) patients were interviewed by public health officials, either because of insufficient contact information (57) or refusal to be interviewed (one). Public health officials conducted a comprehensive medical record review of all cases to identify patient risk factors, contacts, and exposures. Among persons with community-acquired cases, the most commonly identified hepatitis A risk factors were any drug use (85.7%) (including injection drug use [74.5%]) and experiencing homelessness (12.2%) (Table).

---

* During October 1, 2022–March 31, 2023, seven additional hepatitis A cases were identified in association with this outbreak.

† A restaurant-associated case of hepatitis A was defined as an illness meeting the Council of State and Territorial Epidemiologists (CSTE) confirmed case criteria (https://ndc.services.cdc.gov/case-definitions/hepatitis-a-acute-2019/) in a person who dined at any of the three restaurant locations during August 10–26, 2021, or who had close contact with the index patient. A community-acquired case of hepatitis A was defined as an illness meeting the CSTE confirmed case criteria of hepatitis A in a person who did not dine at any of the restaurants during the exposure period, and had no contact with a patient who did dine at any of the restaurants during September 2021–September 2022.

Public Health Response

When the restaurant chain was identified as a common risk during the initial outbreak, RCAHD's environmental health specialists performed risk assessments at each site and determined that the index patient had ungloved-hand contact with ready-to-eat foods while infectious. RCAHD personnel worked with the restaurant's management and the state health department to coordinate risk communication.[§] The first press release was issued on September 24, 2021, recommending that persons with symptoms consistent with hepatitis A seek medical care. Because restaurant exposure was identified outside the 2-week period during which postexposure prophylaxis (PEP) with hepatitis A vaccine or immune globulin is recommended, PEP was not advised for the public. Although RCAHD encouraged and facilitated hepatitis A vaccination for employees of the affected restaurants and close contacts of patients, including providing on-site vaccinations, fewer than 20% of eligible employees were vaccinated.

Similar public health responses were implemented in 2022 when three hepatitis A cases were diagnosed in local restaurant workers. Throughout 2022, RCAHD partnered with community-based organizations to increase education about hepatitis A and access to the hepatitis A vaccine for persons at risk for acquiring HAV. By September 30, 2022, >2,500 hepatitis A vaccine doses had been administered through these efforts.

The financial toll of these outbreaks has exceeded US$3 million in estimated direct costs for hospitalizations ($16,232 per hospitalization), one liver transplant ($1,427,805), and hepatitis A vaccines[¶] (*4,5*). This estimate does not include indirect costs such as personnel costs or missed wages for patients (*4,5*).

Discussion

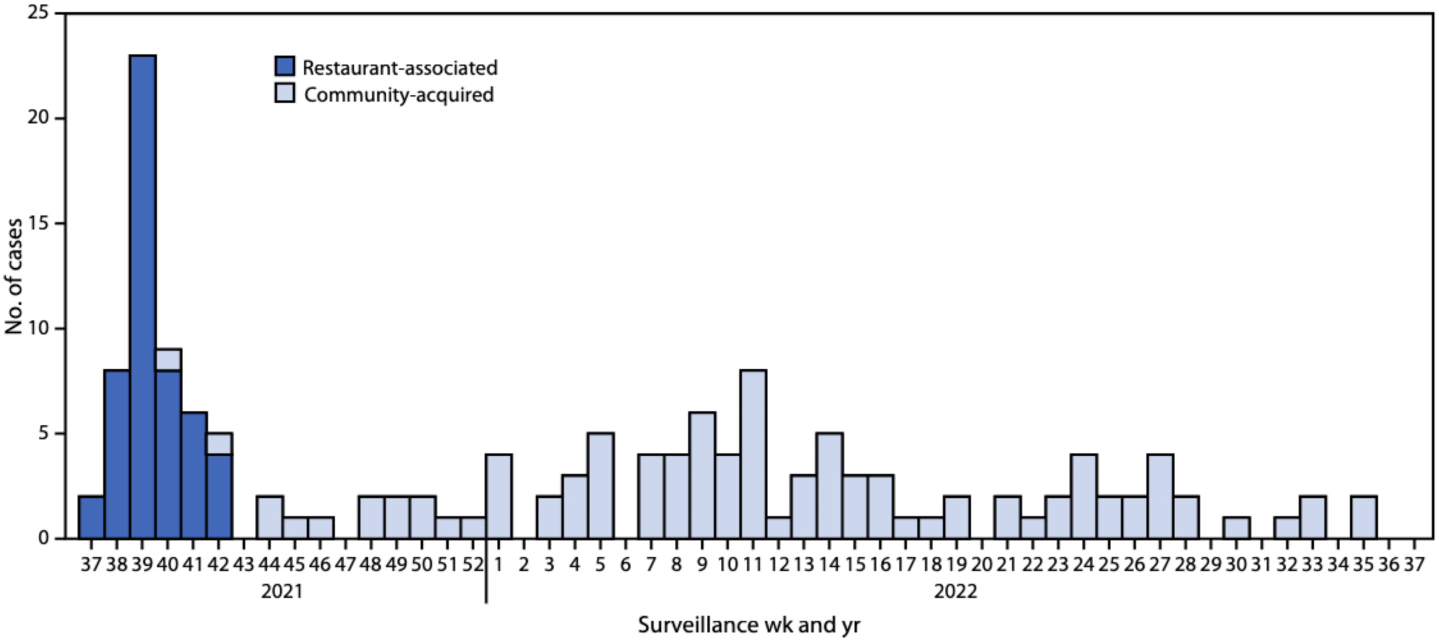
In hepatitis A outbreaks, rapid source identification is critical to interrupting transmission. In this outbreak, RCAHD quickly identified the source; however, because of the long incubation period (15–50 days), a delay in the index patient's seeking medical attention, and that person not disclosing their occupation during the initial interview, widespread transmission, resulting in 51 cases, 31 hospitalizations, and three deaths, had already occurred. The severity of outcomes associated with the restaurant-associated outbreak was likely due to a

---

[§] https://www.vdh.virginia.gov/news/2020-regional-news-releases/health-alert-potential-hepatitis-a-exposure-at-local-restaurant/

[¶] https://www.cdc.gov/vaccines/programs/vfc/awardees/vaccine-management/price-list/index.html (Accessed October 17, 2022).

FIGURE. Confirmed hepatitis A cases (N = 149), by surveillance week of diagnosis and outbreak classification* — Virginia, September 2021–September 2022



Abbreviation: CSTE = Council of State and Territorial Epidemiologists.

* A restaurant-associated case of hepatitis A was defined as an illness meeting the CSTE confirmed-case criteria (https://ndc.services.cdc.gov/case-definitions/hepatitis-a-acute-2019/) in a person who dined at any of the three restaurant locations during August 10–26, 2021, or who had close contact with the index patient. A community-acquired case of hepatitis A was defined as an illness meeting the CSTE confirmed-case criteria of hepatitis A in a person who did not dine at any of the restaurants during the exposure period, and had no contact with a patient who did dine at any of the restaurants during September 2021–September 2022.

combination of the high median patient age and prevalence of comorbidities.

The unvaccinated index patient in this outbreak had risk factors for which hepatitis A vaccine is routinely recommended. Hepatitis A vaccines are safe and effective and became part of the routine childhood vaccination schedule in 2006 (*6*). Current adult vaccination recommendations focus on "any person who requests vaccination" (*7*) and disproportionately affected populations that include persons who use drugs, men who have sex with men, persons experiencing homelessness, and international travelers. In the United States during 2011–2016, approximately two thirds of persons who reported injection drug use (67%) and men who have sex with men (64%) reported that they had not been vaccinated against hepatitis A (*8*).

TABLE. Characteristics of restaurant-associated and community-acquired hepatitis A cases* — Virginia, 2021–2022

Characteristic	No. (%) of cases Restaurant-associated (n = 51)	 Community-acquired (n = 98)
Demographic/Comorbidity		
Median age, yrs (range)	64 (30–86)	40 (24–89)
Male	29 (56.9)	55 (56.1)
Non-Hispanic	51 (100.0)	96 (98.0)
White	50 (98.0)	88 (90.0)
Reported diabetes	11 (21.6)	4 (4.1)
Signs and symptoms		
Abdominal pain	22 (43.1)	59 (60.2)
Anorexia	28 (54.9)	18 (18.4)
Arthritis	3 (5.9)	0 (—)
Chills	11 (21.6)	15 (15.3)
Dark-colored urine	36 (70.6)	33 (33.7)
Diarrhea	15 (29.4)	11 (11.2)
Fatigue or malaise	44 (86.3)	37 (37.8)
Fever	26 (51.0)	17 (17.4)
Itching	5 (10.0)	3 (3.1)
Jaundice	27 (52.9)	53 (54.1)
Light or clay stools	14 (27.5)	12 (12.2)
Muscle aches	14 (27.5)	10 (10.2)
Nausea	38 (74.5)	54 (55.1)
Sweats	5 (10.0)	1 (1.0)
Vomiting	20 (39.2)	38 (38.8)
Weight loss	6 (11.8)	3 (3.1)
Outcomes		
Hospitalized	31 (60.8)	64 (65.3)
Died from illness	3 (5.9)	0 (—)
Received liver transplant	1 (2.0)	0 (—)
Risk factors		
Homelessness	0 (—)	12 (12.2)
Any drug use	2 (3.9)	84 (85.7)
Injection drug use	0 (—)	73 (74.5)
Noninjection drug use	2 (3.9)	69 (70.4)
Male-to-male sexual contact	2 (3.9)	1 (1.0)
Incarceration	0 (—)	8 (8.2)

* Missing data were treated as "no" for the purpose of analysis.

Despite the association of drug use with widespread U.S. hepatitis A outbreaks, vaccination efforts targeting persons who use drugs is challenging for many reasons, including behavioral health issues, limited engagement in health care systems, and transportation problems (*9*). A 2013 Substance Abuse and Mental Health Services Administration study found that, among industries, the restaurant industry had the highest rates of drug use, with nearly 20% of food service workers reporting drug use during the preceding month (*10*). In 2019, the U.S. food industry employed 15.3 million persons, suggesting that nearly 3 million food industry workers might be using drugs.** To improve hepatitis A vaccination coverage among persons who use drugs, public health agencies can explore partnerships with businesses that might employ persons at higher risk for hepatitis A. Persons who use drugs might not disclose being in a high-risk category recommended for hepatitis A vaccination, but might consider vaccination if encouraged by their employer. Health care professionals and public health officials should continue to encourage vaccination among disproportionately affected populations.

The findings in this report are subject to at least four limitations. First, the initial outbreak began during the COVID-19 Delta variant surge, and community transmission of HAV continued during the Omicron variant surge. Pandemic-related response activities in the community might have resulted in underreporting of cases. Second, extensive media coverage of the hepatitis A outbreak might have increased hepatitis A testing in the community, leading to more diagnoses of cases not associated with the outbreak. Third, RCAHD encountered challenges to interviewing patients, which could have resulted in underreporting of risk factors, epidemiologic links, and specific symptoms. This underreporting limited RCAHD's ability to identify direct epidemiologic linkages between restaurant-associated cases and subsequent community transmission. Finally, because the specific genotype IB sequence identified in these outbreaks is not uncommon, a causal association between the restaurant outbreak and the ongoing person-to-person transmission could not be established.

After years of limited HAV transmission in the Roanoke, Virginia area, hepatitis A cases increased sharply in the community following an initial outbreak associated with an unvaccinated food handler with hepatitis A risk factors. Increasing awareness of risk factors for hepatitis A, particularly among food handlers, and increasing vaccine access for persons at risk, particularly those who use drugs, could help prevent similar outbreaks in other communities.

** https://restaurant.org/getmedia/21a36a65-d5d4-41d0-af5c-737ab545d65a/nra-data-brief-restaurant-employee-demographics-march-2022.pdf

Summary

What is already known about this topic?

U.S. hepatitis A incidence has been increasing since 2016.

What is added by this report?

In 2021, a hepatitis A outbreak in Virginia traced to an unvaccinated food handler resulted in 51 cases, 31 hospitalizations, and three deaths. As of September 30, 2022, an additional 98 community hepatitis A cases had been reported in the Roanoke City and Alleghany Health Districts.

What are the implications for public health practice?

Public health partnerships with businesses and other community partners (e.g., harm reduction programs) might increase hepatitis A vaccination among persons at risk for this infection, while also reducing the stigmatization of hepatitis A-associated risk factors.

Acknowledgment

Megan G. Hofmeister, CDC.

Corresponding author: Meagan J. Helmick, Meagan.helmick@vdh.virginia.gov.

---

[1]Division of Surveillance and Investigation, Office of Epidemiology, Virginia Department of Health; [2]Roanoke City and Alleghany Health Districts, Virginia Department of Health.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflicts of interest were disclosed.

References

1. Foster MA, Haber P, Nelson NP. Epidemiology and prevention of vaccine-preventable diseases: hepatitis A [Chapter 9]. In: Hall E, Wodi AP, Hamborsky J, Morelli V, Schillie S, eds. Epidemiology and prevention of vaccine-preventable diseases. 14th ed. Atlanta, GA: US Department of Health and Human Services, CDC; 2021. https://www.cdc.gov/vaccines/pubs/pinkbook/hepa.html
2. CDC. Viral hepatitis: person-to-person outbreaks of hepatitis A across the United States. Atlanta, GA: US Department of Health and Human Services, CDC; 2017. Accessed October 17, 2022. https://www.cdc.gov/hepatitis/outbreaks/2017March-HepatitisA.htm
3. CDC. Viral hepatitis: hepatitis A outbreaks in the United States. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. Accessed October 17, 2022. https://www.cdc.gov/hepatitis/outbreaks/hepatitisaoutbreaks.htm
4. Habka D, Mann D, Landes R, Soto-Gutierrez A. Future economics of liver transplantation: a 20-year cost modeling forecast and the prospect of bioengineering autologous liver grafts. PLoS One 2015;10:e0131764. PMID:26177505 https://doi.org/10.1371/journal.pone.0131764
5. Hofmeister MG, Yin S, Aslam MV, Teshale EH, Spradling PR. Hepatitis A hospitalization costs, United States, 2017. Emerg Infect Dis 2020;26:1040–1. PMID:32310068 https://doi.org/10.3201/eid2605.191224
6. Advisory Committee on Immunization Practices. Fiore AE, Wasley A, Bell BP. Prevention of hepatitis A through active or passive immunization: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2006. MMWR Recomm Rep 2006;55(No. RR-7):1–23. PMID:16708058
7. Nelson NP, Weng MK, Hofmeister MG, et al. Prevention of hepatitis A virus infection in the United States: recommendations of the Advisory Committee on Immunization Practices, 2020. MMWR Recomm Rep 2020;69(No. RR-5):1–38. PMID:32614811 https://doi.org/10.15585/mmwr.rr6905a1
8. Yin S, Barker L, Ly KN, et al. Susceptibility to hepatitis A virus infection in the United States, 2007–2016. Clin Infect Dis 2020;71:e571–9. PMID:32193542 https://doi.org/10.1093/cid/ciaa298
9. Peak CM, Stous SS, Healy JM, et al. Homelessness and hepatitis A—San Diego County, 2016–2018. Clin Infect Dis 2020;71:14–21. PMID:31412358 https://doi.org/10.1093/cid/ciz788
10. Bush DM, Lipari RN. Substance use and substance use disorder by industry. In: Park-Lee E, Hedden SL, Lipari RN, eds. Suicidal thoughts and behavior in 33 metropolitan statistical areas update 2013 to 2015. The CBHSQ Report. Rockville, Maryland: US Department of Health and Human Services, Substance Abuse and Mental Health Services Administration; 2015. https://www.ncbi.nlm.nih.gov/books/NBK343542/

Update on Vaccine-Derived Poliovirus Outbreaks — Worldwide, January 2021–December 2022

John Paul Bigouette, PhD[1]; Elizabeth Henderson[2]; Mohamed A. Traoré[3]; Steven G. F. Wassilak, MD[1]; Jaume Jorba, PhD[2]; Frank Mahoney, MD[1]; Omotayo Bolu, PhD[1]; Ousmane M. Diop, PhD[3]; Cara C. Burns, PhD[2]

Circulating vaccine-derived poliovirus (cVDPV) outbreaks* can occur when oral poliovirus vaccine (OPV, containing one or more Sabin-strain serotypes 1, 2, and 3) strains undergo prolonged circulation in under-vaccinated populations, resulting in genetically reverted neurovirulent virus (*1*,*2*). Following declaration of the eradication of wild poliovirus type 2 in 2015 and the global synchronized switch from trivalent OPV (tOPV, containing Sabin-strain types 1, 2, and 3) to bivalent OPV (bOPV, containing types 1 and 3 only) for routine immunization activities† in April 2016 (*3*), cVDPV type 2 (cVDPV2) outbreaks have been reported worldwide (*4*). During 2016–2020, immunization responses to cVDPV2 outbreaks required use of Sabin-strain monovalent OPV2, but new VDPV2 emergences could occur if campaigns did not reach a sufficiently high proportion of children. Novel oral poliovirus vaccine type 2 (nOPV2), a more genetically stable vaccine than Sabin OPV2, was developed to address the risk for reversion to neurovirulence and became available in 2021. Because of the predominant use of nOPV2 during the reporting period, supply replenishment has frequently been insufficient for prompt response campaigns (*5*). This report describes global cVDPV outbreaks during January 2021–December 2022 (as of February 14, 2023) and updates previous reports (*4*). During 2021–2022, there were 88 active cVDPV outbreaks, including 76 (86%) caused by cVDPV2. cVDPV outbreaks affected 46 countries, 17 (37%) of which reported their first post-switch cVDPV2 outbreak. The total number of paralytic cVDPV cases during 2020–2022 decreased by 36%, from 1,117 to 715; however, the proportion of all cVDPV cases that were caused by cVDPV type 1 (cVDPV1) increased from 3% in 2020 to 18% in 2022, including the occurrence of cocirculating cVDPV1 and cVDPV2 outbreaks in two countries. The increased proportion of cVDPV1 cases follows a substantial decrease in global routine immunization coverage and suspension of preventive immunization campaigns during the COVID-19 pandemic (2020–2022) (*6*); outbreak responses in some countries were also suboptimal. Improving routine immunization coverage, strengthening poliovirus surveillance, and conducting timely and high-quality supplementary immunization activities (SIAs) in response to cVDPV outbreaks are needed to interrupt cVDPV transmission and reach the goal of no cVDPV isolations in 2024.

cVDPV Outbreaks

Poliovirus outbreaks are considered interrupted by the World Health Organization (WHO) International Health Regulations Emergency Committee on International Poliovirus Transmission when ≥13 months have passed since the onset of paralysis in the latest case or isolation sample date (*4*). A total of 172 cVDPV outbreaks have been reported since 2016, 88 (51%) of which were active during 2021–2022 (Table 1). Among these, transmission was interrupted in 38 (42%) active outbreaks (Supplementary Table, https://stacks.cdc.gov/view/cdc/126383). This report does not describe 84 (49%) cVDPV outbreaks in which transmission was interrupted before 2021.

cVDPV1 Outbreaks

Since 2016, 14 cVDPV1 outbreaks from 12 emergences§ have been reported across 10 countries. Nine of these 14 outbreaks were active in five countries (Democratic Republic of the Congo [DRC], Madagascar, Malawi, Mozambique, and Yemen) during 2021–2022, including five new cVDPV1 outbreaks detected in four countries (DRC, Madagascar, Malawi, and Mozambique) (Table 1) (Supplementary Table, https://stacks.cdc.gov/view/cdc/126383). During 2022, acute flaccid paralysis (AFP) surveillance detected 127 paralytic cases, representing a 263% increase from 35 in 2020 and a 694% increase from 16 in 2021.

---

* By genomic sequence analysis of the region encoding capsid viral protein 1 (VP1), a poliovirus with >1% divergence from the parent Sabin strain for serotypes 1 and 3, or >0.6% for serotype 2 is classified as a VDPV. Evidence of circulation (i.e., a cVDPV outbreak) occurs when two or more independent detections of genetically linked VDPVs are identified through AFP surveillance, environmental surveillance, or from healthy community members.

† In April 2016, all OPV-using countries withdrew tOPV from routine immunization activities and switched to bOPV. Each OPV serotype induced protection against paralysis and poliovirus transmission. Monovalent OPV type 2 (mOPV2), tOPV (when there is cocirculation), and novel OPV type 2 (nOPV2) are reserved for use in cVDPV2 outbreak response SIA. At least 1 dose of injectable inactivated poliovirus vaccine (IPV) is included in routine immunization. IPV induces production of antibodies that protect a person against paralysis from all three poliovirus serotypes, but it does not stop poliovirus transmission.

§ VDPV emergences are defined by shared genetic changes in the VP1 capsid region from the parental OPV strain, not genetically related to previous VDPV detections. If an emergence group poliovirus is imported into other countries identified by one or more detections, those are considered additional outbreaks.

Since September 2020, Madagascar has experienced ongoing cVDPV1 transmission, with 13 cases detected during 2021 and 2022. Among three outbreaks active during 2021 (MAD-SUO-1, MAD-SUE-1, and MAD-ANO-1), the latest detection in the MAD-SUO-1 outbreak occurred in February 2021) (Supplementary Table, https://stacks.cdc.gov/view/cdc/126383) (*4*). An additional emergence (MAD-ANO-2) was confirmed in February 2022. DRC detected two cVDPV1 outbreaks in 2022 (RDC-TAN-1 in September and RDC-HLO-3 in November), totaling 91 cases by December and accounting for 72% of the global cVDPV1 cases in 2022. DRC also has concurrent cVDPV2 outbreaks.

TABLE 1. Ongoing circulating vaccine-derived poliovirus outbreaks detected (N = 50), by serotype, emergence group, detection source, and other selected characteristics — worldwide, January 2021–December 2022

WHO Region	Country	cVDPV emergence designation[*]	Years detected	No. of detections (source)[†]			% VP1 genome region divergence from Sabin-strain poliovirus[¶]	Outbreak confirmation date	Most recent case/ positive specimen from healthy child/ environmental sample[**]
				AFP cases	Other human sources (non-AFP)[§]	ES			
cVDPV type 1 outbreaks									
AFR	DRC	RDC-TAN-1	2022	88	4	0	1–2	Sep 12, 2022	Dec 16, 2022
		RDC-HLO-3	2022	3	0	0	2	Nov 14, 2022	Sep 30, 2022
	Madagascar	MAD-SUE-1	2020–22	15	22	78	3–5	Apr 26, 2021	Oct 26, 2022
		MAD-ANO-2	2021–22	8	8	87	4–6	Feb 28, 2022	Oct 25, 2022
		MAD-ANO-1	2021–22	3	2	16	1–2	Aug 2, 2021	Apr 25, 2022
	Malawi	MOZ-NPL-2	2022	4	1	0	5–6	Sep 19, 2022	Dec 1, 2022
	Mozambique	MOZ-NPL-2	2020–22	18	1	0	5	Jul 25, 2022	Nov 20, 2022
cVDPV type 2 outbreaks									
AFR	Algeria	NIE-ZAS-1	2022	3	2	44	3–4	Jul 11, 2022	Dec 27, 2022
	Benin	NIE-ZAS-1	2022	11	1	8	3–5	Jun 27, 2022	Dec 21, 2022
	Botswana	RDC-MAN-5	2022	0	0	6	2	Oct 31, 2022	Dec 13, 2022
	Burkina Faso	NIE-JIS-1	2019–21	2	0	1	4–5	Jan 27, 2020	Dec 28, 2021
	Cameroon	NIE-ZAS-1	2021–22	5	3	1	3–4	Oct 25, 2021	Oct 30, 2022
	Central African Republic	NIE-ZAS-1	2021–22	1	0	2	3–4	Nov 29, 2021	Dec 26, 2022
		CAF-BNG-2	2022	3	0	8	1–2	Aug 22, 2022	Nov 23, 2022
	Chad	NIE-ZAS-1	2021–22	44	3	7	3–5	Jan 31, 2022	Nov 24, 2022
	Côte d'Ivoire	NIE-ZAS-1	2022	0	0	4	2–3	Mar 7, 2022	Jul 18, 2022
	DRC	RDC-MAN-3	2021–22	253	13	5	1–3	Dec 20, 2021	Dec 10, 2022
		RDC-MAN-5	2021–22	21	4	5	1–3	Mar 14, 2022	Nov 21, 2022
		RDC-BUE-1	2022	5	10	0	2–4	Sep 5, 2022	Nov 10, 2022
		RDC-MAN-4	2021–22	11	2	4	1–2	Jan 31, 2022	Sep 20, 2022
		RDC-TSH-1	2022	4	0	0	2	Oct 3, 2022	Sep 20, 2022
		RDC-MAN-2	2021–22	5	3	3	1–2	Nov 1, 2021	Jul 5, 2022
	Eritrea	CHA-NDJ-1	2021–22	2	0	0	3–4	Jun 6, 2022	Mar 2, 2022
	Ethiopia	ETH-SOU-3	2020–22	1	0	0	3	Nov 21, 2022	Apr 1, 2022
	Ghana	NIE-ZAS-1	2022	3	7	37	4–5	May 23, 2022	Oct 4, 2022
	Mauritania	NIE-JIS-1	2021	0	4	9	4–5	Aug 23, 2021	Dec 15, 2021
	Mozambique	MOZ-NPL-1	2021–22	6	0	0	2–4	Feb 14, 2022	Mar 26, 2022
	Niger	NIE-ZAS-1	2021–22	29	3	16	2–5	Nov 1, 2021	Oct 27, 2022
	Nigeria	NIE-ZAS-1	2020–22	413	222	670	2–6	Sep 18, 2020	Dec 14, 2022
		NIE-SOS-7	2019–22	30	12	16	2–4	May 2, 2020	Jan 29, 2022
	Senegal	NIE-JIS-1	2020–22	17	36	26	4–6	Mar 16, 2021	Jan 17, 2022
	Togo	NIE-ZAS-1	2022	2	0	1	4–5	May 16, 2022	Sep 30, 2022
		NIE-JIS-1	2019–22	0	0	1	4	Oct 17, 2019	Mar 22, 2022
	Zambia	RDC-MAN-5	2022	0	0	3	2	Nov 7, 2022	Nov 1, 2022
AMR	United States	IUUC-2022	2022	1	0	12	1	Sep 12, 2022	Sep 22, 2022
EMR	Djibouti	YEM-TAI-1	2021–22	0	0	29	1–2	Jan 31, 2022	May 22, 2022
	Egypt	NIE-ZAS-1	2022	0	0	2	3	Jun 6, 2022	Aug 29, 2022
		YEM-TAI-1	2021–22	0	0	3	2	Dec 20, 2021	Mar 30, 2022
		EGY-QEN-1	2021–22	0	0	3	1–2	Mar 28, 2022	Mar 9, 2022
	Somalia	SOM-BAN-1	2017–22	6	4	4	7–9	Feb 12, 2018	Aug 31, 2022
		YEM-TAI-1	2022	0	0	1	1	Aug 22, 2022	May 19, 2022
	Sudan	NIE-ZAS-1	2022	1	0	1	4–5	Dec 19, 2022	Nov 28, 2022
	Yemen	YEM-TAI-1	2021–22	219	51	70	1–3	Nov 22, 2021	Dec 2, 2022
		YEM-SAN-1	2021–22	6	2	1	1–2	Apr 18, 2022	Aug 17, 2022
EUR	Israel	IUUC-2022	2022	0	0	1	—[††]	Aug 8, 2022	Jun 16, 2022
	UK	IUUC-2022	2022	0	0	5	—[††]	Sep 5, 2022	Aug 8, 2022
	Ukraine	PAK-GB-1	2021	2	18	0	—[††]	Oct 11, 2021	Dec 24, 2021
SEAR	Indonesia	INO-ACE-1	2022	1	4	0	3	Nov 28, 2022	Nov 11, 2022

See table footnotes on the next page.

TABLE 1. (Continued) Ongoing circulating vaccine-derived poliovirus outbreaks detected (N = 50), by serotype, emergence group, detection source, and other selected characteristics — worldwide, January 2021–December 2022

				No. of detections (source)[†]					
WHO Region	**Country**	**cVDPV emergence designation***	**Years detected**	**AFP cases**	**Other human sources (non-AFP)[§]**	**ES**	**% VP1 genome region divergence from Sabin-strain poliovirus[¶]**	**Outbreak confirmation date**	**Most recent case/ positive specimen from healthy child/ environmental sample****
cVDPV type 3 outbreaks									
EMR	Palestinian territories	cVDPV3	2021–22	0	0	16	—[††]	Mar 7, 2022	Mar 12, 2022
EUR	Israel	cVDPV3-ISR	2020–22	1	3	31	—[††]	Dec 13, 2021	Mar 24, 2022

Abbreviations: AFP = acute flaccid paralysis; AFR = African Region; AMR = Region of the Americas; cVDPV = circulating vaccine-derived poliovirus; DRC = Democratic Republic of the Congo; EMR = Eastern Mediterranean Region; ES = environmental surveillance; EUR = European Region; OPV = oral poliovirus vaccine; SEAR = South-East Asian Region; UK = United Kingdom; VDPV = vaccine-derived poliovirus; VP1 = poliovirus capsid viral protein 1; WHO = World Health Organization.

* Emergences indicate detection of cVDPV strains that have unique genetic reversion compared with other VDPVs, and the names of emergences generally designate the country and geographic subnational region of the emergence's first detection and the number of emergences in each subnational region. The emergence designation for cVPDV2 outbreaks in Israel, UK, and United States is the same (IUUC-2022), because of shared circulation in each of a unique Sabin-like virus.

[†] During January 2021–December 2022 with data as of February 14, 2023. For AFP cases, the number with a VDPV-positive specimen or for which a direct contact of the patient had a VDPV-positive specimen when the patient did not. For other human sources, the number of contacts of the patient or healthy children in the community with a VDPV-positive specimen. For detections from ES, the total number of samples with VDPVs detected from environmental (sewage) collections.

[§] Specimens from contacts of polio patients and from healthy children in the community during January 2021–December 2022.

[¶] Percentage of divergence is estimated from the number of nucleotide differences in the genome region encoding VP1 from the corresponding parental Sabin strain.

** For AFP cases, dates refer to the date of paralysis onset. For contacts, healthy children, and environmental (sewage) samples, dates refer to the date of collection during January 2021–December 2022 with data current as of February 14, 2023. Table is restricted to outbreaks with a last reported detection after November 1, 2021 (indicating country virus circulation within 13 months of the reporting period).

[††] Data not released or available.

In Mozambique, the first identified patient in the MOZ-NPL-2 emergence outbreak had paralysis onset in July 2020 (at that time an unclassified VDPV1 case); after the identification of additional genetically linked cases, an outbreak was confirmed in July 2022. Genomic sequence analysis indicated that the emergence had occurred approximately 4 years before the first detection, indicating substantial gaps in poliovirus surveillance (*7*). The MOZ-NPL-2 emergence spread to Malawi, where circulation was identified in September 2022 (*8*). Mozambique also has a concurrent wild poliovirus type 1 outbreak linked to Malawi (*9*). The latest detection of transmission of the Yemen outbreak (YEM-SAD-1 emergence) was in January 2021 (Supplementary Table, https://stacks.cdc.gov/view/cdc/126383).

cVDPV2 Outbreaks

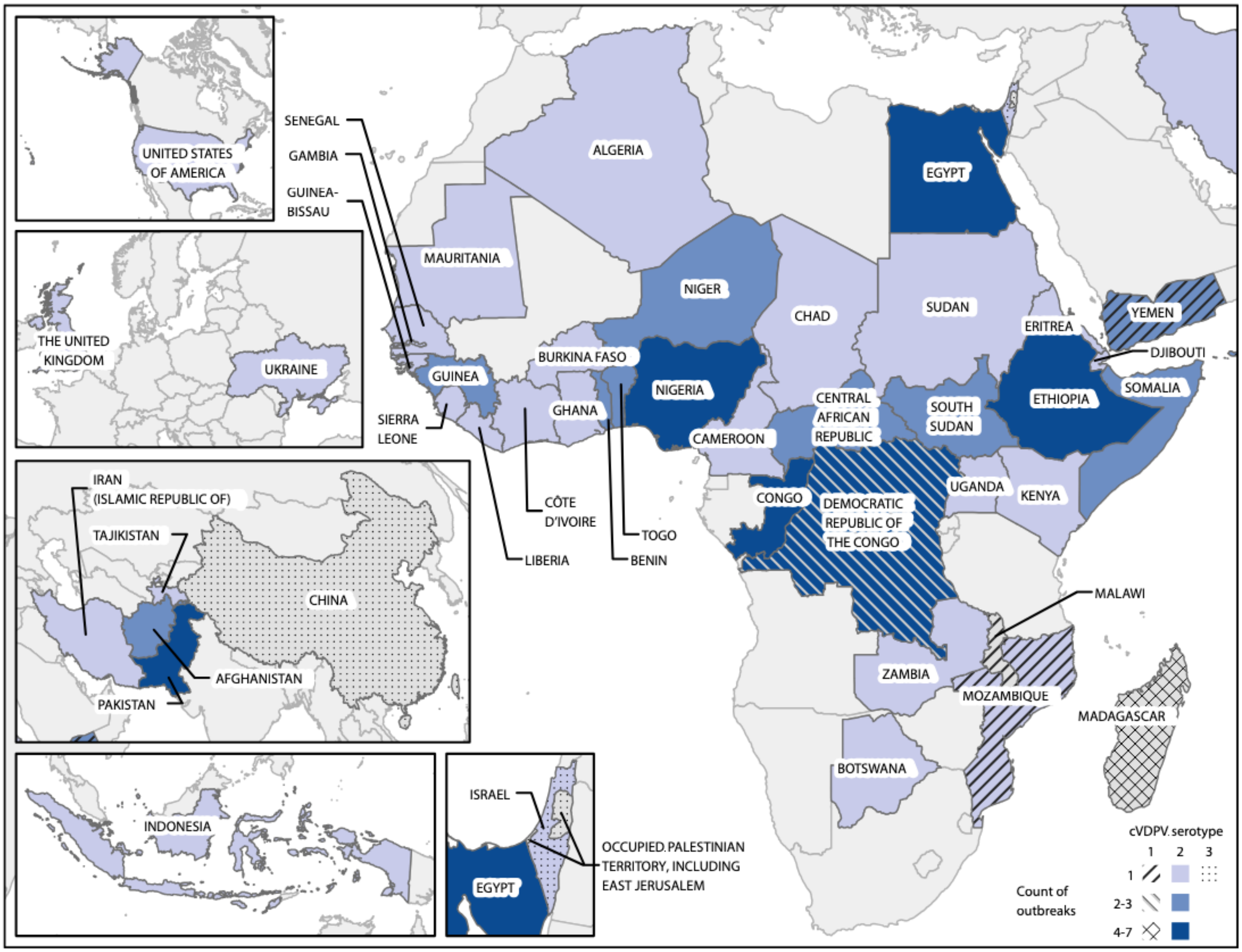
As of December 31, 2022, and since August 2016, a total of 154 cVDPV2 outbreaks from 82 cVDPV2 emergences have been reported in 48 countries. Seventeen (35%) countries reported their first post-switch cVDPV2 emergences and outbreaks in 2021 (eight) and 2022 (nine). Of the 82 emergences detected, 42 (51%) were active during 2021–2022, including nine (11%) new emergences identified in 2021 and five (6%) in 2022 (Table 1). Thirteen (16%) of all 82 emergences spread outside the country of first detection. The NIE-JIS-1 emergence, first detected in January 2018 in Nigeria, has spread to 18 other African countries; active transmission occurred in 13 of those countries during the reporting period. The NIE-ZAS-1 emergence, originally detected in Nigeria in July 2020, has been detected in an additional 12 countries since 2021. The YEM-TAI-1 emergence, first detected in Yemen in 2021, has spread into Egypt and Somalia, and the SOM-BAN-1 emergence group, first detected in Somalia in October 2017, continues to circulate only in that country (*4*).

Among the 154 cVDPV2 outbreaks that have occurred since the 2016 global synchronized switch from tOPV to bOPV for routine immunization, 76 (49%) were active across 42 countries during the reporting period (Figure). Forty-nine (65%) of the active outbreaks across 35 countries were first reported during 2021–2022 (Table 1). Even as cVDPV2 outbreaks have spread, the reported number of paralytic cases has declined from the peak in 2020: 587 paralytic cVDPV2 cases were reported in 2022 (as of February 14, 2023), representing a 14% decrease from 682 in 2021 and a 46% decrease from 1,082 cases in 2020. However, 2022 case counts could ultimately match or surpass 2021 counts as samples collected from the end of 2022 are processed. In 34 (45%) of the 76 active outbreaks, the latest detections occurred ≥13 months earlier, and transmission in those outbreaks is considered interrupted (Supplementary Table, https://stacks.cdc.gov/view/cdc/126383).

Among the 49 new cVDPV2 outbreaks that occurred during the reporting period, 33 occurred in 23 countries in the WHO African Region (AFR), and 10 new outbreaks occurred in six countries of the WHO Eastern Mediterranean Region (EMR). Nine countries (Algeria, Botswana, Eritrea, The Gambia, Guinea-Bissau, Mauritania, Senegal, South Sudan, and Uganda) in AFR and two (Djibouti and Yemen) in EMR reported their first post-switch cVDPV2 outbreaks during this period. Among the 41 cVDPV2 outbreaks that were active at the end of the reporting period, 27 (66%) were in 19 AFR countries and nine (22%) were in five EMR countries (Table 1). In 2022, cVDPV2 cases from outbreaks in two countries (DRC [AFR] and Yemen [EMR]) represented 75% of all type 2 cases reported. The DRC reported 283 cases, an increase of 911% from the 28 cases reported in 2021, representing 48% of global cVDPV2 cases. Yemen reported an increase of 142%, from 66 cases in 2021 to 160 cases in 2022, accounting for 27% of global cVDPV2 cases in 2022.

The PAK-GB-1 emergence detected in Pakistan in 2019 spread to Tajikistan in 2020 and subsequently to Ukraine, with two cases identified during October–December 2021 (*4,6*). In 2022, genetically related VDPV2 detections (IUUC-2022) were reported in Israel, the United Kingdom, and the United States (New York) (*10*). One polio case and 12 environmental surveillance (ES) isolations were reported in the United States, five nonpatient isolations in the United Kingdom, and one nonpatient isolation in Israel. In Indonesia, a new cVDPV2 outbreak (INO-ACE-1) with one case was reported in November 2022. Genetic sequencing analysis suggested the emergence strain had been circulating undetected for approximately 3 years.

FIGURE. Circulating vaccine-derived poliovirus outbreaks (N = 88) — worldwide, January 2021–December 2022*



Abbreviation: cVDPV = circulating vaccine-derived poliovirus.

* Data current as of February 14, 2023.

cVDPV type 3 (cVDPV3) Outbreaks

Four cVDPV3 outbreaks from different emergences have occurred since 2016, two of which were active during the reporting period. One outbreak was in Israel (cVDPV3-ISR) during 2021–2022, with one paralytic case, and one in the Palestinian Territories (cVDPV3) in 2022, with 16 ES detections (Table 1).

Outbreak Control

Of the 172 cVDPV outbreaks reported since 2016, 121 (70%) have been interrupted. A current critical measure of outbreak response performance for the Global Polio Eradication Initiative (GPEI) is the interruption of virus transmission in outbreaks (i.e., the latest detection) within 120 days of the outbreak notification date (*1*). As of February 14, 2023, 19 of 29 (66%) outbreaks confirmed in 2021 had no virus detected after 120 days, compared with 28 (62%) of 45 outbreaks in 2019 and 27 (54%) of 50 in 2020 (Table 2).

Discussion

GPEI's 2022–2026 strategic plan includes the goal of stopping all cVDPV outbreaks by the end of 2023. Ongoing global cVDPV2 transmission and an increasing number of cVDPV1 outbreaks, with cocirculation of cVDPV1 and cVDPV2 in two countries, threaten the attainment of this target (*1*). Although the number of cVDPV2 cases and of new reported emergences have decreased during 2021 and 2022, two major challenges to reaching the target remain: 1) achieving high-quality surveillance that detects poliovirus in a timely manner, and 2) implementing fully effective outbreak control measures that prevent international spread. Wide gaps in poliovirus surveillance led to late detection of some countries' outbreaks (e.g., MOZ-NPL-2), inferred by the extent of the genetic divergence of the initial isolates.

TABLE 2. Circulating vaccine-derived poliovirus outbreaks (N = 149) and timeliness of outbreak control, by serotype and year of confirmation — worldwide, August 2016–December 2022

	Year of outbreak confirmation, no. (%)						
cVDPV type	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022***
Type 1	—[†]	—	1	4	1	3	1
Type 2	2	4	7	41	49	24	8
Type 3	—	—	1	—	—	2	1
Overall	**2**	**4**	**9**	**45**	**50**	**29**	**10**
Controlled within 120 days of outbreak confirmation (n = 85 [57%])							
Type 1	—	—	0 (—)	4 (100)	0 (—)	1 (33)	0 (—)
Type 2	2 (100)	3 (75)	1 (14)	24 (59)	27 (55)	16 (67)	4 (50)
Type 3	—	—	0 (—)	—	—	2 (100)	1 (100)
Overall	**2 (100)**	**3 (75)**	**1 (11)**	**28 (62)**	**27 (54)**	**19 (66)**	**5 (50)**

Abbreviation: cVDPV = circulating vaccine derived poliovirus.

* Data as of February 14, 2023. To account for potential low-level transmission continuing after the outbreak response and delayed detection, cVDPV outbreaks were suppressed if <6 months had elapsed from the 120th day following outbreak confirmation (April 20, 2022).

[†] Dashes indicate that no outbreaks were confirmed during that year.

The number of paralytic cVDPV2 cases reported in 2022 represents a 46% decrease from the peak number in 2020 (*4,9*). During the initial months of the COVID-19 pandemic (March–June 2020), polio outbreak response SIAs were postponed. Most SIAs during the successive months of the reporting period were either delayed or of poor quality, resulting in the detection of breakthrough[¶] cVDPV viruses in many outbreaks (*2,4*). The proportion of outbreaks controlled within 120 days has not substantially changed from that during previous years.

The decrease in number of new cVDPV2 emergences during this period is likely associated with the use of nOPV2 for outbreak response campaigns. Since the first cVDPV2 outbreak response using nOPV2 under the WHO Emergency Use Listing in March 2021 (as of March 2023), >590 million nOPV2 doses[**] have been administered in 24 countries (*5*). Whereas the number of cVDPV2 emergences has declined during the 2021–2022 COVID-19 pandemic and recovery period, international spread has not. During the last 2 years, 17 countries have experienced their first post-switch cVDPV2 outbreaks, reflecting poor outbreak control in the country of origin.

In 2022, the number of new cVDPV1 outbreaks increased substantially and primarily affected countries in sub-Saharan Africa. Routine immunization coverage, which was already low in many subnational areas of outbreak countries, decreased after the start of the COVID-19 pandemic, and the suspension of preventive bOPV SIAs has resulted in an environment with increased susceptibility to the emergence of cVDPV1 outbreaks (*6*). During 2022, in AFR countries, the national proportion of children who received their third dose of polio vaccine (Pol3) by age 1 year was 70%, compared with 74% in 2019; Pol3 coverage in EMR was 83% both years (*6*). Increasing routine immunization coverage will be critical for preventing paralysis and aiding in the interruption of global cVDPV1 transmission.

The findings in this report are subject to at least two limitations. First, delays in shipment and testing of poliovirus surveillance specimens by regional or international reference laboratories might have resulted in delays in detection of emergences and of additional cases during the second half of

---

[¶] Breakthrough transmission is defined as detection of a poliovirus (wild poliovirus or cVDPV) in samples from a patient with AFP, a healthy child, or environmental sampling sites with the date of onset of paralysis (for AFP cases) or the date of sample collection (for healthy children or environmental samples) >21 days after the first day of the last SIA in an area where at least two SIAs have been implemented.

[**] On March 16, 2023, GPEI released a statement on cVDPV2 detections from Burundi and DRC that have been linked with nOPV2 use. https://polioeradication.org/news-post/gpei-statement-on-cvdpv2-detections-in-burundi-and-democratic-republic-of-the-congo/

Summary

What is already known about this topic?

Circulating vaccine-derived polioviruses (cVDPVs) can emerge and cause paralysis in areas with low population immunity to polioviruses.

What is added by this report?

During January 2021–December 2022, 76 cVDPV type 2 outbreaks occurred in 42 countries. Since 2020, the numbers of paralytic cases and new emergences have declined following the introduction of a safer novel type 2 oral poliovirus vaccine for outbreak control. The number of cVDPV type 1 outbreaks increased during 2021–2022 as COVID-19 pandemic–associated global routine immunization coverage declined.

What are the implications for public health practice?

Improving routine immunization coverage, strengthening poliovirus surveillance, and conducting timely and high-quality supplementary immunization activity responses to cVDPV outbreaks in 2023 are necessary to stop cVDPV transmission.

2022. Second, surveillance gaps might have resulted in underestimates of poliovirus cases and the extent of transmission.

Countries responding to cVDPV outbreaks face multiple challenges in implementing effective outbreak responses, including delays in outbreak detection and receipt of vaccine, resulting in substantial transmission before implementation of response SIAs. Countries face competing public health priorities (e.g., outbreaks of measles, cholera, and Ebola virus disease), security challenges, and other national priorities with limited resources, which can negatively affect the overall quality and timeliness of outbreak response SIAs. Recent limitations of sufficient nOPV2 availability have hampered timely SIAs in response to cVPDV2 outbreaks. Thus, improving routine immunization coverage, especially at subnational levels, strengthening poliovirus surveillance, and conducting timely and high-quality outbreak response SIAs will be critical to interrupt cVDPV transmission in outbreaks and reach GPEI's goal of no cVDPV isolations in 2024.

Acknowledgments

World Health Organization (WHO) Global Polio Laboratory Network (GPLN) sequencing laboratories; GPLN regional laboratory coordinators and field surveillance officers at the WHO Eastern Mediterranean Regional Office, WHO Regional Office for the Americas, WHO European Regional Office, WHO Western Pacific Regional Office, WHO South-East Asian Regional Office, and WHO African Regional Office; staff members of the Polio Eradication Branch, Global Immunization Division, Center for Global Health, CDC; staff members of the Polio and Picornavirus Laboratory Branch, Division of Viral Diseases, National Center for Immunization and Respiratory Diseases, CDC; Geospatial Research, Analysis, and Services Program, Agency for Toxic Substances and Disease Registry, CDC; Emergency Operations Center, Center for Preparedness and Response, CDC.

Corresponding author: John Paul Bigouette, qdz1@cdc.gov.

---

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

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflicts of interest were disclosed.

References

1. Global Polio Eradication Initiative. Polio eradication strategy 2022–2026: delivering on a promise. Geneva, Switzerland: World Health Organization; 2021. https://polioeradication.org/gpei-strategy-2022-2026/
2. Global Polio Eradication Initiative. Standard operating procedures: responding to a poliovirus event or outbreak, version 4. Geneva, Switzerland: World Health Organization; 2020. https://www.who.int/publications/i/item/9789240049154
3. Global Polio Eradication Initiative. OPV cessation. Geneva, Switzerland: World Health Organization; 2023. https://polioeradication.org/polio-today/preparing-for-a-polio-free-world/opv-cessation/
4. Alleman MM, Jorba J, Henderson E, et al. Update on vaccine-derived poliovirus outbreaks—worldwide, January 2020–June 2021. MMWR Morb Mortal Wkly Rep 2021;70:1691–9. PMID:34882653 https://doi.org/10.15585/mmwr.mm7049a1
5. Global Polio Eradication Initiative. cVDPV2 outbreaks and the type 2 novel oral polio vaccine (nOPV2). Geneva, Switzerland: World Health Organization; 2022. https://polioeradication.org/wp-content/uploads/2022/10/GPEI-nOPV2-Factsheet-EN-20221011.pdf
6. Rachlin A, Danovaro-Holliday MC, Murphy P, Sodha SV, Wallace AS. Routine vaccination coverage—worldwide, 2021. MMWR Morb Mortal Wkly Rep 2022;71:1396–400. PMID:36327156 https://doi.org/10.15585/mmwr.mm7144a2
7. Wilkinson AL, Diop OM, Jorba J, Gardner T, Snider CJ, Ahmed J. Surveillance to track progress toward polio eradication—worldwide, 2020–2021. MMWR Morb Mortal Wkly Rep 2022;71:538–44. PMID:35421079 https://doi.org/10.15585/mmwr.mm7115a2
8. Rachlin A, Patel JC, Burns CC, et al. Progress toward polio eradication—worldwide, January 2020–April 2022. MMWR Morb Mortal Wkly Rep 2022;71:650–5. PMID:35552352 https://doi.org/10.15585/mmwr.mm7119a2
9. Davlantes E; Malawi Ministry of Health; Global Polio Eradication Initiative. Notes from the field: initial outbreak response activity following wild poliovirus type 1 detection—Malawi, February 2022. MMWR Morb Mortal Wkly Rep 2022;71:776–7. PMID:35679180 https://doi.org/10.15585/mmwr.mm7123a3
10. Ryerson AB, Lang D, Alazawi MA, et al. Wastewater testing and detection of poliovirus type 2 genetically linked to virus isolated from a paralytic polio case—New York, March 9–October 11, 2022. MMWR Morb Mortal Wkly Rep 2022;71:1418–24. PMID: 36327157 http://dx.doi.org/10.15585/mmwr.mm7144e2

Ventilation Improvements Among K–12 Public School Districts — United States, August–December 2022

Miguella Mark-Carew, PhD[1]; Gloria Kang, PhD[2]; Sanjana Pampati, MPH[3]; Kenneth R. Mead, PhD[4]; Stephen B. Martin Jr., PhD[5]; Lisa C. Barrios, DrPH[3]

Improving ventilation has been one of several COVID-19 prevention strategies implemented by kindergarten through grade 12 (K–12) schools to stay open for safe in-person learning. Because transmission of SARS-CoV-2 occurs through inhalation of infectious viral particles, it is important to reduce the concentration of and exposure time to infectious aerosols (*1–3*). CDC examined reported ventilation improvement strategies among U.S. K–12 public school districts using telephone survey data collected during August–December 2022. Maintaining continuous airflow through school buildings during active hours was the most frequently reported strategy by school districts (50.7%); 33.9% of school districts reported replacement or upgrade of heating, ventilation, and air conditioning (HVAC) systems; 28.0% reported installation or use of in-room air cleaners with high-efficiency particulate air (HEPA) filters; and 8.2% reported installation of ultraviolet (UV) germicidal irradiation (UVGI) devices, which use UV light to kill airborne pathogens, including bacteria and viruses. School districts in National Center for Education Statistics (NCES) city locales, the West U.S. Census Bureau region, and those designated by U.S. Census Bureau Small Area Income Poverty Estimates (SAIPE) as high-poverty districts reported the highest percentages of HVAC system upgrades and HEPA-filtered in-room air cleaner use, although 28%–60% of all responses were unknown or missing. Federal funding remains available to school districts to support ventilation improvements. Public health departments can encourage K–12 school officials to use available funding to improve ventilation and help reduce transmission of respiratory diseases in K–12 settings.

MCH Strategic Data (MCH), a private company offering educational, health care, and government data and technology solutions, repeatedly surveyed school district office staff members by telephone during August 8–December 29, 2022, regarding implementation of COVID-19 prevention policies and strategies, including ventilation improvements. Ventilation strategies examined included replacing or upgrading HVAC systems; using in-room air cleaners with HEPA filters; installing UVGI in high-risk areas; and maintaining continuous movement of air supply or airflow through school buildings during active hours, including opening windows and doors, using fans, or adjusting thermostats or central controls.* School districts were asked, "Since the start of the COVID-19 pandemic, which of the following steps to increase ventilation or filter/clean air apply to most schools (at least 50%) in your district?"

MCH attempted to contact 15,871 U.S. K–12 public and public charter school districts† (estimated student enrollment = 52,696,479) at a cadence based on district enrollment size, whereby larger school districts (those with 2,500 or more students) were surveyed weekly, and districts with less than 2,500 students were surveyed biweekly. The most recent response from school districts was included for analysis. Individual school-level enrollment was summed for each district.

Although 1,358 independent charter school districts were surveyed, they were excluded from this analysis because SAIPE school district data were not available for these districts. Descriptive analyses summarizing responses to ventilation questions are presented for the overall sample and stratified by U.S. Census Bureau region,§ NCES locale,¶ and poverty level. Poverty levels were based on the 2021 SAIPE for school-aged children living in poverty** as the percentage of children and adolescents aged 5–17 years experiencing poverty within a school district, grouped into tertiles. Responses were grouped into three categories: 1) school districts in which strategies were completed, in progress, or being done by most schools; 2) those in which they were not being done by most schools, no action had been taken, or the response was not applicable; and 3) unknown or missing. Analyses were conducted using R (version 1.4.1106; R Foundation). This activity was reviewed by CDC and conducted consistent with applicable federal law and CDC policy.††

A total of 8,410 school districts (64.2%) representing an estimated 61.7% of enrolled public school students responded to ventilation-related questions (Table 1). Among responding

---

* The continuous airflow question was amended after the survey was launched. Only responses from October 26, 2022, onward were included in the analysis.

† Surveyed school districts included local education agency district types 1 (regular local school district not part of supervisory union), 2 (regular local school district part of supervisory union), and 7 (independent charter district). https://nces.ed.gov/ccd/commonfiles/glossary.asp

§ https://www.census.gov/programs-surveys/economic-census/guidance-geographies/levels.html#par_textimage_34

¶ NCES locales are divided into four types: rural, town, suburban, and city. https://nces.ed.gov/programs/edge/Geographic/LocaleBoundaries

** https://www.census.gov/data/datasets/2021/demo/saipe/2021-school-districts.html

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

TABLE 1. Number and percentage of K–12 public school districts surveyed* about COVID-19 prevention strategies (N = 8,410), by region, locale, and poverty level compared with total national K–12 public school districts — United States, August–December 2022

	No. (%)			
Characteristic	Participating districts	Estimated students represented by participating districts	National districts†	Estimated students represented by national districts§
Total	**8,410**	**30,656,251**	**13,103**	**49,670,152**
Region¶				
Northeast	1,499 (17.8)	3,850,328 (12.6)	2,703 (20.6)	6,523,546 (13.1)
Midwest	3,137 (37.3)	6,590,076 (21.5)	4,728 (36.1)	10,349,402 (20.8)
South	2,033 (24.2)	10,747,723 (35.1)	3,082 (23.5)	20,015,472 (40.3)
West	1,741 (20.7)	9,468,124 (30.9)	2,589 (19.8)	12,482,171 (25.1)
Locale**				
City	487 (5.8)	9,373,912 (30.6)	747 (5.7)	14,916,562 (30.0)
Rural	4,482 (53.3)	4,962,213 (16.2)	7,009 (53.5)	7,852,801 (15.8)
Suburb	1,892 (22.5)	12,633,748 (41.2)	3,013 (23.0)	21,409,409 (43.1)
Town	1,549 (18.4)	3,686,378 (12.0)	2,333 (17.8)	5,491,380 (11.1)
Poverty level††				
Low	2,643 (31.4)	10,936,819 (35.7)	4,367 (33.4)	16,817,905 (33.9)
Mid	2,824 (33.6)	10,465,957 (34.1)	4,366 (33.3)	16,760,744 (33.7)
High	2,941 (35.0)	9,253,450 (30.2)	4,366 (33.3)	16,091,478 (32.4)

Abbreviations: NCES = National Center for Education Statistics; SAIPE = Small Area Income Poverty Estimates.

* MCH Strategic Data Survey. https://www.mchdata.com/

† National districts are public school districts for which 2021 U.S. Census Bureau SAIPE data (https://www.census.gov/data/datasets/2021/demo/saipe/2021-school-districts.html) and NCES locale data (https://nces.ed.gov/programs/edge/Geographic/LocaleBoundaries) were available.

§ Enrollment data were not available for 191 districts.

¶ Puerto Rico does not have an assigned U.S. Census Bureau region; its one public school district has an estimated 0.6% of students (n = 299,561) represented by national districts.

** Locale was based on NCES locale classification.

†† Four districts did not have students aged 5–17 years in SAIPE data and were not assigned a poverty level; two were participating districts for which MCH Strategic Data estimated combined enrollment of 25 students.

school districts and national K–12 public school districts,[§§] most (53%) were classified as rural, and the largest percentage (37%) were in the Midwest region. Responding school districts were similar to all U.S. K–12 public school districts in terms of U.S. Census Bureau region, locale, and poverty level distributions. Among the four ventilation improvements examined, maintaining continuous airflow in classrooms was reported by just over one half (50.7%) of school districts; one third (33.9%) reported having HVAC system improvements in progress or completed, more than one quarter (28.0%) reported planned or completed use of HEPA-filtered in-room air cleaners, and 8.2% reported UVGI improvements planned or completed in most schools (Table 2). The use of HEPA-filtered in-room air cleaners was also more frequently reported by districts in cities (33.1%) than in those in suburban (29.9%), town (27.4%), and rural (26.9%) districts. UVGI improvements were reported less frequently overall, and by 8.9% of rural school districts, followed by 8.4% of city, 8.0% of town, and 6.6% of suburban districts.

By U.S. Census Bureau region, districts in the West more frequently reported continuous airflow (60.2%), HVAC (40.0%), and in-room air cleaners with HEPA filters (41.6%) ventilation improvements in most schools than did those in the Northeast (53.6%, 32.8%, and 26.8%, respectively), Midwest (46.5%, 32.3%, and 22.7%, respectively), and South (46.1%, 32.1%, and 25.6%, respectively). UVGI improvements were more commonly reported by school districts in the South (10.6%) than by those in West (9.1%), Midwest (7.1%), and Northeast (6.1%) regions. High-poverty school districts more frequently reported each of the four ventilation improvements in most schools than did low- and mid-poverty school districts, with 51.8% reporting maintaining continuous airflow, 35.1% reporting HVAC, 29.9% reporting HEPA-filtered in-room air cleaners, and 10.6% reporting UVGI improvements. For all possible interventions, unknown or missing responses accounted for 28%–60% of responses.

Discussion

This report highlights four strategies public school districts have used to reduce transmission of respiratory infections through improved ventilation and facilitate safe in-school learning (*4*), as well as differences in strategy used by U.S. Census Bureau region, NCES locale, and school district poverty level. The most frequently reported ventilation strategy, maintaining continuous movement of airflow in school buildings, was also the least expensive to implement and was reported by approximately one half of school districts. More

---

[§§] National districts are public school districts for which 2021 U.S. Census Bureau SAIPE data (https://www.census.gov/data/datasets/2021/demo/saipe/2021-school-districts.html) and NCES locale data (https://nces.ed.gov/programs/edge/Geographic/LocaleBoundaries) were available.

TABLE 2. Strategies to improve ventilation in U.S. K–12 public school districts (N = 8,410), by locale,* U.S. Census Bureau region,† and poverty level — United States, August–December 2022§

Ventilation intervention¶ and improvement status	No. (%)											
	NCES locale*				U.S. Census Bureau region†				School district poverty level**			
	City	Rural	Suburb	Town	Northeast	Midwest	South	West	Low	Mid	High	Total
Replaced or upgraded HVAC systems												
Completed or in progress by most schools	189 (38.8)	1,517 (33.8)	663 (35.0)	483 (31.2)	491 (32.8)	1,012 (32.3)	653 (32.1)	696 (40.0)	879 (33.3)	939 (33.3)	1,034 (35.1)	**2,852 (33.9)**
No action taken/Not applicable	63 (12.9)	1,269 (28.3)	254 (13.4)	325 (21.0)	209 (13.9)	876 (27.9)	454 (22.3)	372 (21.4)	560 (21.1)	698 (24.7)	652 (22.2)	**1,911 (22.7)**
Unknown	235 (48.3)	1696 (37.8)	975 (51.5)	741 (47.8)	799 (53.3)	1,249 (39.8)	926 (45.5)	673 (38.6)	1,204 (45.6)	1,187 (42.0)	1,255 (42.7)	**3,647 (43.4)**
Installed or used HEPA filtration systems in classrooms or student dining areas												
Completed or in progress by most schools	161 (33.1)	1,207 (26.9)	566 (29.9)	424 (27.4)	401 (26.8)	713 (22.7)	520 (25.6)	724 (41.6)	719 (27.2)	759 (26.9)	879 (29.9)	**2,358 (28.0)**
No action taken/Not applicable	71 (14.6)	1,455 (32.5)	261 (13.8)	348 (22.5)	226 (15.1)	1,031 (32.9)	518 (25.5)	360 (20.7)	655 (24.8)	761 (26.9)	718 (24.4)	**2,135 (25.4)**
Unknown	255 (52.4)	1,820 (40.6)	1,065 (56.0)	777 (50.2)	872 (58.2)	1,393 (44.4)	995 (48.9)	657 (37.7)	1,269 (48.0)	1,304 (46.2)	1,344 (45.7)	**3,917 (46.6)**
Installed UVGI in high-risk and student dining areas, or where options for ventilation are limited												
Completed or in progress by most schools	41 (8.4)	398 (8.9)	124 (6.6)	124 (8.0)	92 (6.1)	222 (7.1)	215 (10.6)	158 (9.1)	183 (6.9)	191 (6.8)	313 (10.6)	**687 (8.2)**
No action taken/Not applicable	153 (31.4)	2,428 (54.2)	706 (37.3)	715 (46.2)	582 (38.8)	1,686 (53.7)	902 (44.4)	832 (47.8)	1,246 (47.1)	1,427 (50.5)	1,328 (45.2)	**4,002 (47.6)**
Unknown	293 (60.2)	1,656 (36.9)	1,062 (56.1)	710 (45.8)	825 (55.0)	1,229 (39.2)	916 (45.0)	751 (43.1)	1,214 (45.9)	1,206 (42.7)	1,300 (44.1)	**3,721 (44.2)**
Maintained continuous movement of air supply/airflow through the building during active hours††												
Being done by most schools	123 (49.8)	1,195 (52.6)	516 (50.9)	370 (45.5)	429 (53.6)	747 (46.5)	463 (46.1)	565 (60.2)	688 (51.3)	706 (48.9)	810 (51.8)	**2,204 (50.7)**
No action taken/Not being done by most schools	30 (12.1)	450 (19.8)	99 (9.8)	123 (15.1)	59 (7.4)	343 (21.4)	186 (18.5)	114 (12.2)	206 (15.4)	265 (18.4)	231 (14.8)	**702 (16.1)**
Unknown	94 (38.1)	629 (27.7)	398 (39.3)	321 (39.4)	312 (39.0)	515 (32.1)	356 (35.4)	259 (27.6)	447 (33.3)	472 (32.7)	522 (33.4)	**1,442 (33.1)**

Abbreviations: HEPA = high-efficiency particulate air; HVAC = heating, ventilation, and air conditioning; NCES = National Center for Education Statistics; SAIPE = Small Area Income Poverty Estimates; UVGI = ultraviolet germicidal irradiation.

* https://nces.ed.gov/programs/edge/Geographic/LocaleBoundaries

† https://www.census.gov/programs-surveys/economic-census/guidance-geographies/levels.html#par_textimage_34

§ https://www.mchdata.com/

¶ Respondents were asked, "Since the start of the COVID-19 pandemic, which of the following steps to increase ventilation or filter/clean air apply to most schools (at least 50%) in your district?"

** Two districts were not assigned poverty tertiles because they did not include any children or adolescents aged 5–17 years, according to SAIPE school district estimates for 2021.

†† Included opening windows and doors, using fans, and adjusting thermostats or central controls. Only responses on and after October 26, 2022, were included for analysis, which reduced the number of public school districts surveyed to 4,348.

costly strategies such as installation and use of in-room air cleaners with HEPA filters and installation of UVGI were less frequently reported. That none of the four ventilation strategies was reported by more than approximately one half of school districts underscores the ongoing opportunity to improve indoor air quality among K–12 school buildings in the United States. CDC guidance for COVID-19 prevention to support safe in-person learning and improving ventilation in buildings, and the Environmental Protection Agency's Indoor Air Quality Guide for Schools kit highlight various ways to improve ventilation, such as regular air filter replacement and moving barriers that might interfere with airflow (*1*,*5*,*6*).

Rural school districts less frequently reported replacing or upgrading HVAC systems and using HEPA-filtered in-room air cleaners than did school districts in other locales. This difference might be due to limitations in resource availability and difficulty finding contractors available and willing to complete capital improvements (*7*). In addition, rural schools might be more likely to use natural ventilation, such as opening windows, than are suburban and city schools because of less exposure to noise and air pollution in rural areas or simply having windows that can be opened. This finding is supported by an early 2022 report which found that lower-cost strategies were more frequently reported by schools overall, with rural schools least likely to report implementing resource-intensive ventilation strategies (*8*). School districts in the West region were more likely to report replacing or upgrading HVAC systems than were those in the Northeast, Midwest, and South regions, possibly because the buildings were newer and more amenable to implementation of technological improvements

Summary

What is already known about this topic?

To reduce school transmission of SARS-CoV-2, K–12 public school districts implemented ventilation improvements (replacing or upgrading ventilation systems, installing filtration systems, installing ultraviolet germicidal irradiation devices, or improving airflow). Federal funding remains available for ventilation upgrades.

What is added by this report?

None of the ventilation strategies examined was reported by >51% of school districts. Implementation of ventilation improvements varied by school district U.S. Census Bureau region, geographic locale, and poverty level. High-poverty school districts reported implementation of the highest percentage of strategies.

What are the implications for public health practice?

Many public school districts have not taken steps to improve school building ventilation. Equitable access and support might be needed to assist school districts in their efforts to prevent respiratory infections through ventilation improvements.

compared with older buildings in other regions. High-poverty school districts more frequently implemented all ventilation strategies compared with mid- and low-poverty school districts; these districts might have been prioritized and might have more experience applying for federal funding. A recent report found that high-poverty schools were more likely to use federal funds to undertake ventilation improvements (*8*).

The findings in this report are subject to at least six limitations. First, because ventilation strategies were reported by school district administrative staff members, responses might be influenced by respondents' level of awareness of ventilation strategies used within their district. Limited awareness might be reflected by the high percentage of unknown responses to survey questions, resulting in a likely underreporting of ventilation improvements implemented. Second, these data were captured at the school district level. School-level variation in implementation of ventilation strategies within school districts might exist, but was not able to be examined. Third, strategies examined were not exhaustive, and school districts might have implemented additional improvements that were not identified by this survey. Fourth, although this study used a census-based approach to survey all U.S. K–12 public school districts, systematic differences between participating and nonparticipating schools could have affected the representativeness of these data; however, the distribution of participating school districts by U.S. Census Bureau region, NCES locale, and poverty level was similar to that of all U.S. K–12 public school districts. Fifth, without knowledge of the baseline ventilation status of participating school districts, a complete assessment of ventilation improvements was not possible. Finally, energy consumption before and during the COVID-19 pandemic was not evaluated as a means to measure the expense of adjusting thermostats and central controls to school districts.

Substantial federal funding remains available for ventilation improvements in school buildings that have been shown to reduce SARS-CoV-2 transmission[¶¶] (*4*). Such improvements are part of a multicomponent approach to enhancing the school environment and could have benefits for COVID-19 and other airborne infectious disease prevention. Ventilation improvements can also reduce asthma exacerbations and allergy symptoms and have been linked to better academic outcomes for students (*9*); such improvements might also protect schools from extreme weather events, which have been shown to result in approximately one third of unplanned school closures that result in transition to remote learning (*10*), highlighting a need for adequate heating and cooling in school buildings as seasons change. Ventilation improvements can improve infectious and noninfectious disease outcomes for students and staff members (*4,10*).

Combined with staying current with COVID-19 vaccinations, staying home when sick, practicing proper hand hygiene and respiratory etiquette (including masking when appropriate), ventilation is part of a comprehensive approach to reducing COVID-19 spread and maintaining safe, in-person learning. Public health and education professionals can support districts in undertaking ventilation improvements now that might lead to far-reaching improvements among a variety of student and staff member health outcomes. Ensuring equitable access to resources, support, and other facilitators of ventilation improvements is important given identified geographic and socioeconomic disparities.

[¶¶] https://oese.ed.gov/offices/american-rescue-plan/american-rescue-plan-elementary-and-secondary-school-emergency-relief

Acknowledgments

Johns Hopkins University Applied Physics Laboratory; Palantir Technologies; MCH Strategic Data.

Corresponding author: Miguella Mark-Carew, ocr2@cdc.gov.

---

[1]Global Government Solutions, San Antonio, Texas; [2]Division of Preparedness and Emerging Infections, National Center for Zoonotic and Emerging Infectious Diseases, CDC; [3]Division of Adolescent and School Health, National Center for HIV, Viral Hepatitis, STD, and TB Prevention, CDC; [4]Division of Field Studies and Engineering, National Institute for Occupational Safety and Health, CDC; [5]Respiratory Health Division, National Institute for Occupational Safety and Health, CDC.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflicts of interest were disclosed.

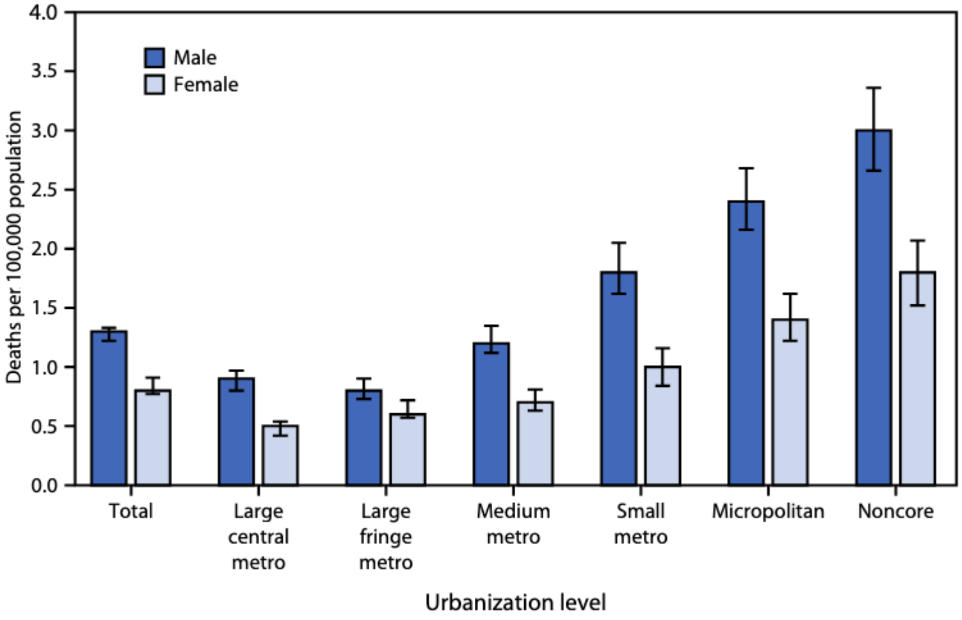
References

1. CDC. COVID-19: ventilation in buildings. Atlanta, GA: US Department of Health and Human Services, CDC; 2021. Accessed February 15, 2023. https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html
2. Thornton GM, Fleck BA, Dandnayak D, Kroeker E, Zhong L, Hartling L. The impact of heating, ventilation and air conditioning (HVAC) design features on the transmission of viruses, including the 2019 novel coronavirus (COVID-19): a systematic review of humidity. PLoS One 2022;17:e0275654. PMID:36215321 https://doi.org/10.1371/journal.pone.0275654
3. Environmental Protection Agency. Indoor air and coronavirus (COVID-19). Washington, DC: US Environmental Protection Agency; 2023. Accessed February 15, 2023. https://www.epa.gov/coronavirus/indoor-air-and-coronavirus-covid-19
4. Gettings J, Czarnik M, Morris E, et al. Mask use and ventilation improvements to reduce COVID-19 incidence in elementary schools—Georgia, November 16–December 11, 2020. MMWR Morb Mortal Wkly Rep 2021;70:779–84. PMID:34043610 https://doi.org/10.15585/mmwr.mm7021e1
5. CDC. COVID-19: ventilation in schools and childcare programs. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. Accessed February 15, 2023. https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html
6. Environmental Protection Agency. Indoor air quality tools for schools action kit. Washington, DC: US Environmental Protection Agency; 2022. Accessed February 15, 2023. https://www.epa.gov/iaq-schools/indoor-air-quality-tools-schools-action-kit
7. American Association of School Administrators. School district spending of American Rescue Plan funding: a snapshot. Alexandria, VA: American Association of School Administrators; 2021. Accessed March 7, 2023. https://www.aasa.org/docs/default-source/resources/reports/american-rescue-plan-survey-part-i.pdf
8. Pampati S, Rasberry CN, McConnell L, et al. Ventilation improvement strategies among K–12 public schools—The National School COVID-19 Prevention Study, United States, February 14–March 27, 2022. MMWR Morb Mortal Wkly Rep 2022;71:770–5. PMID:35679198 https://doi.org/10.15585/mmwr.mm7123e2
9. Fisk WJ. The ventilation problem in schools: literature review. Indoor Air 2017;27:1039–51. PMID:28683161 https://doi.org/10.1111/ina.12403
10. Jahan FA, Zviedrite N, Gao H, Ahmed F, Uzicanin A. Causes, characteristics, and patterns of prolonged unplanned school closures prior to the COVID-19 pandemic—United States, 2011–2019. PLoS One 2022;17:e0272088. PMID:35905084 https://doi.org/10.1371/journal.pone.0272088

QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Rates* of Death Due to Unintentional Injury from Fire or Flames,† by Sex and Urbanization Level§ — National Vital Statistics System, United States, 2021



* Crude rate of deaths per 100,000 population; 95% CIs indicated by error bars.

† Deaths due to unintentional injury from fire or flames were identified using *International Classification of Diseases, Tenth Revision* underlying cause-of-death codes X00–X09.

§ Counties were classified using the 2013 National Center for Health Statistics Urbanization Classification Scheme for Counties. https://www.cdc.gov/nchs/data/series/sr_02/sr02_166.pdf

In 2021, the rates of death due to unintentional injury from fire or flames were 1.3 per 100,000 population among males and 0.8 among females and were higher for males than for females at each level of urbanization. Rates among males were lowest in large fringe (0.8) and large central (0.9) metropolitan areas and then increased with decreasing urbanization to 3.0 in noncore areas. Rates among females were lowest in large central metropolitan areas (0.5) and increased with decreasing urbanization to 1.8 in noncore areas.

Source: National Center for Health Statistics, National Vital Statistics System, Mortality Data, 2021. https://www.cdc.gov/nchs/nvss/deaths.htm

Reported by: Merianne R. Spencer, MPH, MSpencer@cdc.gov; Matthew F. Garnett, MPH.

The *Morbidity and Mortality Weekly Report (MMWR)* Series is prepared by the Centers for Disease Control and Prevention (CDC) and is available free of charge in electronic format. To receive an electronic copy each week, visit *MMWR* at *https://www.cdc.gov/mmwr/index.html*.

Readers who have difficulty accessing this PDF file may access the HTML file at https://www.cdc.gov/mmwr/index2023.html. Address all inquiries about the *MMWR* Series to Editor-in-Chief, *MMWR* Series, Mailstop V25-5, CDC, 1600 Clifton Rd., N.E., Atlanta, GA 30329-4027 or to mmwrq@cdc.gov.

All material in the MMWR Series is in the public domain and may be used and reprinted without permission; citation as to source, however, is appreciated.

MMWR and *Morbidity and Mortality Weekly Report* are service marks of the U.S. Department of Health and Human Services.

Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services.

References to non-CDC sites on the Internet are provided as a service to *MMWR* readers and do not constitute or imply endorsement of these organizations or their programs by CDC or the U.S. Department of Health and Human Services. CDC is not responsible for the content of these sites. URL addresses listed in *MMWR* were current as of the date of publication.

ISSN: 0149-2195 (Print)