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Cannabis Use Among Students in Grades 8, 10, and 12, by Sex — King County, Washington, 2008–2021

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Abstract

Cannabis use during adolescence is associated with poor outcomes, including cognitive impairment, cannabis use disorder, and impaired driving. To guide prevention and use reduction strategies, Public Health — Seattle & King County described recent trends in cannabis use by sex among King County, Washington students in grades 8, 10, and 12 and examined trends in sex-based differences. Data collected during seven 2008–2021 survey periods by the Healthy Youth Survey (administered by the Washington State Department of Health) and restricted to King County students in grades 8, 10, and 12 (range = 33,439–39,391 students per cycle) were analyzed. Prevalence estimates were generated and sex-based prevalence differences (PDs) in current use (≥1 day during the previous 30 days) and frequent use (≥6 days during the previous 30 days) were assessed. PD models used weighted generalized linear regression with an interaction between sex and survey year. During 2008–2021, cannabis use declined among both male and female students. During 2008–2014, cannabis use was higher among male students than among female students (e.g., PD in 2008 = 4.8%) and not significantly different during 2014–2016; however, in 2021, current-use prevalence was lower among male students than among female students for the first time (PD = −1.3%). Frequent-use prevalence was similar among males and females. By grade levels, the highest prevalence of both current and frequent cannabis use was observed among 12th grade students, followed by 10th and 8th graders. Sex-specific differences by grade mirrored overall patterns. Developing tailored interventions that consider potential differences in risk and protective factors by sex or gender identity could promote equity in youth (grades 8, 10, and 12) cannabis use reduction measures.

Introduction

Cannabis use during adolescence is associated with poor outcomes, including cognitive impairment, cannabis use disorder (the inability to stop using cannabis despite the presence of health and social problems), and an increased risk for being involved in a motor vehicle collision because of impaired driving (*1*). More frequent use might be a stronger predictor of these outcomes (*1*). In 2012, Washington was among the first states to legalize nonmedical cannabis use for adults aged ≥21 years, prompting concern about how this measure might affect use by younger persons. Multiple factors might lead to increased cannabis use by youths, including increased permissiveness, reduced perception of potential harm, and an increase in alternative consumption methods (e.g., edibles and vaping) (*2*,*3*). Despite these concerns, however, data from Washington suggest that legalization was not associated with increased cannabis use by adolescents and young adults (*4*,*5*). Although the Healthy Youth Survey, administered by Washington State Department of Health, shows overall declines in cannabis

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use based on data through 2016, less is known about trends among more frequent users, or how trends might have varied by gender or sex assigned at birth (*5*). Historically, prevalence of cannabis use has been higher among male youths than their female counterparts (*6*). However, recent national data indicate a shift, with prevalence now higher among female youths compared with male youths (*7*). To guide prevention and reduction strategies, Public Health — Seattle & King County (PHSKC) described trends and examined sex-based differences in both current and more frequent cannabis use among youths in King County, Washington.

Methods

Data Source

The Healthy Youth Survey is a representative, biennial, cross-sectional survey of health and health-related behaviors administered by Washington State Department of Health to public school students in grades 6, 8, 10, and 12. Students complete anonymous self-administered questionnaires during structured classroom time. The Healthy Youth Survey has been conducted in even numbered years, except 2020, when it was delayed until 2021 because of shifts to remote learning during the COVID-19 pandemic (*8*). PHSKC used data from seven survey cycles conducted during 2008–2021, restricting analyses to King County students in grades 8, 10, and 12. The analytic sample from each cycle ranged from 33,439 students in 2021 to 39,391 students in 2016.

Data Analysis

Current (≥1 day during the previous 30 days) and frequent (≥6 days during the previous 30 days) cannabis use prevalence estimates by sex assigned at birth were generated, and patterns were described. Crude prevalence differences (PDs) and 95% CIs by sex were assessed using separate generalized linear models for each outcome containing a quasibinomial distribution and identity link. Models contained an interaction term between sex and categorical survey year, accounting for variations in PDs over time; PDs corresponded to the coefficients for sex. P-values <0.05 were considered statistically significant, corresponding to estimates for which 95% CIs exclude 0. Lastly, analyses were replicated, stratifying by grade (8, 10, and 12). Analyses used raked weights based on grade by sex by school district margins to be representative of King County public school students in grades 8, 10, and 12. Analyses were conducted using R software (version 4.2.3; R Foundation). This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.*

Results

During 2008, 2010, and 2012, the prevalence of current cannabis use was stable among both male students (19.2%, 20.4%,

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

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and 20.3%, respectively) and female students (14.4%, 14.9%, and 15.5%, respectively) (Table). The 2014 survey cycle identified a decline in current use for male students (from 20.3% in 2012 to 16.4% in 2014), whereas current use remained stable among female students (15.5% in 2012 and 15.2% in 2014). Prevalence of current use was lowest during the 2021 cycle for both male (7.7%) and female students (9.0%). Patterns of frequent cannabis use by sex over time were similar. Likewise, frequent-use prevalence was lowest during the 2021 cycle for both male students (3.7%) and female students (3.6%).

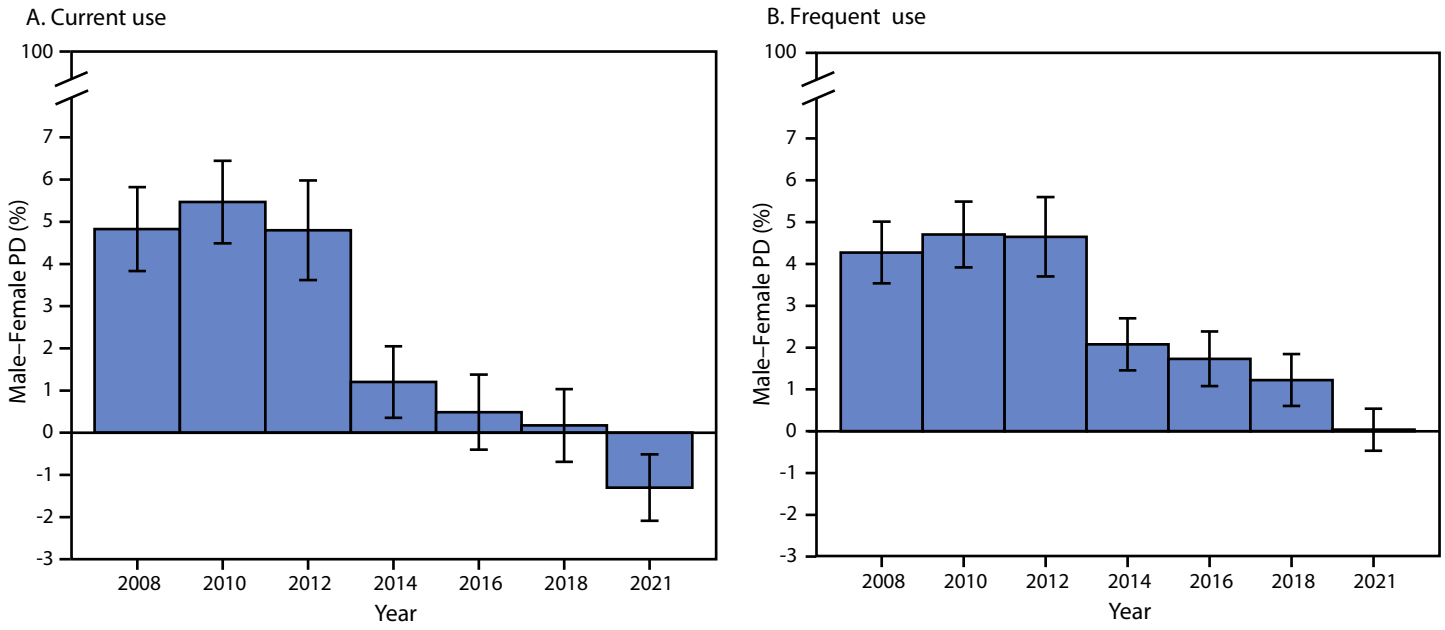
Examination of current cannabis use by sex revealed that prevalence among male students was significantly higher than that among female students between the 2008 (PD = 4.8%, 95% CI = 3.8%–5.8%) and 2014 (PD = 1.2%, 95% CI = 0.4%–2.0%) cycles (Figure), although sex-specific current-use prevalences among male and female students were not significantly different during the 2016 and 2018 cycles. In 2021, however, current-use prevalence among male students was significantly lower than that among female students, representing a reversal of previous sex-specific differences (PD = −1.3%, 95% CI = −2.1% to −0.5%). Frequent-use prevalence among male students was significantly higher than that among female students across all cycles except 2021, during which no substantial difference existed. During 2021, the highest prevalence of current cannabis use was observed among 12th grade students (males 15.3%, females 17.4%), followed by 10th (males 5.1%, females 7.0%) and 8th graders (males 1.8%, females 2.1%). Similar patterns were seen for frequent cannabis use by grade levels with the highest use among 12th grade students. (Supplementary Table; https://stacks.cdc.gov/view/cdc/140555).

TABLE. Weighted* prevalence of current† and frequent§ cannabis use among students in grades 8, 10, and 12, by sex assigned at birth — Washington Healthy Youth Survey, King County, Washington, 2008–2021

Survey year	Cannabis use status, % (95% CI)			
	Current use†		Frequent use§	
	Male	Female	Male	Female
2008	19.2 (17.5–21.1)	14.4 (13.0–16.0)	9.0 (8.0–10.1)	4.7 (4.1–5.4)
2010	20.4 (18.7–22.1)	14.9 (13.7–16.1)	9.8 (8.8–10.9)	5.1 (4.5–5.7)
2012	20.3 (18.5–22.3)	15.5 (14.1–17.0)	10.0 (8.9–11.2)	5.3 (4.7–6.0)
2014	16.4 (14.9–18.0)	15.2 (13.9–16.6)	7.5 (6.6–8.4)	5.4 (4.8–6.0)
2016	15.0 (13.4–16.8)	14.6 (13.1–16.2)	7.2 (6.3–8.2)	5.4 (4.8–6.2)
2018	15.3 (13.9–16.8)	15.1 (13.7–16.6)	6.5 (5.8–7.4)	5.3 (4.7–6.0)
2021	7.7 (6.4–9.3)	9.0 (7.7–10.6)	3.7 (3.0–4.5)	3.6 (3.0–4.4)

* Reflects King County, Washington public school enrollment by grade and sex assigned at birth.
† One or more days during the previous 30 days.
§ Six or more days during the previous 30 days.

FIGURE. Weighted sex-based prevalence differences* in current† (A) and frequent§ (B) cannabis use among students in grades 8, 10, and 12 — Washington Healthy Youth Survey, King County, Washington, 2008–2021¶



Abbreviation: PD = prevalence difference.
* With 95% CIs indicated by error bars.
† One or more days during the previous 30 days.
§ Six or more days during the previous 30 days.
¶ 2020 survey delayed from 2020 until 2021 because of the COVID-19 pandemic.

Summary

What is already known about this topic?

Cannabis use during adolescence is associated with poor outcomes, including cognitive impairment and impaired driving. Cannabis use among younger persons has been declining, but less is known about sex-specific trends.

What is added by this report?

During 2008–2021, in King County, Washington, current cannabis use prevalences among male and female students in grades 8, 10, and 12 declined. During 2008–2014, current-use prevalence was higher among male students than among female students. In 2021, for the first time, current-use prevalence was lower among male students than female students.

What are the implications for public health practice?

Developing tailored interventions that consider potential differences in risk and protective factors by sex or gender identity could promote equity in youth cannabis use reduction strategies.

Discussion

During 2008–2021, in addition to overall decreases in cannabis use among students in grades 8, 10, and 12 in King County, Washington, a narrowing and possible reversal of sex-based differences in current cannabis use was observed. These reported recent decreases in cannabis use among students in grades 8, 10, and 12 are consistent with overall statewide trends (*8*) and sex-stratified trends in national data showing larger decreases among male students (*7*).

Decrease in Cannabis Use

The observed overall decreases in cannabis use among students in grades 8, 10, and 12 might be associated with changes in the availability of cannabis among persons aged ≥21 years as well as limited opportunities to engage in use. The period 2012–2014 includes the legalization of nonmedical cannabis in Washington in 2012. Researchers studying the association of cannabis laws with cannabis use among high school students (grades 9–12) have observed similar declines in cannabis use after legalization of nonmedical cannabis (*9*). The legalization of nonmedical cannabis for adults aged ≥21 years in Washington with licensed dispensaries requiring proof of age might have affected availability of cannabis to younger persons as well as their opportunities to engage in its use. This, in turn, might have had an impact on use prevalence. The period 2018–2021 also included the unexpected shift to remote learning environments in 2020 associated with the COVID-19 pandemic. With increased time spent at home, students might have been subject to increased parental supervision, which could deter substance use, including use of cannabis. Increased parental supervision could have been compounded by limited access to cannabis, if a main source was from friends or social settings away from the home.

Sex Differences in Cannabis Use

Shifts in sex-specific differences in cannabis use raise questions about underlying factors and potential implications for prevention and use reduction strategies for youths. One explanation for diminishing sex-specific differences might be related to a previous focus on higher prevalence users. For example, interventions might have been most effective among males because of their higher use prevalences. A second explanation might be related to evolving social norms regarding cannabis use. Among adolescents, a positive association between cannabis use and norms surrounding its use has been established (*2*). However, whether the strength of the association has changed over time, varies by sex, or has become stronger for females than for males is unclear. Future studies might examine trends in cannabis use norms by sex, and the association between norms and cannabis use by sex.

Limitations

The findings in this report are subject to at least four limitations. First, because cannabis use was self-reported, use might have been underreported (e.g., because of legal implications). To mitigate this potential bias, the Healthy Youth Survey was administered during structured classroom time in a test-like environment, and no identifying information was collected (*10*). Second, this report relied on self-reported sex assigned at birth to categorize students by sex and does not include students who identify as transgender or nonbinary. The Healthy Youth Survey introduced gender identity questions in 2018; thus, examining trends by gender identity was not possible. Third, this report provides trends in prevalence of cannabis use among King County students in grades 8, 10, and 12, and was not intended to identify contextual factors that might have influenced cannabis use estimates (e.g., legalization or the COVID-19 pandemic). Finally, findings do not necessarily apply to students who are not in grades 8, 10, and 12 enrolled in King County, Washington public schools.

Implications for Public Health Practice

Although downward trends in cannabis use among King County students in grades 8, 10, and 12 are encouraging, continued monitoring is necessary to better understand longer-term effects of social phenomena, including cannabis legalization and pandemic-related disruptions, and to assess whether observed decreases are sustained. It is important for monitoring to prioritize identifying differences across demographic characteristics, including sex or gender identity, which can potentially support the development of tailored interventions and ensure equity in programmatic cannabis use reduction and prevention measures. Lastly, whereas the focus of the present analysis was on sex, future analyses could explore potential variations across additional demographic variables including race, ethnicity, or socioeconomic status.

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References

1. Volkow ND, Baler RD, Compton WM, Weiss SR. Adverse health effects of marijuana use. N Engl J Med 2014;370:2219–27. PMID:24897085 https://doi.org/10.1056/NEJMra1402309
2. Stone AL. Adolescent cannabis use and perceived social norm trends pre- and post-implementation of Washington state's liberalized recreational cannabis policy: Healthy Youth Survey, 2008–2018. Prev Sci 2020;21:772–83. PMID:32507995 https://doi.org/10.1007/s11121-020-01136-0
3. Mennis J, McKeon TP, Stahler GJ. Recreational cannabis legalization alters associations among cannabis use, perception of risk, and cannabis use disorder treatment for adolescents and young adults. Addict Behav 2023;138:107552. PMID:36413909 https://doi.org/10.1016/j.addbeh.2022.107552
4. Bailey JA, Tiberio SS, Kerr DCR, Epstein M, Henry KL, Capaldi DM. Effects of cannabis legalization on adolescent cannabis use across 3 studies. Am J Prev Med 2023;64:361–7. PMID:36372654 https://doi.org/10.1016/j.amepre.2022.09.019
5. Dilley JA, Richardson SM, Kilmer B, Pacula RL, Segawa MB, Cerdá M. Prevalence of cannabis use in youths after legalization in Washington state. JAMA Pediatr 2019;173:192–3. PMID:30566196 https://doi.org/10.1001/jamapediatrics.2018.4458
6. Johnson RM, Fairman B, Gilreath T, et al. Past 15-year trends in adolescent marijuana use: differences by race/ethnicity and sex. Drug Alcohol Depend 2015;155:8–15. PMID:26361714 https://doi.org/10.1016/j.drugalcdep.2015.08.025
7. Hoots BE, Li J, Hertz MF, et al. Alcohol and other substance use before and during the COVID-19 pandemic among high school students—Youth Risk Behavior Survey, United States, 2021. MMWR Suppl 2023;72(No. Suppl 1): 84–92. https://doi.org/10.15585/mmwr.su7201a10
8. Washington State Health Care Authority, Washington State Department of Health, Office of the Superintendent of Public Instruction, Liquor and Cannabis Board. Healthy Youth Survey 2021 analytic report. Olympia, WA: Looking Glass Analytics, Inc.; 2022. https://www.askhys.net/HYS/GetDocument?path=Reports&fileName=HYS%202021%20Analytic%20Report.pdf
9. Anderson DM, Hansen B, Rees DI, Sabia JJ. Association of marijuana laws with teen marijuana use: new estimates from the Youth Risk Behavior surveys. JAMA Pediatr 2019;173:879–81. PMID:31282944 https://doi.org/10.1001/jamapediatrics.2019.1720
10. Washington State Health Care Authority, Washington State Department of Health, Office of the Superintendent of Public Instruction, Liquor and Cannabis Board. 2021 Healthy Youth Survey interpretive guide. Olympia, WA: Looking Glass Analytics, Inc.; 2022. https://www.askhys.net/HYS/GetDocument?path=Training&fileName=Interpretive%20Guide.pdf

Pseudomonas Infection Outbreak Associated with a Hotel Swimming Pool — Maine, March 2023

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Abstract

Treated recreational water venues (e.g., pools and hot tubs) located at hotels represent one third of sources of reported treated recreational water–associated outbreaks; when these outbreaks are caused by *Pseudomonas aeruginosa*, they predominantly occur during January–April. On March 8, 2023, the Maine Center for Disease Control and Prevention (Maine CDC) initiated an investigation in response to reports of illness among persons who had used a swimming pool at hotel A during March 4–5. A questionnaire was distributed to guests who were at hotel A during March 1–7. Among 35 guests who responded, 23 (66%) developed ear pain, rash, or pain or swelling in feet or hands within days of using the pool during March 4–5. *P. aeruginosa*, a chlorine-susceptible bacterium, was identified in cultures obtained from skin lesions of three patients; a difference of two single nucleotide polymorphisms was found between isolates from two patients' specimens, suggesting a common exposure. Hotel A management voluntarily closed the pool, and Maine CDC's Health Inspection Program identified multiple violations, including having no disinfectant feeder system, all of which had been identified during a previous inspection. Because chlorine had been added to the pool water after the pool was voluntary closed, environmental samples were not collected. The pool remained closed until violations were addressed. Health departments can play an important role in reducing the risk for outbreaks associated with hotel pools and hot tubs. This reduction in risk can be achieved by collaborating with operators to ensure compliance with public health codes, including maintaining chlorine concentration and otherwise vigilantly managing the pool, and by disseminating prevention messages to pool and hot tub users.

Investigation and Results

Reports of Illnesses Associated with Hotel A Swimming Pool

On March 7, 2023, the Maine Center for Disease Control and Prevention (Maine CDC) received a report from a group of hotel guests who had developed ear pain, rashes, and eye irritation after using a swimming pool at hotel A during the March 4–5 weekend. Later that day, an additional family that had used hotel A's swimming pool the same weekend reported experiencing similar illness, in addition to redness and pain of their hands and feet. Over the next 2 days, four additional groups of guests reported similar illnesses after using the hotel A pool during the same weekend. On March 7, in response to the reports, Maine CDC's Health Inspection Program contacted hotel A and learned that management had voluntarily closed the pool after receiving guest complaints. In response, on March 8, Maine CDC initiated an epidemiologic, laboratory, and environmental health investigation.

Case Identification

Maine CDC used illness reports to identify six households with members who had visited hotel A's pool during the weekend of March 4–5 and interviewed a representative from each household using a standard questionnaire. Interviewers asked about other groups or persons who had used the hotel pool; additional identified persons were also contacted and interviewed. Guests were asked about their use of the hotel A pool, other pools, and hot tubs since February 24, and subsequent illness.

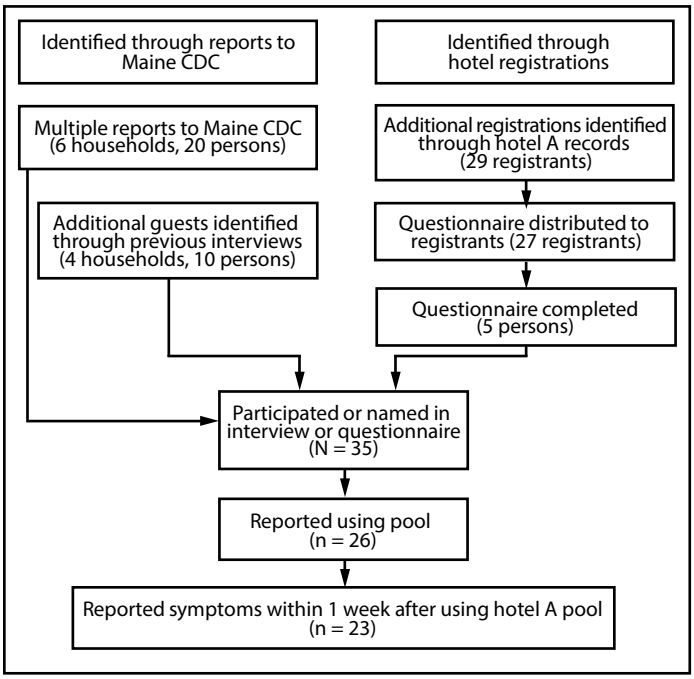
A total of 10 households (30 guests) were identified as having visited or used the hotel A pool during March 4–5 (Figure 1); one person per household was interviewed about all household members who used the pool. To further assess the scope of the outbreak, Maine CDC obtained a list of registered guests who were at hotel A during March 1–7 and identified 29 additional registrants who might have been present at hotel A during March 4–5. These additional registrants were sent the standardized questionnaire by text or email and asked to fill out a separate questionnaire for each household member who used the pool. Questionnaires were completed for five additional guests.

A total of 15 interviews or questionnaires were completed for 35 unique persons. Maine CDC requested that symptomatic guests ask their health care provider to obtain a skin lesion swab for laboratory analysis and requested that laboratories send any isolates to Maine's Health and Environmental Testing Laboratory. This study was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.*

A case was defined as the occurrence of ear pain, rash, or pain or swelling in feet or hands in a person within 7 days after

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

FIGURE 1. Identification of guests who used the pool at hotel A — Maine, March 4–5, 2023*,†



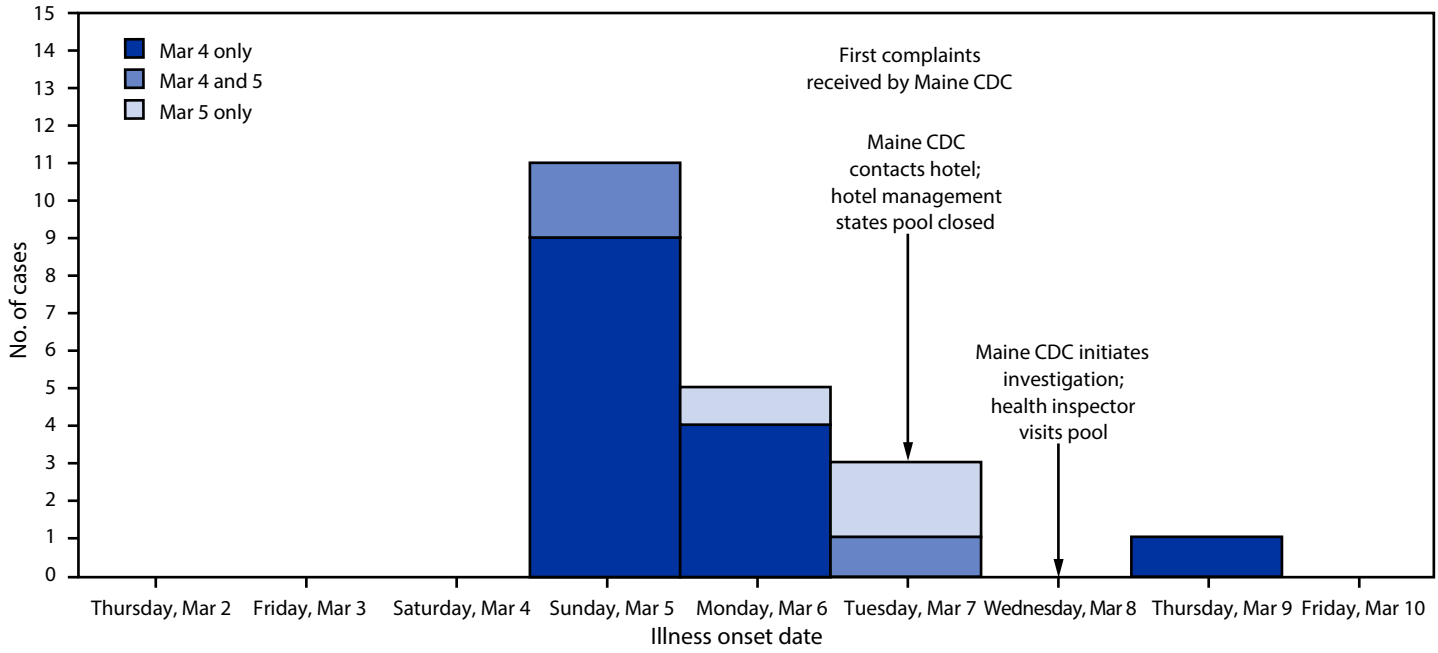
Abbreviation: Maine CDC = Maine Center for Disease Control and Prevention.
* "Additional registrations" are registration records for guests not previously identified; records did not include the total number of guests per registration.
† The survey questionnaire was not distributed to two of the 29 hotel A registrants; these two guests booked through a third-party website and did not input a telephone number or email address.

using the hotel pool during March 4–5. Among 35 persons for whom information was available, 26 (74%) reportedly used the hotel A swimming pool during March 4–5. Among these 26 persons, 23 (88%) experienced an illness meeting the case definition; illness onset date was available for 20 persons (Figure 2). Among the 23 patients, 16 (70%) had ear pain, 15 (65%) had a rash, and seven (30%) had pain or swelling in their feet or hands (Table). Fifteen (65%) patients were female. Among 22 patients with available information, age ranged from 5 months to 61 years (median = 8 years). Among 20 patients with reported time and date of illness onset, illness began a median of 24 hours (range = 8 hours–6 days) after use of the hotel A pool.

Laboratory Evaluation

Skin lesion swabs were obtained from three patients, two of whom were family members who lived in separate households, spent time together outside of the hotel pool, and had no other pool or hot tub exposures. *P. aeruginosa* was identified in all three specimens; the isolates of the two family members were sent to Maine's Health and Environmental Testing Laboratory for whole genome sequencing. Single nucleotide polymorphism (SNP) analysis, using CLC-BIO (version 23.0.2; Qiagen Aarhus), indicated that the two isolates were highly related with a two-SNP difference, suggesting a common exposure.

FIGURE 2. Identified cases of *Pseudomonas* infection, by dates of illness onset and hotel swimming pool use (n = 20)* — Maine, March 2023



Abbreviation: Maine CDC = Maine Center for Disease Control and Prevention.
* Illness onset date not available for three pool users with reported illness.

TABLE. Characteristics of illness and exposure to swimming pool water — hotel A, Maine, March 2023

Characteristic	No. of cases (%)
Total	**23 (100)**
Time of illness onset after pool use, hrs	
<12	1 (4)
12–23	5 (22)
24–48	13 (57)
>48	1 (4)
Unknown	3 (13)
Signs and symptoms	
Ear pain	16 (70)
Rash	15 (65)
Runny nose	9 (39)
Pain or swelling in hands or feet	7 (30)
Eye irritation	5 (22)
Fatigue	4 (17)
Diarrhea	3 (13)
Joint pain	2 (9)
Lymphadenopathy	2 (9)
Vomiting	2 (9)
Length of time spent in pool, hrs	
<1	4 (17)
1–2	12 (52)
>2	3 (13)
Unknown	4 (17)
Interval from pool use to showering after pool use, hrs	
<1	2 (9)
>1, same day	3 (13)
No shower same day	4 (17)
Unknown or no response	14 (61)

Hotel A Pool Inspections

In January 2022, the hotel pool had failed a routine health department inspection. During that inspection, several violations were identified: 1) no operator had successfully completed approved training, 2) no pool logs documenting free chlorine[†] concentration readings at least three times per day while the pool was open for use, 3) no posted routine operating procedures, and 4) no functioning disinfectant feeder installed. During the subsequent March 8, 2023, inspection, the health inspector noted that although the hotel did have an operator who had successfully completed approved training <2 weeks before inspection, none of the other previously identified violations had been corrected. The pool logs for March 1–5 showed two compliant free chlorine concentration readings, not the expected 15, and both readings were dated March 3. The inspector also noted that an indeterminant amount of chlorine had been added to the pool water by hotel staff members after they voluntarily closed the pool; therefore, water quality and environmental samples were not collected.

Because the identified violations included imminent health hazards and uncorrected previously identified violations, Maine CDC's Health Inspection Program directed hotel A to not reopen the pool until all the violations were addressed. The health inspector provided recommendations to address the violations. On reinspection 1 month later, the violations were noted to be corrected. No additional hotel A pool-associated illnesses were identified after reopening.

[†] Free chlorine is the most active disinfectant form of chlorine.

Discussion

P. aeruginosa can cause acute otitis externa (swimmer's ear), folliculitis (hot tub rash) (*1*), and painful nodular lesions on the soles or palms (hot hand-foot syndrome) (*2*) and is likely to be transmitted through contact with contaminated water in pools or hot tubs and not through person-to-person contact (*3*). *P. aeruginosa* is readily inactivated by disinfectants such as chlorine and bromine. Because of this, maintaining a minimum free chlorine concentration of at least 1 ppm[§] in treated recreational water venues open to the public as recommended by CDC and as required by Maine's pool code, prevents waterborne transmission of most pathogens, including *P. aeruginosa*. The lack of an installed and functioning disinfectant feeder in this pool and inadequate monitoring of the free chlorine concentration during March 1–5, particularly the March 4–5 weekend, would make it more challenging to maintain adequate free chlorine concentration, and thus, more challenging to prevent pathogen transmission. Inadequately maintained disinfectant concentration can lead to proliferation of *P. aeruginosa* and buildup of biofilm on wet venue surface, scale, and sediment. Biofilm is a primarily polysaccharide matrix that is produced by microbial cells and in which bacteria are embedded; biofilm is difficult to remove and cannot be removed by gentle rinsing (*4*). Even when adequate disinfectant concentration is maintained, the extracellular matrix of the biofilm can protect *P. aeruginosa* and other pathogens from disinfectants.

Among 987 treated recreational water–associated outbreaks reported to CDC for the period 1971–2021, 369 (37.4%) were linked to a hotel setting (i.e., hotel, motel, lodging, inn, or resort) (*5*). In addition, for the period 1971–2021, 38 states reported 222 outbreaks associated with treated recreational water venues that were confirmed or suspected to be caused by *P. aeruginosa* (*5*), 152 (68%) of which were associated with a hotel setting. Seventeen (11%) of these 152 outbreaks were associated with pools only and 87 (57%) with hot tubs only.[¶] Among the 152 outbreaks, 100 (66%) began during January–April. Outbreak exposures often occur during a weekend, when trained operators might not be on duty, and when events, including parties and sports tournaments, are scheduled (*6*).

[§] At 1 ppm free chlorine, most pathogens are inactivated within minutes at a pH of 7.0–7.8 and temperature of 77°F (25°C). pH determines the relative amounts of hypochlorous acid (HOCl, the most active free chlorine disinfectant) and hypochlorite ion (OCl^-, a less active free chlorine disinfectant).

[¶] Another 44 (29%) outbreaks were associated with both pools and hot tubs; the remaining four (3%) were associated with other or unknown treated recreational water venues.

Summary

What is already known about this topic?

Treated recreational water venues (e.g., pools and hot tubs) located at hotels or resorts represent one third of sources of reported outbreaks associated with treated recreational water.

What is added by this report?

In March 2023, 23 persons developed ear pain, rash, or pain or swelling in their feet or hands after swimming in a hotel pool in Maine. The outbreak was caused by *Pseudomonas aeruginosa*. Inadequate maintenance and monitoring of chlorine concentration likely contributed to this outbreak.

What are the implications for public health practice?

Outbreak prevention strategies include maintaining chlorine concentration and otherwise vigilantly managing the pool, especially during January–April, and disseminating prevention messaging to pool and hot tub users.

To help prevent outbreaks caused by *P. aeruginosa* and other pathogens readily inactivated by disinfectants, local, state, territorial, and tribal jurisdictions can voluntarily adopt recommendations in CDC's Model Aquatic Health Code (MAHC).** Such recommendations include having an operator who has successfully completed approved training to ensure adequate recreational water disinfectant concentration (MAHC 5.7.3.1.1 and 5.7.3.1.2) (*7*,*8*) and conducting a daily preopening inspection for biofilm (MAHC 6.4.1.3.1) and, if needed, removing biofilm by vigorous scrubbing. Public health officials can also increase awareness of healthy swimming by disseminating prevention messages, including recommendations to check the latest inspection score before using the pool. Much like restaurant inspection scores, scores from inspections of treated recreational water venues open to the public provide an assessment of operation and management. These scores are often posted waterside or on the jurisdiction's website. Because inspections are a snapshot in time, pool and hot tub users can additionally protect themselves by conducting their own mini-inspection before getting in the water†† (e.g., measuring the disinfectant levels and pH using test strips that are readily available at hardware and big-box stores); such interventions should not replace pool and hot tub management but can provide users a timely assessment of water conditions.

Limitations

The findings in this report are subject to at least two limitations. First, the reported number of persons who used the hotel pool and subsequently developed illness meeting the case definition likely underestimates the actual incidence. For example, although the hotel identified 29 additional guest registrants who were at the hotel during the March 4–5 weekend, only five completed the questionnaire. Second, a definitive link between illness and the hotel pool could not be established. The two isolates found to be only two SNPs apart were from family members who both used the hotel pool but also spent time together outside of the hotel pool. Not collecting environmental samples precluded molecular characterization of an isolate and comparison with clinical isolates. However, neither family member reported other pool or hot tub exposures, and *P. aeruginosa* is likely to be transmitted through contaminated water but not person to person. The hotel pool remains the most likely source of exposure.

Implications for Public Health Practice

Enforcement of local, state, territorial, and tribal codes and dissemination of prevention messaging to pool and hot tub users can reduce the likelihood of outbreaks caused by *P. aeruginosa* and other pathogens. Healthy swimming promotion efforts are especially necessary when the public might be more likely to stay at hotels and use the pools and hot tubs. To prevent outbreaks, operators should be vigilant about proper operation and management, especially during January–April and weekends.

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** For reference purposes, MAHC elements that could reduce the risk for illness or injury are discussed in this report are followed by the specific section number that covers that element.

†† https://www.cdc.gov/healthywater/swimming/materials/infographic-inspection.html

References

1. Ratnam S, Hogan K, March SB, Butler RW. Whirlpool-associated folliculitis caused by *Pseudomonas aeruginosa*: report of an outbreak and review. J Clin Microbiol 1986;23:655–9. PMID:3082930 https://doi.org/10.1128/jcm.23.3.655-659.1986
2. Yu Y, Cheng AS, Wang L, Dunne WM, Bayliss SJ. Hot tub folliculitis or hot hand-foot syndrome caused by *Pseudomonas aeruginosa.* J Am Acad Dermatol 2007;57:596–600. PMID:17658195 https://doi.org/10.1016/j.jaad.2007.04.004
3. Gustafson TL, Band JD, Hutcheson RH Jr, Schaffner W. *Pseudomonas* folliculitis: an outbreak and review. Rev Infect Dis 1983;5:1–8. PMID:6828809 https://doi.org/10.1093/clinids/5.1.1
4. Donlan RM. Biofilms: microbial life on surfaces. Emerg Infect Dis 2002;8:881–90. PMID:12194761 https://doi.org/10.3201/eid0809.020063
5. CDC. National Outbreak Reporting System (NORS) dashboard. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. (Accessed December 11, 2023) https://wwwn.cdc.gov/norsdashboard/
6. Hlavsa MC, Roberts VA, Anderson AR, et al.; CDC. Surveillance for waterborne disease outbreaks and other health events associated with recreational water—United States, 2007–2008. MMWR Surveill Summ 2011;60(No. SS-12):1–32. PMID:21937976
7. Buss BF, Safranek TJ, Magri JM, Török TJ, Beach MJ, Foley BP. Association between swimming pool operator certification and reduced pool chemistry violations—Nebraska, 2005–2006. J Environ Health 2009;71:36–40. PMID:19408431
8. Johnston K, Kinziger M. Certified operators: does certification provide significant results in real-world pool & spa chemistry? Int J Aquat Res Educ 2007;1(1):18–33. https://doi.org/10.25035/ijare.01.01.03

Detecting Mpox Cases Through Wastewater Surveillance — United States, August 2022–May 2023

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Abstract

In October 2022, CDC's National Wastewater Surveillance System began routine testing of U.S. wastewater for *Monkeypox virus*. Wastewater surveillance sensitivity, positive predictive value (PPV), and negative predictive value (NPV) for *Monkeypox virus* were evaluated by comparing wastewater detections (*Monkeypox virus* detected versus not detected) to numbers of persons with mpox in a county who were shedding virus. Case ascertainment was assumed to be complete, and persons with mpox were assumed to shed virus for 25 days after symptom onset. A total of 281 cases and 3,492 wastewater samples from 89 sites in 26 counties were included in the analysis. Wastewater surveillance in a single week, from samples representing thousands to millions of persons, had a sensitivity of 32% for detecting one or more persons shedding *Monkeypox virus*, 49% for detecting five or more persons shedding virus, and 77% for detecting 15 or more persons shedding virus. Weekly PPV and NPV for detecting persons shedding *Monkeypox virus* in a county were 62% and 80%, respectively. An absence of detections in counties with wastewater surveillance signified a high probability that a large number of cases were not present. Results can help to guide the public health response to *Monkeypox virus* wastewater detections. A single, isolated detection likely warrants a limited public health response. An absence of detections, in combination with no reported cases, can give public health officials greater confidence that no cases are present. Wastewater surveillance can serve as a useful complement to case surveillance for guiding the public health response to an mpox outbreak.

Introduction

The global mpox outbreak began in May 2022 when mpox began spreading widely outside countries with endemic transmission.* Persons with mpox can shed *Monkeypox virus* DNA in skin lesions, urine, and stool; thus, *Monkeypox virus* infections can be tracked through wastewater surveillance (*1*). In October 2022, CDC's National Wastewater Surveillance System (NWSS),† which was established during the COVID-19 pandemic, began testing U.S. wastewater for *Monkeypox virus*. By May 2023, more than 500 sampling sites in 49 states were testing wastewater for *Monkeypox virus*.§ The goal of this analysis was to evaluate the sensitivity, positive predictive value (PPV), and negative predictive value (NPV) of wastewater surveillance for detecting mpox cases in the United States.

Methods

Data Sources

Sample-level NWSS wastewater data from August 2022–May 2023 (as of June 2023) were analyzed. *Monkeypox virus* wastewater data were reported to NWSS by a commercial contractor and an academic partner program; these entities began *Monkeypox virus* testing in October 2022 and June 2022, respectively¶ (*2,3*). Wastewater surveillance data were compared with case surveillance data** from the same period, as of July 2023. CDC mpox case definitions were used,†† and both confirmed and probable cases were included.

Data Analysis

Because of differences in reporting units for wastewater surveillance and case data, analyses were conducted by county and were restricted to counties with ≥90% population coverage by wastewater surveillance (Supplementary Figure 1, https://stacks.cdc.gov/view/cdc/140513). Population coverage was determined by dividing estimated numbers of persons served by all sampling sites in a county by the county population§§ (*4,5*). Only dates during which all sites serving a county were collecting samples were included in the analysis. Exact dates of

* https://www.cdc.gov/poxvirus/mpox/response/2022/index.html
† https://www.cdc.gov/nwss/wastewater-surveillance.html
§ https://www.cdc.gov/poxvirus/mpox/cases-data/wastewater-surveillance.html

¶ NWSS's commercial contractor began testing wastewater for *Monkeypox virus* in October 2022; it tested raw wastewater using quantitative polymerase chain reaction against a nonvariola Orthopoxvirus target that enables detection of both *Monkeypox virus* Clade I and Clade II. Detections were defined as samples with average concentrations >0 copies per liter. The academic partner program began testing wastewater for *Monkeypox virus* in July 2022; the program tested settled wastewater solid and primary sludge using droplet digital polymerase chain reaction. During July–December 2022, the program tested samples against a generic mpox target that enables detection of both *Monkeypox virus* Clade I and Clade II; a subset of samples was also tested using an assay specific to Clade II. In December 2022, generic mpox testing was discontinued, and all samples were tested with the Clade II assay. Detections were defined as samples with average concentrations >1,100 copies per gram.
** Jurisdictions reported case-level data to CDC electronically via a standardized case report form or the National Notifiable Disease Surveillance System (NNDSS). County of residence was reported for cases.
†† https://www.cdc.gov/poxvirus/mpox/clinicians/case-definition.html
§§ 2022 U.S. Census Bureau and 2021 State Health Department data (when U.S. Census Bureau estimates were not available by county) were used for county population estimates.

inclusion varied by county.[¶¶] Overall, included samples were collected during August 2022–May 2023.

Persons with mpox were assumed to shed virus uniformly for 25 days from the date of symptom onset[***] (*1*). Missing symptom onset dates (for approximately 20% of cases) were imputed by subtracting empirical median lag times (time between symptom onset and other clinical dates[†††]) from the earliest date available for each case (Supplementary Table, https://stacks.cdc.gov/view/cdc/140513).[§§§] Mpox case ascertainment was assumed to be complete, and only persons with confirmed or probable mpox were assumed to be shedding virus (*6*). Dichotomous county wastewater results (*Monkeypox virus* detection versus nondetection) were compared with the number of persons presumed to be shedding virus in the county on the sample collection date. If *Monkeypox virus* was detected in at least one sample from a county on a given day or week, that day or week was considered a virus detection day or week; if no *Monkeypox virus* was detected, that day or week was classified as a nondetection.

Sensitivity, PPV, and NPV of wastewater surveillance on a single day or week for detecting persons shedding *Monkeypox virus* in a county were calculated.[¶¶¶] Sensitivity was defined as the probability of a wastewater detection assuming that one or more persons was shedding virus. Sensitivities for detecting varying minimum numbers of persons shedding virus were also calculated. PPV was defined as the probability that at least one person was shedding virus when a wastewater detection occurred, and NPV was defined as the probability that no persons were shedding virus in the absence of wastewater detections. The probabilities that different numbers of persons were shedding virus given the presence or absence of wastewater detections were also examined.[****]

Three sensitivity analyses were performed. First, the assumed shedding duration was varied from 5 to 60 days in 5-day increments. Second, the earliest date available for all cases was used, rather than imputed symptom onset dates. Third, rolling 7-day average estimates were calculated,[††††] rather than weekly estimates. Analyses were conducted using R software (version 4.2.3; R Foundation). This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.[§§§§]

Results

A total of 3,492 wastewater samples from 89 sites and 26 counties (16 states) were included in the analysis (Table 1). *Monkeypox virus* DNA was detected in 95 samples (3%) from 17 counties (65%); 281 cases from 12 counties were included.[¶¶¶¶]

Sensitivity

Sensitivity of wastewater surveillance increased as the number of persons shedding *Monkeypox virus* increased. The probability that *Monkeypox virus* was detected in wastewater on a given day was 13.8% (95% CI = 10.7%–17.4%) when at least one person was shedding virus, 28.9% (95% CI = 21.9%–36.8%) when five or more persons were shedding virus, and 48.3% (95% CI = 35.2%–61.6%) when 15 or more persons were shedding virus (Table 2). When examining sensitivity during a given week, these estimates increased to 31.7% (95% CI = 23.6%–40.7%), 48.9% (95% CI = 33.7%–64.2%), and 76.5% (95% CI = 50.1%–93.2%), respectively.

Positive Predictive Value

PPV for predicting the presence of at least one person shedding *Monkeypox virus* in a county on a given day or

[¶¶] Earliest county inclusion dates were the maximum of minimum sample collection dates for all county sites (minus 6 days to account for sampling on different days of the week). Last inclusion dates were the minimum of maximum sample collection dates for all county sites (plus 6 days) or May 7, 2023 (1 month before data download), whichever date was earliest. For duplicate sites (collecting samples for two sources), dates were included if at least one source was collecting samples.

[***] Twenty-five days is the median time from illness onset to viral clearance in skin lesion samples, the sample type with the longest clearance time and highest viral load.

[†††] Other clinical dates included diagnosis date, date first reported to a public health department, first positive mpox test result date, rash onset date, case investigation start date, CDC case report date, and hospital admission date.

[§§§] Median lag times from symptom onset date were calculated from the full case data set (30,026 cases). Negative lag times and implausible dates were excluded from calculations. In the study data set, symptom onset date was changed to rash onset date if rash onset was earlier (four cases). The earliest date available for most cases (60%) with missing symptom onset date (59 cases) was diagnosis date (median lag time = 6 days).

[¶¶¶] Sensitivity = true positive (TP) / TP + false negative (FN); PPV = TP / TP + false positive (FP); NPV = true negative (TN) / TN + FN. TPs and FNs were defined as days or weeks with wastewater detections and no detections, respectively, and cases shedding. TNs and FPs were defined as days or weeks with no detections and detections, respectively, and no cases shedding. CIs were calculated using exact binomial tests. Specificity was not included because of limited utility in this context.

[****] Equations for sensitivity, PPV, and NPV were used for calculations; however, the definitions of TPs, FNs, FPs, and FNs were changed. TPs and FNs were defined as days or weeks with wastewater detections and no detections, respectively, and at least a specified number of cases shedding. TNs and FPs were defined as days or weeks with no detections and detections, respectively, and less than a specified number of cases shedding. For example, FPs for detecting five or more cases were days or weeks with wastewater detections and fewer than five cases shedding.

[††††] For each day in a given county, samples collected on that day and within 3 days earlier or later were included. If *Monkeypox virus* was detected in any of the samples, that day's 7-day period was considered a detection, and otherwise it was considered a nondetection. Wastewater results were compared with the average number of cases shedding over the 7-day period.

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

[¶¶¶¶] Cases were included in the analysis if they shed *Monkeypox virus* during dates of inclusion for county of residence; 281 cases were included in the main analysis (assuming 25 days of shedding). The number of cases included in all analyses ranged from 203 (assuming 5 days of shedding) to 632 (assuming 60 days of shedding).

TABLE 1. Information on population, *Monkeypox virus* wastewater samples, and persons with mpox during the study period for counties included in the analysis* — United States, August 2022–May 2023

County†	Population§	No. of wastewater samples	Average no. of samples collected per site per week (range)	No. of days with MPXV wastewater detections	No. of persons with mpox included¶	Wastewater sample collection date range**
1	250,000–999,999	487	2.9 (1–4)	29	70–79	Aug 2022–May 2023
2	250,000–999,999	73	1.4 (1–2)	6	20–29	Oct 2022–May 2023
3	≥1,000,000	215	1.7 (1–2)	6	60–69	Oct 2022–May 2023
4	≥1,000,000	172	1.7 (1–2)	9	50–59	Oct 2022–May 2023
5	20,000–249,999	20	1.1 (1–2)	7	0	Oct 2022–Mar 2023
6	2,500–19,999	104	1.4 (1–2)	0	0	Oct 2022–May 2023
7	250,000–999,999	80	1.8 (1–2)	4	1–9	Nov 2022–May 2023
8	250,000–999,999	194	1.8 (1–3)	0	0	Nov 2022–May 2023
9	20,000–249,999	107	1.7 (1–3)	1	0	Nov 2022–May 2023
10	20,000–249,999	31	1.4 (1–2)	0	0	Nov 2022–May 2023
11	20,000–249,999	33	1.6 (1–2)	3	1–9	Nov 2022–May 2023
12	20,000–249,999	38	1.7 (1–2)	0	0	Nov 2022–May 2023
13	20,000–249,999	34	1.5 (1–2)	0	0	Nov 2022–May 2023
14	250,000–999,999	123	1.6 (1–3)	1	1–9	Nov 2022–May 2023
15	250,000–999,999	360	2.4 (1–4)	1	0	Dec 2022–May 2023
16	250,000–999,999	322	2.0 (1–3)	1	0	Dec 2022–May 2023
17	≥1,000,000	77	2.8 (1–3)	1	20–29	Dec 2022–Mar 2023
18	250,000–999,999	160	1.6 (1–3)	6	1–9	Dec 2022–May 2023
19	≥1,000,000	229	2.4 (1–4)	3	10–19	Jan–May 2023
20	≥1,000,000	77	7.0 (7–7)	1	0	Feb–May 2023
21	≥1,000,000	306	7.0 (6–7)	0	1–9	Feb–May 2023
22	20,000–249,999	57	2.8 (2–3)	0	0	Feb–May 2023
23	≥1,000,000	106	1.5 (1–3)	4	10–19	Mar–May 2023
24	≥1,000,000	69	2.1 (1–3)	1	0	Mar–May 2023
25	20,000–249,999	12	3.0 (3–3)	0	0	Apr–May 2023
26	20,000–249,999	6	2.0 (2–2)	0	0	Apr–May 2023
Total	**24,700,152**	**3,492**	**2.2 (1–7)**	**84**	**281**	**Aug 2022–May 2023**

Abbreviation: MPXV = *Monkeypox virus*.

* Twenty-six counties that had ≥90% population coverage by wastewater sampling sites testing for MPXV were included in the analysis.

† County numbers were arbitrarily assigned.

§ County population estimates were obtained from 2022 U.S. Census Bureau population estimates or 2021 state health department population estimates where U.S. Census Bureau estimates by county were not available.

¶ Numbers of persons with mpox included in the main analysis (assuming persons with mpox shed virus from the date of symptom onset until 25 days later) are shown. This number includes persons with mpox with symptom onset dates (reported or imputed) within 25 days before the first study inclusion date through the last study inclusion date for the county of residence.

** Date ranges include dates during which all sites in a county were collecting wastewater samples for MPXV testing. Samples from a county were included in the analysis if they were collected within the county's data range. The earliest inclusion date per county was the maximum of the minimum sample collection dates for all sites in the county (minus 6 days to account for sampling on different days of the week). The last inclusion date per county was the minimum of the maximum sample collection dates for all sites in the county (plus 6 days), or May 7, 2023, (1 month before data download), whichever date was earliest. For duplicate sites (sites collecting samples for two different sources), dates were eligible for inclusion if at least one source was collecting samples on that date.

week was 72.6% (95% CI = 61.8%–81.8%) and 61.9% (95% CI = 48.8%–73.9%), respectively. When virus was detected in wastewater during a given week, the probability that five or more persons were shedding virus was 34.9% (95% CI = 23.3%–48.0%) and the probability that 15 or more persons were shedding virus was 20.6% (95% CI = 11.5%–32.7%).

Negative Predictive Value

NPV for predicting the absence of any persons shedding *Monkeypox virus* in a county on a given day or week was 72.9% (95% CI = 70.5%–75.2%) and 80.3% (95% CI = 76.2%–84.0%), respectively. When virus was not detected in wastewater during a given week, the probability that fewer than five persons were shedding virus was 94.6% (95% CI = 92.0%–96.6%) and the probability that fewer than 15 persons were shedding virus was 99.1% (95% CI = 97.6%–99.7%).

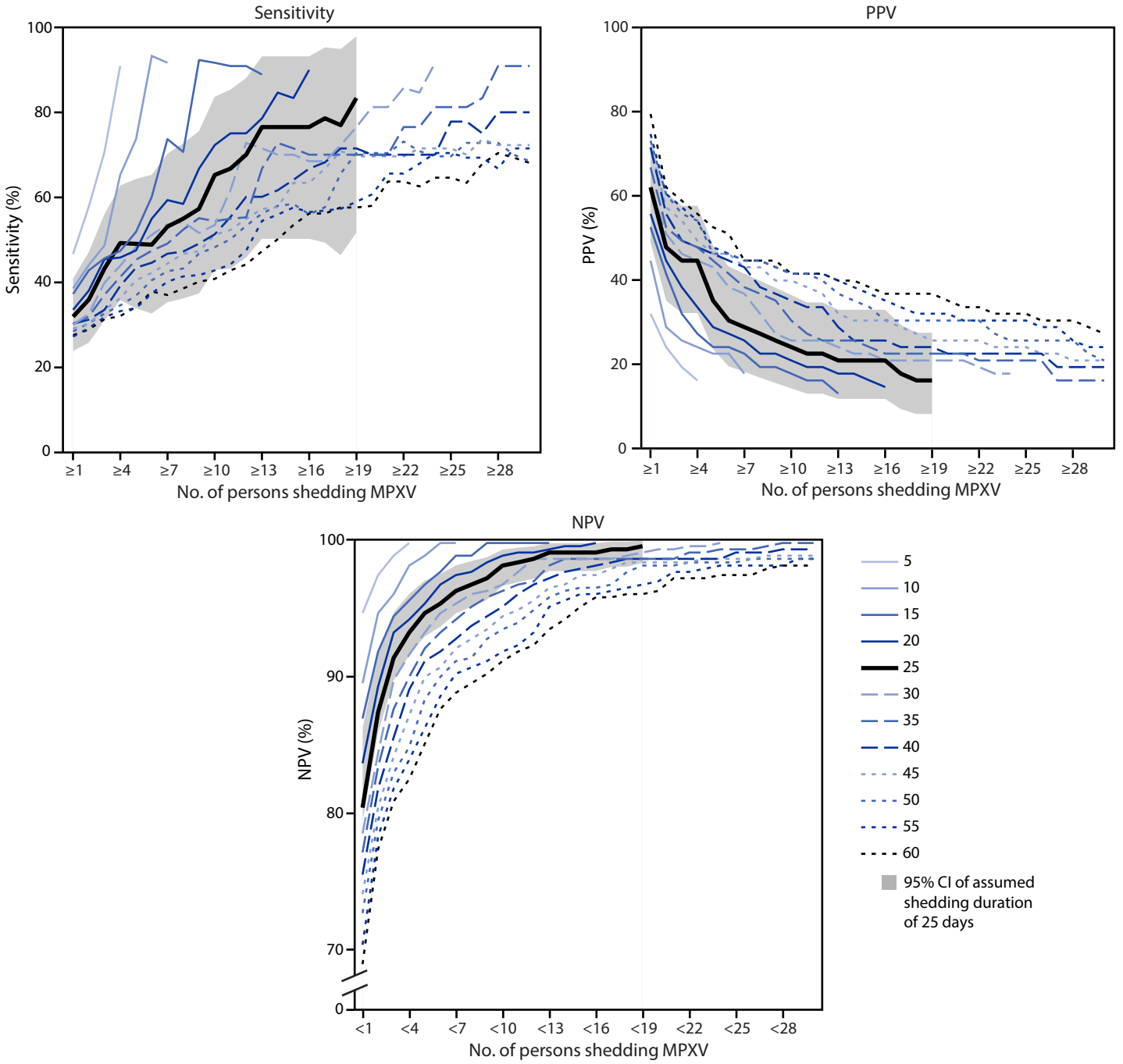
Additional Analyses

In sensitivity analyses examining varying shedding durations, weekly sensitivity and NPV decreased and PPV increased as shedding duration increased (Figure). Daily sensitivity, NPV, and PPV followed these same trends (Supplementary Figure 2, https://stacks.cdc.gov/view/cdc/140513). Results changed only slightly in other sensitivity analyses (Table 2).

Discussion

This study is the first to examine the performance of wastewater surveillance for detecting mpox cases using empirical

FIGURE. Sensitivity, positive predictive value, and negative predictive value* of wastewater surveillance† for detecting persons shedding *Monkeypox virus*§ in a county in a week¶ for different assumed shedding durations — United States, August 2022–May 2023**



Abbreviations: MPXV = *Monkeypox virus*; NPV = negative predictive value; PPV = positive predictive value.

* Sensitivity is the probability that MPXV was detected in wastewater when at least one person with mpox were shedding MPXV. PPV was defined as the probability that at least one person was shedding virus when a wastewater detection occurred. NPV was defined as the probability that no persons were shedding virus in the absence of wastewater detections. Probabilities for specific numbers of persons with mpox shedding MPXV when MPXV was and was not detected in wastewater are also shown.

† Wastewater test results were combined for all sites serving a county: if at least one site serving a county detected MPXV in wastewater in a given sample collection week, that week was considered a detection for that county, and otherwise a nondetection.

§ Persons with reported mpox were assumed to shed MPXV in their county of residence from the day of symptom onset until 25 days later. The number of persons with mpox shedding MPXV were summed to determine the number of persons with mpox shedding MPXV on each day in a given county.

¶ Wastewater test results for a given sample collection week were compared to the average numbers of mpox cases shedding MPXV in that week in a given county.

** The assumed shedding duration was varied from 5 to 60 days in 5-day increments. Main results are shown with an assumed shedding duration of 25 days with 95% CIs. CIs were calculated using exact binomial tests.

TABLE 2. Sensitivity, positive predictive value, and negative predictive value* of wastewater surveillance† for detecting persons shedding *Monkeypox virus* in a county, by day and week — United States, August 2022–May 2023

No. of persons shedding MPXV§	Daily estimates,¶ % (95% CI)		Weekly estimates,** % (95% CI)		
	Main analysis††	Analysis using earliest date§§	Main analysis††	Analysis using earliest date§§	Analysis of 7-day rolling average¶¶
Sensitivity (probability of MPXV detection in wastewater when no. of persons with mpox were shedding MPXV)					
≥1	13.8 (10.7–17.4)	13.7 (10.7–17.2)	31.7 (23.6–40.7)	31.0 (23.0–39.8)	29.2 (24.8–33.9)
≥5	28.9 (21.9–36.8)	29.1 (22.0–37.1)	48.9 (33.7–64.2)	53.3 (37.9–68.3)	54.1 (45.7–62.4)
≥10	37.9 (27.7–49.0)	37.5 (27.4–48.5)	65.2 (42.7–83.6)	64.0 (42.5–82.0)	69.9 (58.8–79.5)
≥15	48.3 (35.2–61.6)	46.9 (34.3–59.8)	76.5 (50.1–93.2)	77.8 (52.4–93.6)	81.7 (69.6–90.5)
≥20	60.0 (44.3–74.3)	57.8 (42.2–72.3)	—	—	—
≥25	63.0 (42.4–80.6)	61.5 (40.6–79.8)	—	—	—
≥30	58.3 (27.7–84.8)	63.6 (30.8–89.1)	—	—	—
PPV (probability of no. of persons with mpox shedding MPXV when MPXV was detected in wastewater)					
≥1	72.6 (61.8–81.8)	73.8 (63.1–82.8)	61.9 (48.8–73.9)	61.9 (48.8–73.9)	65.9 (58.6–72.8)
≥5	52.4 (41.2–63.4)	52.4 (41.2–63.4)	34.9 (23.3–48.0)	38.1 (26.1–51.2)	43.4 (36.1–50.9)
≥10	39.3 (28.8–50.5)	39.3 (28.8–50.5)	23.8 (14.0–36.2)	25.4 (15.3–37.9)	31.9 (25.2–39.2)
≥15	34.5 (24.5–45.7)	35.7 (25.6–46.9)	20.6 (11.5–32.7)	22.2 (12.7–34.5)	26.9 (20.6–34.0)
≥20	32.1 (22.4–43.2)	31.0 (21.3–42.0)	—	—	—
≥25	20.2 (12.3–30.4)	19.0 (11.3–29.1)	—	—	—
≥30	8.3 (3.4–16.4)	8.3 (3.4–16.4)	—	—	—
NPV (probability of no. of persons with mpox shedding MPXV when MPXV was not detected in wastewater)					
<1	72.9 (70.5–75.2)	72.3 (69.8–74.6)	80.3 (76.2–84.0)	79.6 (75.5–83.3)	77.8 (75.4–80.0)
<5	92.3 (90.8–93.7)	92.4 (90.9–93.7)	94.6 (92.0–96.6)	95.1 (92.6–96.9)	94.9 (93.5–96.0)
<10	96.2 (95.0–97.1)	96.1 (94.9–97.0)	98.1 (96.3–99.2)	97.9 (96.0–99.0)	98.1 (97.2–98.8)
<15	97.8 (96.9–98.5)	97.6 (96.6–98.3)	99.1 (97.6–99.7)	99.1 (97.6–99.7)	99.2 (98.5–99.6)
<20	98.7 (98.0–99.2)	98.6 (97.9–99.2)	—	—	—
<25	99.3 (98.7–99.7)	99.3 (98.7–99.7)	—	—	—
<30	99.6 (99.2–99.9)	99.7 (99.3–99.9)	—	—	—

Abbreviations: MPXV = *Monkeypox virus*; NPV = negative predictive value; PPV = positive predictive value.

* Probabilities for N persons with mpox shedding MPXV when MPXV was and was not detected in wastewater were also calculated.

† Wastewater results were combined for all sites serving a county; if at least one site serving a county detected MPXV in wastewater on a given sample collection day, that day was considered a detection for that county, and otherwise a nondetection.

§ Persons with reported mpox were assumed to shed MPXV in their county of residence from the day of symptom onset until 25 days later. The number of persons with mpox shedding MPXV were summed to determine the number of persons with mpox shedding MPXV on each day in a given county.

¶ Wastewater results for a given sample collection day were compared with the minimum numbers of persons with mpox shedding virus on that day in a given county.

** Wastewater results were combined by calendar week; if at least one site serving a county detected MPXV in wastewater in a given sample collection week, that week was considered a detection for that county, and otherwise a nondetection. Wastewater results for a given sample collection week were compared with the average minimum numbers of persons with mpox shedding virus that week in a given county. Estimates for larger numbers of persons with mpox shedding virus are missing because cell counts when examining data by week were small.

†† The main analysis used the date of symptom onset (imputed and not imputed) for all calculations.

§§ This sensitivity analysis used the earliest date available for persons with mpox for all calculations. Imputed symptom onset dates were not used.

¶¶ This sensitivity analysis examined weekly results by a 7-day rolling average, rather than by calendar week. For each sample collection day, the sample collection day, 3 days before, and 3 days after was examined. If at least one site serving the county detected MPXV in wastewater during those 7 days, that sample was considered a detection, and otherwise, it was considered a nondetection. Wastewater results were compared with the average minimum numbers of persons with mpox shedding MPXV in the county during those 7 days.

data. Wastewater surveillance had a sensitivity of 14% on a given day for detecting the presence of at least one mpox case. However, most sites were collecting more than one sample per week. Weekly sensitivity for detecting the presence of at least one mpox case was substantially higher (32%). As the number of cases shedding virus increased, weekly sensitivity increased to 49% for detecting five or more persons and 77% for detecting 15 or more persons shedding virus. Weekly PPV and NPV were both high (62% and 80%, respectively).

Although sensitivity might seem low compared with clinical testing, each wastewater sample represents thousands to millions of persons. Results show that wastewater surveillance was sufficiently sensitive to detect even a single mpox case in these large, pooled samples. These findings contrast those for SARS-CoV-2 (the virus that causes COVID-19), for which the minimum number of cases required for a wastewater detection is thought to be much higher (8–38 cases per 100,000 persons for detection rates at 50% and 99% probability, respectively) (*7*). Unlike SARS-CoV-2, high levels of *Monkeypox virus* are present in skin lesions as well as in urine and stool (*1,8–10*), and poxviruses are highly stable in the environment (*9*).

When *Monkeypox virus* was detected in wastewater on a single day or week, there was most likely (but not always) at least one case present in the county. Wastewater detections in the absence of known cases might have been the result of travelers, commuters, patients experiencing prolonged shedding, or subclinical or unreported infections (i.e., wastewater detections might have reflected true infections that had not been detected

Summary

What is already known about this topic?

CDC's National Wastewater Surveillance System began testing wastewater for *Monkeypox virus* in October 2022. The performance of wastewater surveillance for detecting mpox cases is unknown.

What is added by this report?

Monkeypox virus wastewater detections were compared with reported mpox cases. Wastewater surveillance has a sensitivity of 32% for detecting a single mpox case in wastewater samples that represent thousands to millions of persons. Sensitivity increases as the number of cases in the community increases. Positive and negative predictive values are high.

What are the implications for public health practice?

An isolated *Monkeypox virus* wastewater detection likely warrants a limited public health response. Absence of *Monkeypox virus* detection in a monitored community can provide reassurance that large numbers of cases are not present. *Monkeypox virus* wastewater surveillance is a useful complement to mpox case surveillance.

by case surveillance). Moreover, when *Monkeypox virus* was detected in wastewater on a single day or week, it was rare that 15 or more persons were shedding virus in the county. Because most samples were collected in fall 2022 or later, after case counts in the United States began to decline, large numbers of cases were infrequent. In addition, when *Monkeypox virus* was not detected in wastewater, there were most likely zero cases (and almost certainly no large numbers of cases) present in the county. High NPV can likely be partially attributed to low disease prevalence during the study period.

Limitations

The findings in this report are subject to at least five limitations. First, because data on viral shedding patterns and clinical case information were lacking,***** variations in case shedding patterns were not included. Second, persons shedding *Monkeypox virus* might have resided within counties included in the analysis but outside areas covered by wastewater surveillance. This limitation would bias sensitivity and PPV estimates downward and NPV estimates upward, because wastewater surveillance cannot detect persons shedding virus if they reside outside covered areas. Third, because data from all sites serving a county were combined, results could not be stratified by sampling or testing methods or site population size and thus represent average estimates of wastewater surveillance performance across sites and time. Fourth, because case counts during the study period were low, estimates for detecting large numbers of cases are highly uncertain. Finally, although mpox is a nationally notifiable disease in the United States and all cases should be reported, and studies suggest that most cases are diagnosed, some cases might remain unreported (*6*).

***** Information on case characteristics, including immunosuppressing conditions and vaccination status, was frequently missing (≥60% of cases) or absent from the data set.

Implications for Public Health Practice

The findings in this report can help guide the public health response to *Monkeypox virus* wastewater detections. Because wastewater surveillance is sufficiently sensitive to detect very few mpox cases, a single, isolated wastewater detection might not warrant a large public health response. Moreover, because most wastewater detections during the study period resulted from five or fewer cases, the public health response to a single wastewater detection might be scaled to one recommended for small case numbers, as long as mpox case counts remain low. Finally, nondetection of *Monkeypox virus* in wastewater, in combination with no reported cases, can provide reassurance to public health officials that large numbers of cases are not present in communities where wastewater surveillance is occurring. Wastewater surveillance for *Monkeypox virus* has a sensitivity of 32% for detecting a single case, with sensitivity increasing to 49% and 77% for detecting five or more and 15 or more cases, respectively. PPV and NPV for *Monkeypox virus* wastewater surveillance are high (62% and 80%, respectively). Wastewater surveillance can be a useful complement to case surveillance for guiding the mpox outbreak response.

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References

1. Suñer C, Ubals M, Tarín-Vicente EJ, et al.; Movie Group. Viral dynamics in patients with monkeypox infection: a prospective cohort study in Spain. Lancet Infect Dis 2023;23:445–53. PMID:36521505 https://doi.org/10.1016/S1473-3099(22)00794-0
2. Acer P, Imakaev M, Stansifer K, Tsui C. Limit of detection for Biobot Analytics's E9L-NVAR orthopoxvirus assay in a wastewater context. Cambridge, MA: Biobot Analytics; 2023. https://biobot.io/wp-content/uploads/2022/12/BIOBOT_WHITEPAPER_MPXV_ASSAY_LOD_V01-1.pdf

3. Wolfe MK, Yu AT, Duong D, et al. Wastewater surveillance for Monkeypox virus in nine California communities. medRxiv [Preprint posted online September 9, 2022]. https://www.medrxiv.org/content/10 .1101/2022.09.06.22279312v1
4. U.S. Census Bureau. County population totals and components of change: 2020–2022. Washington, DC: US Department of Commerce, US Census Bureau; 2023. https://www.census.gov/data/datasets/time-series/demo/popest/2020s-counties-total.html#v2022
5. Connecticut State Department of Public Health. Annual town and county population for Connecticut. Hartford, Connecticut: Connecticut State Department of Public Health; 2023. https://portal.ct.gov/DPH/Health-Information-Systems--Reporting/Population/Annual-Town-and-County-Population-for-Connecticut
6. Ogale YP, Baird N, Townsend MB, et al.; DC Mpox Response Project Team. Evidence of mpox virus infection among persons without characteristic lesions or rash presenting for first dose of JYNNEOS vaccine—District of Columbia, August 2022. Clin Infect Dis 2023;77:298–302. PMID:36916132 https://doi.org/10.1093/cid/ciad145
7. Li Q, Lee BE, Gao T, et al. Number of COVID-19 cases required in a population to detect SARS-CoV-2 RNA in wastewater in the province of Alberta, Canada: sensitivity assessment. J Environ Sci (China) 2023;125:843–50. PMID:36375966 https://doi.org/10.1016/j.jes.2022.04.047
8. Lim CK, McKenzie C, Deerain J, et al. Correlation between monkeypox viral load and infectious virus in clinical specimens. J Clin Virol 2023;161:105421. PMID:36893717 https://doi.org/10.1016/j.jcv.2023.105421
9. Atoui A, Jourdain F, Mouly D, Cordevant C, Chesnot T, Gassilloud B. A review on mpox (monkeypox) virus shedding in wastewater and its persistence evaluation in environmental samples. Case Stud Chem Environ Eng 2023;7:100315. https://doi.org/10.1016/j.cscee.2023.100315
10. Palich R, Burrel S, Monsel G, et al. Viral loads in clinical samples of men with monkeypox virus infection: a French case series. Lancet Infect Dis 2023;23:74–80. PMID:36183707 https://doi.org/10.1016/S1473-3099(22)00586-2

Mpox Outbreak — Los Angeles County, California, May 4–August 17, 2023

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Abstract

Since May 2022, approximately 2,500 mpox cases have been reported in Los Angeles County (LAC), California. Beginning in May 2023, the LAC Department of Public Health observed a consistent increase in mpox cases after a prolonged period of low incidence. A total of 56 cases were identified during May 4–August 17, 2023. A minority of mpox patients were fully vaccinated (29%). One patient was hospitalized; no deaths were reported. Two cases of reinfection occurred, both of which were associated with mild illness. The increasing number of cases during this period was significant, as few other health departments in the United States reported an increase in mpox cases during the same period. The outbreak spread similarly to the 2022 U.S. mpox outbreak, mainly through sexual contact among gay, bisexual, and other men who have sex with men. Vaccination against mpox became available in June 2022 and has been shown to be effective at preventing mpox disease. This outbreak was substantially smaller than the 2022 mpox outbreak in LAC (2,280 cases); possible explanations for the lower case count include increased immunity provided from vaccination against mpox and population immunity from previous infections. Nonetheless, mpox continues to spread within LAC, and preventive measures, such as receipt of JYNNEOS vaccination, are recommended for persons at risk of *Monkeypox virus* exposure.

Epidemiologic Investigation and Findings

During May 4–August 17, 2023, a total of 56 laboratory-confirmed mpox cases occurred in Los Angeles County (LAC), based on illness onset date or laboratory specimen collection date (if onset date was missing) (Figure). In contrast, during the 3 months preceding May 4, 2023, only seven mpox cases were reported in LAC. In addition to requirements for laboratory reporting of all mpox tests, health care providers must report all mpox or orthopoxvirus infections and information on illness characteristics to the LAC Department of Public Health (LACDPH). LAC residents with laboratory-confirmed mpox were contacted for interview by a public health disease investigator to obtain information on demographic, epidemiologic, and clinical characteristics. Clinical information was obtained from a combination of self-report from interviews and the medical provider report from the patients' provider. Among the 56 patients, 32 (57%) were unvaccinated, eight (14%) were partially vaccinated, and 16 (29%) were fully vaccinated.* All 56 cases occurred in persons who were assigned male sex at birth and who identified as male (Table). Overall, 45 (80%) mpox patients identified as gay or bisexual. The median patient age was 35 years (IQR = 26–42 years). Overall, 21 patients (38%) were non-Hispanic White (White) men, 18 (32%) were Hispanic or Latino (Hispanic), 13 (23%) were non-Hispanic Black or African American (Black), and four (7%) identified as another race. More than one half of patients (57%; 32) lived in the Los Angeles metropolitan area. Among 55 interviewed patients, 48 (87%) reported sexual contact in the 3 weeks preceding symptom onset. No common social events were reported. Two pairs of patients were epidemiologically linked (i.e., a patient disclosed sexual contact with another patient in the 3 weeks preceding symptom onset). Forty-two (76%) interviewed patients did not report any travel outside of LAC in the 3 weeks before symptom onset, suggesting local mpox transmission. This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.†

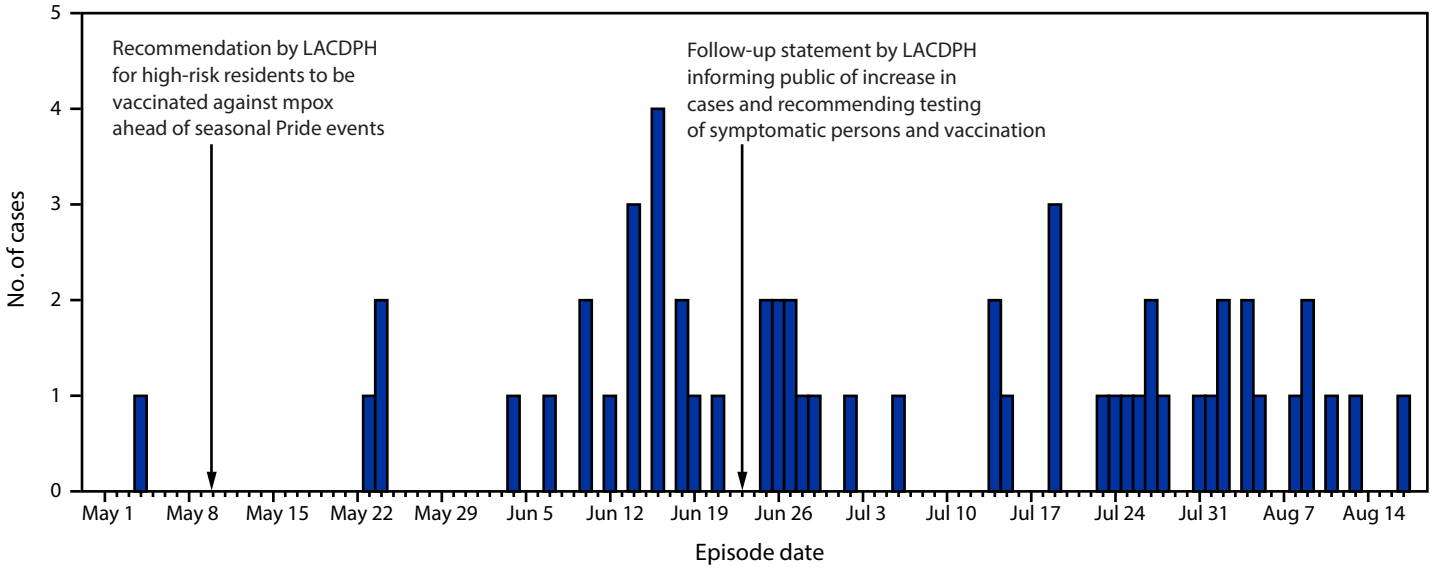
Demographic and Other Characteristics by Vaccination Status

Demographic and other patient characteristics were assessed by vaccination status (fully vaccinated with JYNNEOS vaccine, partially vaccinated, or unvaccinated). The median age of fully vaccinated patients was 37 years (IQR = 31–46 years), of partially vaccinated patients was 35 years (IQR = 25–45 years), and of unvaccinated patients was 30 years (IQR = 26–38 years). Black persons accounted for 23% of all cases; however, no Black patients were fully vaccinated. Likewise, whereas Hispanic persons accounted for approximately one third of all patients, only three of 18 were fully vaccinated at the time of infection. In contrast, among White patients, who accounted for 38% of all patients, 57% were fully vaccinated. Seventeen (30%) patients were living with HIV, five of whom were fully vaccinated. Three patients living with HIV had CD4 counts <350 cells/mm^3; none of these patients was fully

* Full vaccination was defined as receipt of ≥2 doses of JYNNEOS vaccine ≥24 days apart, with the second dose received ≥2 weeks before mpox episode date (illness onset date or laboratory specimen collection date [if onset date was missing]). Partial vaccination was defined as receipt of ≥1 dose of JYNNEOS vaccine ≥2 weeks before illness onset but fully vaccinated criteria was not met. Unvaccinated was defined as no evidence of vaccination before illness onset, or illness onset <2 weeks after receipt of the first vaccine dose.

† 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.

FIGURE. Laboratory-confirmed mpox cases, by episode date* (N = 56) — Los Angeles County, California, May 4–August 17, 2023



Abbreviation: LACDPH = Los Angeles County Department of Public Health.
* Episode date is calculated from the symptom onset date or, if the symptom onset date is unknown, from specimen collection date.

vaccinated. Among HIV-negative patients, 100% of those who were fully vaccinated were receiving HIV preexposure prophylaxis (PrEP) at time of interview, compared with 48% who were unvaccinated. Fully vaccinated patients reported more sex partners in the 3 weeks preceding symptom onset (median = three) than did those who were unvaccinated (one) or partially vaccinated (two).

Previous Mpox Diagnosis

Two unvaccinated patients had previously received a diagnosis of mpox in 2022, 10 months and 12 months, respectively, before their 2023 infection. Review of clinical information confirmed that both patients had complete resolution of their previous infections before new symptom onset. Both secondary infections occurred in Black persons aged 35–45 years. One patient was living with HIV with a CD4 count <350 cells/mm^3. Signs and symptoms in both patients with secondary infection were mild, and complete resolution was noted within the 3-week follow-up period.

Mpox Severity

Data for fully assessing clinical severity according to the mpox severity scoring system (*1*) are incomplete; however, patient interviews indicated that most cases were mild. Compared with patients who were fully vaccinated with JYNNEOS vaccine, a larger proportion of those who were unvaccinated reported signs or symptoms of fever (47% versus 31%) and chills (34% versus 19%); other symptoms were similar irrespective of vaccination status. Eighteen (32%) patients, including seven who were fully vaccinated, received the antiviral drug tecovirimat to treat mpox symptoms. One HIV-negative patient with no immunocompromising conditions and who had not received any JYNNEOS vaccine was hospitalized for pain management and infectious disease evaluation while awaiting mpox laboratory test results.

Mpox Vaccination History

Among the 16 fully vaccinated patients, the median interval from receipt of the second JYNNEOS vaccine dose to mpox symptom onset was 10 months (IQR = 9–11 months). Among fully vaccinated patients, six had received 2 subcutaneous vaccine doses and 10 had received 1 subcutaneous and 1 intradermal dose. Among the eight patients who had received 1 vaccine dose, five had received a subcutaneous dose and three had received an intradermal dose.

Laboratory Investigation

Whole-genome sequencing followed by genomic analyses (*2*,*3*) were performed on outbreak specimens obtained from 45 patients (14 fully vaccinated, six partially vaccinated, and 25 unvaccinated) as part of LAC's *Monkeypox virus* (MPXV) genomic surveillance program; specimens from three patients were sequenced by the California Department of Public Health. Phylogenetic analysis (*4*) (data set tag 2023–08–01T12:00:00Z) determined that 32 (71.1%) cases involved MPXV belonging to the B.1.20 lineage of clade IIb, which is currently the dominant lineage identified through surveillance in the United States. Twelve (26.7%) cases involved MPXV assigned a lineage of B.1 that formed a monophyletic group defined by four mutations relative to the B.1 reference genome (G70002A, G143951A, C148604T, and G154188A), and might represent an emerging

TABLE. Characteristics of patients with mpox, by vaccination status — Los Angeles County, California, May 4–August 17, 2023

Characteristic	Vaccination status, No. (column %)*			
	All (N = 56)	Fully vaccinated (n = 16)	Partially vaccinated (n = 8)	Unvaccinated (n = 32)
Median age, yrs (IQR)	**35 (26–42)**	37 (31–46)	35 (25–45)	30 (26–38)
Current gender identity				
Male	**56 (100)**	16 (100)	8 (100)	32 (100)
Sexual orientation				
Gay or bisexual	**45 (80)**	14 (88)	6 (75)	25 (78)
Heterosexual	**6 (11)**	0 (—)	1 (13)	5 (16)
Other/Unknown	**5 (9)**	2 (13)	1 (13)	2 (6)
Race and ethnicity				
Black or African American, non-Hispanic	**13 (23)**	0 (—)	1 (13)	12 (38)
White, non-Hispanic	**21 (38)**	12 (75)	3 (38)	6 (19)
Hispanic or Latino	**18 (32)**	3 (19)	3 (38)	12 (38)
Other	**4 (7)**	1 (6)	1 (13)	2 (6)
Geographic area				
Metro LA area	**32 (57)**	10 (63)	6 (75)	16 (50)
Outside metro LA	**24 (43)**	6 (37)	2 (25)	16 (50)
Persons living with HIV	**17 (30)**	**5 (31)**	**3 (38)**	**9 (28)**
CD4 >350	**14 (82)**	5 (100)	3 (100)	6 (67)
CD4 200–350	**3 (18)**	0 (—)	0 (—)	3 (33)
Not virally suppressed†	**6 (35)**	2 (40)	1 (33)	3 (33)
Persons who are HIV-negative	**39 (68)**	**11 (69)**	**5 (63)**	**23 (72)**
Receiving HIV PrEP§	**26 (67)**	11 (100)	4 (80)	11 (48)
Persons hospitalized for mpox	**1 (2)**	0 (—)	0 (—)	1 (3)
Symptoms¶				
Pruritis	**25 (46)**	7 (44)	4 (57)	14 (44)
Fever	**22 (40)**	5 (31)	2 (29)	15 (47)
Chills	**16 (29)**	3 (19)	2 (29)	11 (34)
Enlarged lymph nodes	**20 (37)**	5 (31)	3 (43)	12 (38)
Rectal bleeding	**11 (20)**	3 (19)	1 (14)	7 (22)
Lesions on the genital area	**36 (65)**	10 (63)	6 (86)	20 (63)
Received tecovirimat	**18 (32)**	7 (44)	2 (25)	9 (28)
Reported contact with someone with mpox¶, symptoms**	**7 (13)**	1 (6)	1 (14)	5 (16)
Reported sexual contact 3 weeks before episode date¶,††	**48 (87)**	14 (88)	6 (86)	28 (88)
Median no. of sex partners (range)¶,**	**2 (0–55)**	3 (0–10)	2 (0–3)	1 (0–55)
Reported travel outside LA county ≤3 wks before episode date¶,††	**13 (24)**	5 (31)	2 (29)	6 (19)

Abbreviations: LA = Los Angeles; PrEP = preexposure prophylaxis.
* Some percentages might not sum to 100% because of rounding.
† Last viral load result >200 copies/mL or no viral load result reported in previous 12 months.
§ At time of mpox case interview; all persons who were HIV-negative were interviewed.
¶ Fifty-five of 56 patients were interviewed, including all who were fully vaccinated, seven out of eight who were partially vaccinated, and all who were unvaccinated.
** Three weeks before symptom onset.
†† Episode date is calculated from the symptom onset date or specimen collection date if symptom onset is unknown.

sublineage. One case (2.2%) associated with travel to China involved MPXV belonging to the C.1 lineage, which is prevalent in East Asia. Recently, a tecovirimat-resistant MPXV variant was identified in LAC (*5*); however, mutations associated with tecovirimat resistance were not detected in any outbreak specimens.

Public Health Response

On May 10, 2023, LACDPH issued a statement recommending that residents at high risk§ receive mpox vaccine ahead of seasonal Pride events.¶ LACDPH prepared for a potential increase in mpox cases before summer 2023 and supported mpox vaccinations at numerous on-site pop-up clinics at Pride events and festivals during May 1–August 31. During this period, 3,524 JYNNEOS vaccine first doses and 1,660 second doses were administered in LAC. On June 23, 2023, LACDPH released a follow-up statement notifying the public of the rise in cases and encouraging testing for persons with symptoms and vaccination for populations at high risk.

Public health disease investigators interviewed and followed up with patients who had received an mpox diagnosis to assess their disease progression and provide support. Among the 56 patients,

§ Persons at high risk were defined as 1) men or transgender persons who have sex with men or transgender persons, 2) persons of any gender or sexual orientation who have sex or intimate physical contact with others in association with a large event or engage in commercial or transactional sex, 3) persons living with HIV, especially those with uncontrolled or advanced HIV, or 4) sexual partners of persons belonging to any of the previous groups.

¶ http://publichealth.lacounty.gov/phcommon/public/media/mediapubhpdetail.cfm?prid=4380

Summary

What is already known about this topic?

Mpox has disproportionately affected gay, bisexual, and other men who have sex with men. Vaccination against mpox has been shown to be protective against symptomatic mpox.

What is added by this report?

Mpox transmission occurred in Los Angeles County, California, during May–August 2023 at lower levels than in 2022 but at higher levels than during previous months and in other U.S. jurisdictions. Most mpox patients were not fully vaccinated. Two mild reinfections were reported.

What are the implications for public health practice?

Mpox continues to spread within Los Angeles County. This outbreak underscores the ongoing need for accessible mpox vaccination for persons at risk, particularly among young, Black or African American, and Hispanic or Latino persons, and persons living with HIV.

55 (98%) were reached for interview. Public health disease investigators also elicited close contact information and performed follow-up, offering postexposure prophylaxis to contacts when indicated. However, most patients reported sexual contact in the 3 weeks before symptom onset, but few patients disclosed names of their contacts. Although it is not unusual for persons with sexually transmitted infections to have a low contact index (the number of sex partners for whom information is sufficient to initiate contact efforts divided by the number of persons interviewed), this circumstance limited the ability to control mpox transmission through contact tracing efforts.

Discussion

Mpox is spreading at low levels within LAC, which could be indicative of endemic transmission, especially as vaccination rates decline. The outbreak described in this report includes a smaller number of mpox cases (average of one case per day) compared with the number reported during the summer 2022 LAC outbreak, when an average of 39 cases per day were reported during the outbreak's August 2022 peak (*6*). Vaccination against mpox has been shown to be an effective measure to prevent mpox disease, with the highest protection provided after receipt of 2 doses of JYNNEOS vaccine (*7*,*8*). The substantially lower number of cases in the 2023 outbreak could be due to increased immunity provided by vaccination against mpox or population immunity from previous infections. Fewer than one third of cases in this outbreak (29%) occurred in persons who were fully vaccinated, in contrast to the 2023 Chicago mpox outbreak (March–June) in which the majority of cases (55%) occurred in persons who were fully vaccinated (*9*). Similar to the 2023 Chicago mpox outbreak, all LAC patients identified as male (93% for Chicago), and the majority of patients were gay or bisexual (80% for both the LAC and Chicago outbreaks). In addition, the majority of patients in both outbreaks experienced self-limited illness that was managed in outpatient facilities. Genetic sequencing results from a subset of four cases in the Chicago outbreak identified MPXV among patients to be consistent with the B.1 lineage of clade IIb MPXV, similar to most of the cases from the LAC outbreak (44 of 45).

Mpox vaccination is recommended for all persons at risk, including men who have sex with men who have more than one sex partner and persons living with HIV (*10*). Only approximately 18% of persons living with HIV in LAC are fully vaccinated against mpox (LACDPH, unpublished data, October 2023). Although mpox vaccines are free (*10*), this outbreak underscores the ongoing need for accessible mpox vaccination for persons at risk for severe disease, particularly persons with uncontrolled or advanced HIV disease, and groups with low vaccination coverage, including young, Black, and Hispanic persons, and persons living with HIV. Better understanding of reasons for low vaccination rates could help increase coverage; alternative vaccination strategies for persons living with HIV might be needed at a time when the number of HIV specialty medical visits is declining because of the effectiveness of HIV antiretroviral therapy. Other measures, such as limiting the number of one's sex partners, can also help prevent mpox transmission.

Implications for Public Health Practice

Detection of this outbreak relied on the ability to detect cases through provider and laboratory reporting of laboratory-confirmed mpox. With the continued spread of mpox, health care providers should recommend vaccination to all persons at risk (*10*). Providers should remain aware of the ongoing transmission of MPXV, even among persons with previous infection or who have been vaccinated. Local mpox surveillance remains critical to differentiating whether mpox is causing more severe disease or spreading by new routes and to new risk groups.

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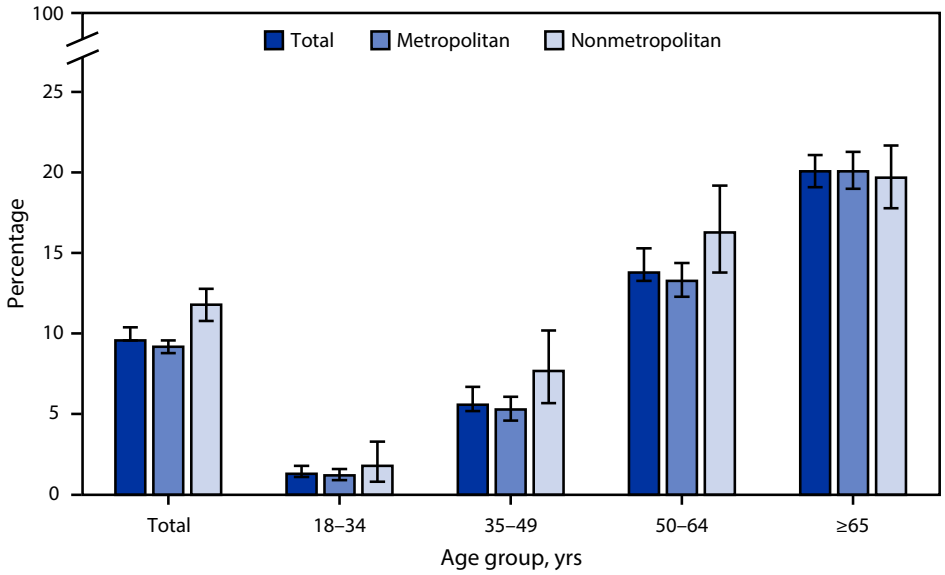
References

1. Zucker J, McLean J, Huang S, et al. Development and pilot of an MPOX severity scoring system (MPOX-SSS) (Abstract 738). Conference on Retroviruses and Opportunistic Infections; February 19–22, 2023; Seattle, Washington.
2. Chen NFG, Chaguza C, Gagne L, et al. Development of an amplicon-based sequencing approach in response to the global emergence of mpox. PLoS Biol 2023;21:e3002151. PMID:37310918 https://doi.org/10.1371/journal.pbio.3002151
3. Libuit KG, Doughty EL, Otieno JR, et al. Accelerating bioinformatics implementation in public health. Microb Genom 2023;9:mgen001051. PMID:37428142 https://doi.org/10.1099/mgen.0.001051
4. Aksamentov I, Roemer C, Hodcroft EB, Neher R. Nextclade: clade assignment, mutation calling and quality control for viral genomes. J Open Source Softw 2021;6:3773. https://doi.org/10.21105/joss.03773
5. Garrigues JM, Hemarajata P, Espinosa A, et al. Community spread of a human monkeypox virus variant with a tecovirimat resistance-associated mutation. Antimicrob Agents Chemother 2023;67:e0097223. PMID:37823631 https://doi.org/10.1128/aac.00972-23
6. County of Los Angeles Department of Public Health. Los Angeles County mpox case summary (weekly). Case counts by episode date. Los Angeles, CA: County of Los Angeles; 2023. Accessed October 9, 2023. http://publichealth.lacounty.gov/media/monkeypox/data/index.htm
7. Dalton AF, Diallo AO, Chard AN, et al.; CDC Multijurisdictional Mpox Case Control Study Group. Estimated effectiveness of JYNNEOS vaccine in preventing mpox: a multijurisdictional case-control study—United States, August 19, 2022–March 31, 2023. MMWR Morb Mortal Wkly Rep 2023;72:553–8. PMID:37200229 https://doi.org/10.15585/mmwr.mm7220a3
8. Deputy NP, Deckert J, Chard AN, et al. Vaccine effectiveness of JYNNEOS against mpox disease in the United States. N Engl J Med 2023;388:2434–43. PMID:37199451 https://doi.org/10.1056/NEJMoa2215201
9. Faherty EAG, Holly T, Ogale YP, et al. Notes from the field: emergence of an mpox cluster primarily affecting persons previously vaccinated against mpox—Chicago, Illinois, March 18–June 12, 2023. MMWR Morb Mortal Wkly Rep 2023;72:696–8. PMID:37347713 https://doi.org/10.15585/mmwr.mm7225a6
10. CDC. Mpox vaccine recommendations. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. Accessed January 11, 2024. https://www.cdc.gov/poxvirus/mpox/vaccines/vaccine-recommendations.html

QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Adults Aged ≥18 Years with Diagnosed Diabetes,† by Urbanization Level§ and Age Group — National Health Interview Survey, United States, 2022¶



* With 95% CIs indicated with error bars.
† Based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" Respondents were asked not to include prediabetes, borderline diabetes, or gestational diabetes.
§ Urbanization level is based on the Office of Management and Budget's February 2013 delineation of metropolitan statistical areas (MSAs), in which each MSA must have at least one urbanized area of ≥50,000 inhabitants. Areas with <50,000 inhabitants are grouped into the nonmetropolitan category.
¶ Estimates are based on household interviews of a sample of the civilian, noninstitutionalized U.S. population.

In 2022, 9.6% of adults aged ≥18 years had diagnosed diabetes, with the percentage lower among adults living in metropolitan areas (9.2%) compared with adults in nonmetropolitan areas (11.8%). The prevalence of diagnosed diabetes was lower in metropolitan areas only among those aged 35–49 years (5.3% versus 7.7%) and aged 50–64 years (13.3% versus 16.3%). The prevalence of diagnosed diabetes increased with age overall, from 1.3% among adults aged 18–34 years to 20.1% among adults aged ≥65 years, and in both metropolitan and nonmetropolitan areas.

Source: National Center for Health Statistics, National Health Interview Survey, 2022. https://www.cdc.gov/nchs/nhis.htm

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