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Progress Toward Poliomyelitis Eradication — Afghanistan, January 2021–September 2022

Abdinoor Mohamed, MD[1]; Irfan Elahi Akbar, MBBS[2]; Sumangala Chaudhury, MBBS[2]; Mufti Zubair Wadood, MBBS[3]; Fazal Ather, MBBS[4]; Jaume Jorba, PhD[5]; Maureen Martinez, MPH[1]

Afghanistan and Pakistan are the two remaining countries with endemic wild poliovirus type 1 (WPV1) transmission (*1*). During 2019–2020, these countries reported their highest numbers of WPV1 cases since 2014 and experienced outbreaks of type 2 circulating vaccine-derived poliovirus (cVDPV2) (*2–4*).* In Afghanistan, the number of WPV1 cases nearly doubled, from 29 in 2019 to 56 in 2020; 308 cVDPV2 cases were reported during 2020. After years of active conflict, the Afghanistan government was fully replaced by the Taliban de facto government on August 15, 2021. This report describes activities and progress toward polio eradication in Afghanistan during January 2021–September 2022 and updates previous reports (*3*,*4*). During January–December 2021, four WPV1 and 43 cVDPV2 cases were detected, representing decreases of 93% from 56 cases and 86% from 308 cases, respectively, during 2020. During January–September 2022 (reported as of October 20), two WPV1 cases and zero cVDPV2 cases were detected. Although no supplementary immunization activities (SIAs)† occurred during July–October 2021, SIAs resumed during November 2021 in all districts after the political transition, and 3.5–4.5 million previously unreachable persons have been vaccinated since. However, restrictions on how SIAs are conducted are still in place in the critical South Region provinces of Kandahar, Helmand, and Uruzgan. If efforts to vaccinate all children are enhanced and expanded, Afghanistan has an opportunity to interrupt WPV1 transmission during 2023.

Immunization Activities

The World Health Organization (WHO) and UNICEF estimate of national 2021 immunization coverage with 3 doses of oral poliovirus vaccine (OPV3) among children aged 12–23 months was 71% compared with 75% in 2020. The estimated 1-dose coverage with injectable inactivated poliovirus vaccine was 67% in 2021 compared with 62% in 2020 (*5*). However, these national estimates obscure substantial subnational coverage gaps.

Because of the low quality of routine immunization (RI) data, caregiver recall dose history from investigations of acute flaccid paralysis (AFP) in children who do not have laboratory evidence of poliovirus infection (nonpolio AFP [NPAFP]) is used as a proxy for RI coverage. Among the 2,567 infants and children aged 6–59 months with NPAFP in 2021, 68% had received ≥3 RI OPV doses nationwide; 17% had not received

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*Vaccine-derived polio viruses can emerge when attenuated oral polio vaccine (OPV) virus reverts to neurovirulence as a result of transmission in areas with low immunization coverage. cVDPV2s are genetically linked VDPV2 isolates for which there is evidence of person-to-person transmission in the community.

†SIAs are mass immunization campaigns intended to supplement the routine immunization systems and target children aged <5 years with OPV, regardless of their vaccination history. In Afghanistan, SIAs are conducted using a variety of methods such as house-to-house, mosque-to-mosque, or site-to-site.

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any RI dose. In 2022, as of August 31, these percentages were similar (67% and 17%, respectively). In 2021, 4% of children with NPAFP had not received any OPV through RI or SIAs (zero-dose children); the percentage of zero-dose children declined to 2% in 2022. By province, the highest percentages of zero-dose children in 2021 were reported from Zabul (28%) and Helmand (17%) provinces in the South Region, and from Nuristan (11%) in the East Region in 2022, as of August 31.

In 2015, WHO declared wild poliovirus type 2 to be eradicated.[§] In 2016, Afghanistan joined OPV-using countries around the world in implementing a synchronized withdrawal of trivalent OPV (tOPV), containing Sabin-strain types 1, 2, and 3, and replacement with bivalent OPV (bOPV), containing Sabin-strain types 1 and 3, and ≥1 dose of inactivated poliovirus vaccine as part of containment efforts for all type 2 polioviruses (*6*). However, in 2020 when Afghanistan began to report both cVDPV2 and WPV1 polio cases, the Global Polio Eradication Initiative authorized the use of tOPV for outbreak response. During January–December 2021, five SIAs were conducted, including two after the political transition; all were national immunization days (NIDs). During January–September 2022, nine SIAs targeting children aged <5 years were conducted: six NIDs, one subnational immunization day, and two large-scale SIAs conducted in response to a polio case (case-response SIAs). The NIDs conducted in January, March, November, and December 2021 used tOPV; the remaining SIAs in 2021 and 2022 used bOPV.

In November 2021, during the first SIA after the political transition, only 53% of the 10 million children targeted by SIAs lived in areas without any restriction on how SIAs were conducted. This percentage gradually increased and reached 76% by the September 2022 NID. The reported NID OPV coverage in areas where SIAs were conducted without restrictions increased from 72% in June 2021 to approximately 100% in March, May, and June 2022, although this figure likely overestimates true coverage because of poor target setting and data management. Reported coverage was <50% in districts with restrictions on SIA implementation. In 2022, to date, the program has reached 3.5–4.5 million children previously unreachable because the insurgency prevented access before the government transition.

Lot quality assurance sampling (LQAS)[¶] surveys are conducted to assess SIA quality. Previously limited in implementation, these surveys were expanded nationwide in 2022 to

[§] https://polioeradication.org/news-post/global-eradication-of-wild-poliovirus-type-2-declared

[¶] LQAS is a rapid survey method to assess the quality of vaccination activities after SIAs in predefined areas, such as health districts (lots), using a sample size of 60. LQAS involves dividing the population into lots and ascertaining receipt of vaccination by randomly selecting children within each lot. If the number of unvaccinated children in the sample exceeds three, then the SIA quality in that area is classified as failed (i.e., at a pass threshold of ≥90%) and mop-up activities are recommended. If the threshold of ≥90% is met, the SIA's quality for the area is classified as having passed.

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include all districts. During the first five 2022 NIDs, 1,319 lots were assessed, a 65% increase over the 797 assessed during 2021, and the quality of implementing LQAS surveys improved. More lots were reported as failed at the 90% SIA coverage threshold in 2022 (37%) than in 2021 (18%); however, the primary reason was that approximately all lots in districts where SIA implementation methods were restricted failed LQAS assessments.

Poliovirus Surveillance

AFP surveillance. The Afghanistan AFP surveillance network comprises 1,947 active surveillance sites (visited by surveillance officers), 3,222 zero-reporting sites with passive monthly reporting, and 46,000 community-based reporting volunteers. Detection of two or more NPAFP cases per 100,000 persons aged <15 years** along with collection of adequate stool specimens†† from ≥80% of AFP cases indicates that surveillance is sufficiently sensitive to detect a case of paralytic polio. During 2021, the national NPAFP rate was 19 per 100,000 persons aged <15 years (regional range = 12–26); during January–August 2022, the annualized NPAFP rate was 25 (regional range = 17–40). The percentage of AFP cases with adequate specimens was 94% in 2021 and 95% to date in 2022 (regional range = 90%–98% in 2021 and 92%–98% in 2022) (Table).

Environmental surveillance. Poliovirus surveillance in Afghanistan is supplemented by environmental surveillance (ES), the systematic sampling and virologic testing of sewage at 30 sites in 13 provinces. In 2021, only one WPV1 sample was detected among ES samples from the Helmand province in the South Region. As of October 20, 2022, WPV1 was detected during the reporting period in three sites: one in Nangarhar and two in Kunar provinces in the East Region, with the latest from a site in Kunar province in September 2022. During 2021, cVDPV2 was isolated from 40 ES specimens from Helmand, Herat, Kabul, Kandahar, Kunduz, and Nangarhar provinces; the latest isolation was from an ES sample collected in June 2021 in Kandahar province.

Epidemiology of Polio Cases and Genomic Sequence Analysis of Poliovirus Isolates

Four WPV1 cases were detected in 2021, one from Ghazni province in the Southeast Region and three from Kunduz province in the Northeast Region. During January–September 2022 (as of October 20, 2022), only two WPV1 cases were reported in two regions: one each from Paktika (Southeast Region) and Kunar provinces (East Region) (Table) (Figure 1) (Figure 2). All six patients in 2021 and 2022 were aged 10–25 months; three had never received OPV through RI services but had received

** NPAFP cases are those that are discarded as not having laboratory or other proof of poliovirus as the cause. The expected background rate of NPAFP is two or more cases per 100,000 children aged <15 years per year, the standard WHO performance indicator target for sufficiently sensitive surveillance to detect one case of polio.

†† Adequate stool specimens are defined as two stool specimens of sufficient quality for laboratory analysis, collected ≥24 hours apart, both within 14 days of paralysis onset, and arriving in good condition at a WHO-accredited laboratory with reverse cold chain maintained, without leakage or desiccation, and with proper documentation. The global standard surveillance performance indicator target is ≥80% of AFP cases with adequate stool specimens collected.

TABLE. Acute flaccid paralysis surveillance performance indicators, reported cases of wild poliovirus and vaccine-derived poliovirus type 2,* and number of environmental samples with detection of wild poliovirus type 1, by region and period — Afghanistan, January 2021–September 2022†

	AFP surveillance performance indicators						No. of cases reported						No. of ES samples with WPV1 detected§		
	No. of AFP cases		NPAFP rate¶		% of cases with adequate stool specimens**		WPV1			cVDPV2					
							2021		2022	2021		2022	2021		2022
Region	2021	2022	2021	2022††	2021	2022	Jan–Jun	Jul–Dec	Jan–Sep	Jan–Jun	Jul–Dec	Jan–Sep	Jan–Jun	Jul–Dec	Jan–Sep
All	**4,088**	**3,580**	**18.7**	**24.8**	**94.0**	**94.9**	**1**	**3**	**2**	**42**	**1**	**0**	**1**	**0**	**3**
Badakhshan	90	102	14.2	24.1	95.6	96.1	0	0	0	0	0	0	0	0	0
Central	843	612	17.1	18.6	98.2	97.7	0	0	0	3	1	0	0	0	0
East	573	577	26.4	39.8	95.5	94.5	0	0	1	0	0	0	0	0	3
North	329	313	12.0	17.4	90.6	93.5	0	0	0	2	0	0	0	0	0
Northeast	408	348	16.8	21.5	93.9	93.9	0	3	0	0	0	0	0	0	0
South	827	721	21.8	28.7	89.7	91.9	0	0	0	12	0	0	1	0	0
Southeast	388	364	17.7	25.2	96.1	97.5	1	0	1	8	0	0	0	0	0
West	630	543	21.1	28.0	93.2	95.4	0	0	0	17	0	0	0	0	0

Abbreviations: AFP = acute flaccid paralysis; cVDPV2 = type 2 circulating vaccine-derived poliovirus; ES = environmental surveillance; NPAFP = nonpolio acute flaccid paralysis; WPV1 = wild poliovirus type 1.

* cVDPVs are genetically linked VDPV2 isolates for which there is evidence of person-to-person transmission in the community.

† Data as of October 20, 2022.

§ Total number of ES samples by period, January 2021–September 2022.

¶ Cases per 100,000 persons aged <15 years. The surveillance performance indicator target is two or more NPAFP cases per 100,000 persons aged <15 years per year.

** Adequate stool specimens are defined as two stool specimens of sufficient quality for laboratory analysis, collected ≥24 hours apart, both within 14 days of paralysis onset, and arriving in good condition at a World Health Organization–accredited laboratory with reverse cold chain maintained, without leakage or desiccation, and with proper documentation.

†† Annualized from AFP surveillance data through August 2022.

1 SIA dose, one had never received any OPV, one reportedly received 2 RI doses and 1 SIA dose, and one reportedly received 4 RI doses and 7 SIA doses.

Genomic sequence analysis of the region encoding the viral capsid protein 1 (VP1) of poliovirus isolates provided evidence of cross-border transmission between Afghanistan and Pakistan during 2019–2022, with sustained local transmission in both countries. During January 2021–September 2022, four of six WPV1 isolates from AFP patients and one of four WPV1 ES isolates from Afghanistan had their closest genetic links to WPV1 isolates from Pakistan. The poliovirus isolated from the first case during 2022, reported from Paktika province (Southeast Region), was genetically linked to previous circulation in Pakistan's Baluchistan province. The poliovirus from the second 2022 case, reported from Kunar province (East Region), was genetically linked with transmission in the Northeast Region of Afghanistan. During January 2021–September 2022, only two WPV1 genetic clusters (groups of viruses sharing ≥95% VP1 sequence identity) were detected among AFP cases and environmental samples. Of the five WPV1 viruses detected in 2021, two (40%) were orphan viruses,[§§] indicating possible gaps in surveillance; no orphan viruses have been detected in 2022 to date.

[§§] Orphan viruses are ≥1.5% divergent from their closest genetic match (i.e., ≤98.5% identity) and can indicate gaps in AFP surveillance.

Summary

What is already known about this topic?

Afghanistan and Pakistan are the only countries where wild poliovirus type 1 (WPV1) remains endemic.

What is added by this report?

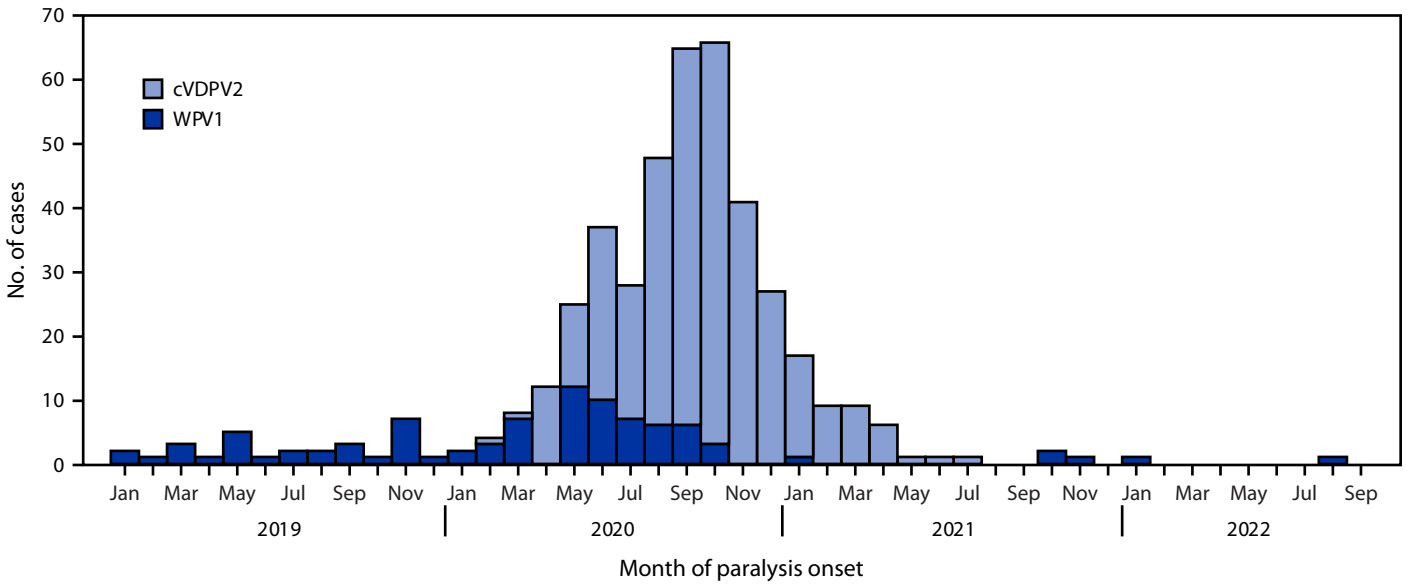
Two WPV1 cases had been reported in 2022 as of September 30, compared with one case during the same period in 2021. No type 2 circulating vaccine-derived poliovirus was reported in 2022 compared with 43 cases in 2021. Since the political transition in August 2021, 3.5–4.5 million previously unreachable children were vaccinated; supplementary immunization activity (SIA) restrictions persist in the South Region.

What are the implications for public health practice?

Ensuring implementation of high-quality SIAs in all parts of Afghanistan, especially in the high-risk provinces of the South Region, will accelerate progress toward interrupting WPV1 transmission.

Among 43 cVDPV2 cases reported in 2021, 29 (67%) were in the PAK-GB-1 emergence group, first detected in Gilgit-Baltistan, Pakistan, and 14 were in the AFG-NGR-1 emergence group, first detected in Afghanistan's Nangarhar province (*3*). Paralysis onset in the patient with the most recently detected cVDPV2 case was in July 2021.

FIGURE 1. Number of wild poliovirus type 1 cases and circulating vaccine-derived poliovirus type 2[*,†] cases, by month of onset of paralysis — Afghanistan, January 2019–September 2022[§]



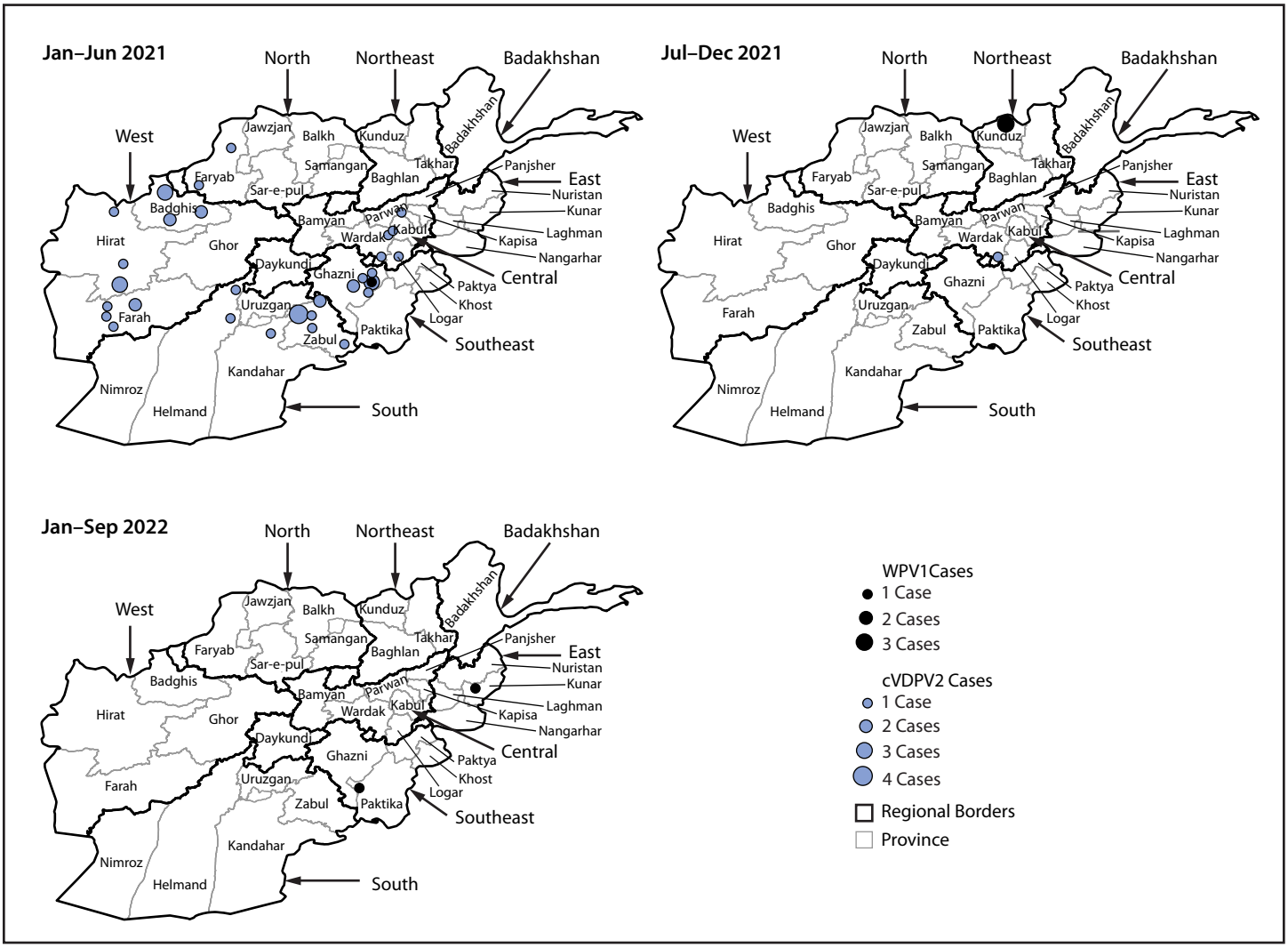
Abbreviations: cVDPV2 = circulating vaccine-derived poliovirus type 2; WPV1 = wild poliovirus type 1.
* The number of cases of WPV1 and cVDPV2 were 90 and 351, respectively.
† cVDPVs are genetically linked VDPV2 isolates for which there is evidence of person-to-person transmission in the community.
§ Data as of October 20, 2022.

Discussion

After confirmation of large numbers of both WPV1 and cVDPV2 polio cases during 2019–2020 in Afghanistan and Pakistan, both countries jointly reported five WPV1 and 51 cVDPV2 cases in 2021 (*1*). Given that the latest cVDPV2 detection was in Pakistan in August 2021, transmission of cVDPV2 in both countries is likely interrupted. Resurgence of WPV1 cases occurred in 2022 in the south of Khyber Pakhtunkhwa province of Pakistan, an area that directly borders Afghanistan, with substantial social ties and population movement. As of October 20, 2022, Afghanistan has reported two WPV1 cases, one each in the East and Southeast regions. After the political transition, the de facto government's public health authorities implemented an aggressive SIA schedule during November 2021–September 2022, which resulted in a substantial reduction in the number of unreached children. However, as of September 2022, >85% of children in the South Region where polio is endemic live in areas where restrictions on SIA implementation methods continue.

The findings in this report are subject to at least one limitation. The quality of data on SIA implementation is limited by the low accuracy of reported coverage data. The Global Polio Eradication Initiative is supporting the national program to establish a comprehensive data management system and providing ongoing staff member training.

FIGURE 2. Cases of polio caused by wild poliovirus type 1 and circulating vaccine-derived poliovirus type 2,* by province and period — Afghanistan, January 2021–September 2022†,§



Abbreviations: cVDPV2 = circulating vaccine-derived poliovirus type 2; WPV1 = wild poliovirus type 1.

* cVDPVs are genetically linked VDPV2 isolates for which there is evidence of person-to-person transmission in the community.

† Total cases by period: January–June 2021 = one WPV1 and 42 cVDPV2, July–December 2021 = three WPV1 and one cVDPV2, and January–September 2022 = two WPV1 and zero cVDPV2.

§ Data as of October 20, 2022.

Current polio eradication efforts in Afghanistan are challenged by a complex humanitarian emergency resulting from the combined impacts of a rapid government transition and a depressed economy, droughts, floods, food insecurity, displacement, and severe gaps in delivery of health services (*7*). In June 2022, a 5.9 magnitude earthquake struck Khost province in the Southeast Region, killing more than 1,000 persons and displacing entire communities (*8*). With progress broadening SIA access since the political transition, the opportunity to end WPV1 transmission in Afghanistan before the end of 2023 appears to be attainable. Ending transmission, however, depends on continued and expanded SIAs throughout the country, including in the high-risk provinces of the South Region.

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Corresponding author: Abdinoor Mohamed, wyr5@cdc.gov, 678-237-3701.

[1]Global Immunization Division, Center for Global Health, CDC; [2]Polio Eradication Department, World Health Organization, Kabul, Afghanistan; [3]Polio Eradication Department, World Health Organization, Geneva, Switzerland; [4]Polio Eradication Department, World Health Organization, Amman, Jordan; [5]Division of Viral Diseases, National Center for Immunization and Respiratory Diseases, CDC.

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Human Rabies — Texas, 2021

Dawn Blackburn, BVMS[1,*]; Faisal S. Minhaj, PharmD[2,3,*]; Roukaya Al Hammoud, MD[4]; Lillian Orciari[2]; Jael Miller[1]; Trevor Maness, PhD[5]; Jon Stewart, MPH[5]; Brittany Singletary[1]; Elvia Ledezma, MPH[5]; Misti Ellsworth, MD[4]; Andrea Carlo-Angleró, MD[4]; Michael Niezgoda, MS[2]; Crystal M. Gigante, PhD[2]; Agam K. Rao, MD[2]; Panayampalli S. Satheshkumar, PhD[2]; Gloria P. Heresi, MD[4]; Amanda Kieffer, DVM[5]; Ryan M. Wallace, DVM[2]

In late August 2021, a boy aged 7 years was bitten by a bat while he was playing outside his apartment home in Medina County, Texas. He informed his parents; however, no rabies postexposure prophylaxis (PEP) was sought because there were no visible bite marks, and the family was unaware that contact with a bat, including in the absence of visible bite marks, might cause rabies. Approximately 2 months later, the child was hospitalized for altered mental status, seizures, and hypersalivation and ultimately received a diagnosis of rabies. Experimental therapies were attempted; however, the child died 22 days after symptom onset. Fifty-seven persons who met criteria for suspected or known exposure to infectious secretions in this case were advised to consult with a medical provider about the need for rabies PEP in accordance with Advisory Committee on Immunization Practices (ACIP) guidelines (*1*). Rabies, an acute, progressive neuroencephalitis, is nearly always fatal. Although dogs are the most common source of human rabies deaths worldwide and account for an estimated 59,000 annual cases of human rabies globally (*2*), bats are the most common source of domestically acquired rabies in the United States and have been implicated in 31 (81.6%) of 38 human infections since 2000 (*3*). Attempts to prevent death or poor neurologic outcomes once rabies symptoms develop have been largely unsuccessful (*4*). Administration of rabies PEP, comprising rabies immunoglobulin and a series of doses of rabies vaccine, is critical to preventing rabies after an exposure; enhanced public education about the risk posed by bats, and the availability of PEP to prevent rabies, is needed.

On October 21, 2021, the boy aged 7 years was evaluated at a freestanding emergency department (facility A) for a 2-day history of right-hand pruritus and right upper extremity pain. He was given an oral steroid and discharged home. The following day, he was assessed at a different hospital emergency department (facility B) for a rash on the right side of his head, right scapular area, and right hand and arm along with continued pain in his right arm. He received a diagnosis of presumptive herpes zoster (shingles) and was prescribed a 5-day course of acyclovir along with antihistamines and ibuprofen. One day later, on October 23, he returned to facility B with delusions and worsening pruritus of his forehead and was discharged with diazepam for spasms and gabapentin for pain. Later that same day, he returned to facility B with nausea, vomiting, fever of 104°F (40°C), hypersalivation, and change in mental status, including confusion and delusions; he was intubated for airway protection. That evening, he was transferred to facility C, where he was admitted and began treatment with empiric antimicrobial drugs for presumed central nervous system infection. Initial testing included cerebrospinal fluid (CSF) and blood cultures and testing for herpes simplex virus, varicella zoster virus, enterovirus, mycoplasma, Bartonella, Epstein-Barr virus, and cytomegalovirus; all tests later had negative results. On October 25 (the third day of hospitalization), a diagnosis of rabies was suspected after infectious disease clinicians solicited a detailed history that disclosed the bat bite approximately 2 months earlier. Although the child had reported the bite to parents, no bite marks were seen, and the risk of rabies from bat contact was not considered; therefore, care was not sought. Aggressive intensive care management was initiated in facility C, and the patient began treatment with experimental intrathecal human rabies immune globulin on hospital day 7; however, this regimen was not successful, and the patient died on hospital day 16.

Public Health Investigation

Once rabies was suspected, saliva, nuchal skin biopsy, serum, and CSF were collected and sent to CDC's National Rabies Reference Laboratory. On October 27, nuchal skin biopsy and saliva specimens confirmed the presence of rabies viral RNA via real-time reverse transcription–polymerase chain reaction testing, confirming rabies virus infection (*5,6*). Sequencing of viral RNA collected from the patient was consistent with rabies virus found in the Mexican free-tailed bat (*Tadarida brasiliensis*), the most commonly reported rabid animal in Texas (*7*). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[†]

Texas Department of State Health Services (DSHS) interviewed family and community contacts to determine potential exposures to the patient during the infectious period, estimated to have commenced on October 5 (2 weeks before symptom onset) (*8*). Once the diagnosis was confirmed, persons who met exposure criteria (i.e., suspected or known exposure to infectious secretions) were advised to speak with a medical

*These authors contributed equally to this report.

[†] 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.

provider about administration of rabies PEP in accordance with ACIP guidelines (*1*). Among 10 of the patient's family members assessed, six met exposure criteria and received PEP (Table). One additional family member elected to receive PEP despite having no reported exposure risk.

The child had attended school and an extracurricular program during his infectious period. DSHS met with school administration and the extracurricular program director to identify persons who could have met exposure criteria (e.g., sharing of food or exertional face-to-face interactions). Among 49 community contacts, 46 met exposure criteria, and 34 contacts sought PEP. Most who sought PEP were students participating in the extracurricular program because they reported close contact during which tears and saliva were potentially exchanged. Local hospitals and physicians were advised of the potential increased demand for PEP.

Infection preventionists at facilities A, B, and C were provided a health care worker rabies risk exposure assessment tool[§] that included information about each health care worker's rabies vaccination status, the amount of time spent with and nature of physical contact with the patient (e.g., kissing or being bitten), and whether there was any contact with the patient's body fluids while not wearing personal protective equipment. The schedule for rabies PEP was also provided to infection preventionists. Five health care contacts among 118 assessed for exposure risk met exposure criteria; one sought PEP.

Following confirmation that the patient's exposure was caused by a bat bite outside his residence, DSHS contacted the apartment complex where he had resided and sent email and printed rabies advisories[¶] to the residents notifying them of the rabies risk from bats and the availability of treatment for exposed persons. Receipt of the health advisory was confirmed by telephone; among 175 residents, 124 (71%) were successfully contacted. Twenty-four residents reported sightings of bats in or around the complex; none reported physical contact with a bat. Evaluation of interviews from residents who reported bat sightings enabled DSHS and local animal control to identify the bat colony location. Immediate remediation of the colony was advised by DSHS and successfully completed by a pest management company.

After the patient's death, the funeral home and embalmer were contacted to ascertain the possibility of any further potential rabies exposures. No recommendations for rabies PEP were made because appropriate precautions had been taken (*9*).

Among the 42 contacts who initiated PEP, all were determined by DSHS to have completed PEP. No additional human rabies exposures or cases have been identified as a result of contact with this patient or the index bat in the apartment complex.

On October 29, 2021, DSHS issued a news release reporting the case and informing the public that at-risk contacts had been identified and were being assessed regarding the need for rabies PEP. General recommendations were provided for preventing rabies such as not approaching wild animals, seeking medical attention after an animal bite or scratch, and ensuring domestic dogs and cats are up to date with rabies vaccination.

[§] The Rabies Risk Assessment Tool is available by emailing rabies@cdc.gov.
[¶] Rabies advisories are available by emailing rabies@cdc.gov.

TABLE. Health care, community, and family contacts* of a human rabies case who met exposure criteria† and who sought rabies postexposure prophylaxis — Texas, 2021

	Contact setting, no. (%)			
	Health care	Community	Family	Total
Contact characteristic	n = 118	n = 49	n = 10	N = 177
Met exposure criteria	5 (4.2)	46 (93.9)	6 (60.0)	**57 (32.2)**
Sought PEP	1 (0.9)	34 (69.4)	7§ (70.0)	**42 (23.7)**

Abbreviation: PEP = postexposure prophylaxis.
* Persons having any contact with patient during infectious period.
† Any suspected or known exposure to infectious secretions; contacts meeting exposure criteria were advised to speak with a medical provider about rabies PEP.
§ One family member elected to receive PEP despite not having met exposure criteria.

Discussion

Bats are a reservoir species for rabies virus in all U.S. states except Hawaii. Bat-mediated human rabies deaths increased in 2021 following 2 years with no confirmed cases (*10*). In this case, bite marks were not recognized by the patient's immediate family members, and there was a lack of awareness of the risk for rabies from a bat in the absence of a visible bite mark, resulting in their not seeking medical care as well as a delay in eliciting the exposure history across multiple health systems. Contact with bats, including bites, is typically recognized by the recipient because of the bite force impact, despite many North American bat species typically having small teeth. Bites might not leave observable puncture marks, and given the high risk for rabies virus transmission from bats, PEP is recommended for any bat contact when a bite or scratch cannot be ruled out. Increased public health outreach and education about the rabies risk associated with bats and that rabies is preventable with PEP is needed. As part of its educational effort, Texas DSHS sponsors an annual rabies poster contest for school-aged children.**

Humans shed rabies virus during the clinical phase of disease; however, there has been no confirmed human-to-human transmission of rabies apart from that occurring through organ or tissue transplantation, including in health care settings. Rabies virus is transmitted through direct contact (such as through broken skin or mucous membranes in the eyes, nose, or mouth) with saliva, tears, respiratory secretions, and brain

** https://www.dshs.texas.gov/idcu/disease/rabies/information/contest.aspx

Summary

What is already known about this topic?

U.S. human rabies deaths typically result from contact with rabid bats. Rabies is preventable when postexposure prophylaxis (PEP) is promptly administered; once clinical signs develop, the disease is nearly always fatal.

What is added by this report?

A young boy was bitten by a bat; multiple persons knew of the exposure but did not recognize the rabies risk in the absence of a visible bite mark. Medical care was not sought until the child developed signs and symptoms 2 months later. One third of the child's contacts met exposure criteria, and one quarter sought PEP; no secondary cases were detected.

What are the implications for public health practices?

Enhanced public education about the risk for rabies associated with bat contact and the importance of seeking PEP if contact occurs is needed.

or nervous system tissue. Use of standard precautions[††] protects health care workers against potential exposure to rabies. In this investigation, compliance with standard COVID-19 precautions[§§] at health facilities enabled nearly all health care providers to confidently rule out exposure. However, a significant number of community members received PEP because of possible exposure during the patient's social activities and lack of reliable information about nature of exposures to the patient from his peers, who were mostly children aged <10 years.

This case serves as a reminder that rabies virus is still present in the United States and that exposures to bats and other mammalian wildlife should always prompt a consultation with public health officials or medical providers. It is important to inform animal control or local public health officials when bats build roosts within and around human dwellings. PEP is highly effective and should be administered as soon as possible after an exposure to prevent rabies.

[††] https://www.cdc.gov/oralhealth/infectioncontrol/summary-infection-prevention-practices/standard-precautions.html

[§§] https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html

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Corresponding author: Faisal S. Minhaj, fminhaj@cdc.gov.

[1]Texas Department of State Health Services Region 6/5 South, Houston, Texas; [2]Division of High Consequence Pathogens and Pathology, National Center for Emerging and Zoonotic Diseases, CDC; [3]Epidemic Intelligence Service, CDC; [4]Division of Infectious Diseases, Department of Pediatrics, McGovern Medical School at UTHealth Houston and Children's Memorial Hermann Hospital, Houston, Texas; [5]Texas Department of State Health Services Region 8, San Antonio, Texas.

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Chronic Obstructive Pulmonary Disease Mortality by Industry and Occupation — United States, 2020

Girija Syamlal, MBBS[1]; Laura M. Kurth, PhD[1]; Katelynn E. Dodd, MPH[1]; David J. Blackley, DrPH[1]; Noemi B. Hall, PhD[1]; Jacek M. Mazurek, MD[1]

Chronic obstructive pulmonary disease (COPD), a progressive lung disease, is characterized by long-term respiratory symptoms and airflow limitation (*1*). COPD accounts for most of the deaths from chronic lower respiratory diseases, the sixth leading cause of death in the United States in 2020.* Workplace exposures and tobacco smoking are risk factors for COPD; however, one in four workers with COPD have never smoked (*2–4*). To describe COPD mortality among U.S. residents aged ≥15 years categorized as ever-employed (i.e., with information on their usual industry and occupation), CDC analyzed the most recent 2020 multiple cause-of-death data† from 46 states and New York City.§ Among 3,077,127 decedents, 316,023 (10.3%) had COPD¶ listed on the death certificate. The highest age-adjusted** COPD death rates per 100,000 ever-employed persons were for females (101.3), White persons (116.9), and non-Hispanic or Latino (non-Hispanic) persons (115.8). The highest proportionate mortality ratios (PMRs)†† were for workers employed in the mining industry (1.3) and in food preparation and serving related occupations (1.3). Elevated COPD mortality among workers in certain industries and occupations underscores the importance of targeted interventions (e.g., reduction or elimination of COPD-associated risk factors, engineering controls, and workplace smoke-free policies) to prevent COPD from developing and to intervene before illness becomes symptomatic or severe.

The analysis included 3,077,127§§ U.S. residents aged ≥15 years from 47 jurisdictions (46 states and New York City) who died during 2020 and whose record in National Vital Statistics System public use multiple-cause-of-death data included information on their usual¶¶ industry and occupation. COPD was identified using the *International Classification of Diseases, Tenth Revision* (ICD-10) codes J40–J44 listed as the underlying or contributing cause of death. The 23 two-digit industries and 26 occupations were grouped according to the 2012 North American Industry Classification System and the 2010 Standard Occupational Classification, respectively.***

Death rates (per 100,000 ever-employed persons) were based on postcensal population estimates as of July 1, 2020. Death rates were age-adjusted to the 2000 U.S. population. PMRs adjusted for age, sex, and race were calculated. A PMR with the lower 95% CI >1.0 indicated a significantly higher proportion of deaths associated with COPD in a specified industry or occupation than expected. CIs were calculated assuming Poisson distribution of data. Analyses were conducted using SAS software (version 9.4; SAS Institute).

Among the 3,077,127 decedents, 316,023 (10.3%; age-adjusted death rate = 102.5 deaths per 100,000 ever-employed persons) had COPD listed on their death certificates as the underlying or contributing cause of death. The highest age-specific COPD death rate (855.8 deaths per 100,000 ever-employed persons) was for persons aged ≥75 years (Table 1). The highest age-adjusted death rates were for females (101.3), White persons (116.9), and non-Hispanic persons (115.8) (Table 1).

* https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm

† https://www.cdc.gov/nchs/nvss/mortality_public_use_data.htm

§ Forty-six states and New York City participated in a collaborative (National Center for Health Statistics [NCHS] and the National Institute for Occupational Safety and Health) program to translate industry and occupation information on death certificates to U.S. Census Bureau Industry and Occupation codes (https://www.cdc.gov/nchs/data/dvs/Industry-and-Occupation-data-mortality-2020.pdf). Arizona, District of Columbia, North Carolina, and Rhode Island did not participate. Because of differences in collection methods, Iowa's data were not consistent with those from other states and were excluded.

¶ ICD-10 codes J40 (bronchitis, not specified as acute or chronic), J41 (simple mucopurulent chronic bronchitis), J42 (unspecified chronic bronchitis), J43 (emphysema), and J44 (other chronic obstructive pulmonary disease), assigned as the underlying (the disease or injury that initiated the chain of events that led directly and inevitably to death) or contributing cause of death. https://wonder.cdc.gov/; https://www.cdc.gov/nchs/icd/icd10.htm

** Age-adjusted death rates were calculated by applying age-specific death rates to the 2000 U.S. Census Bureau standard population age distribution. https://wonder.cdc.gov/wonder/help/mcd.html#Age-Adjusted

†† PMR was defined as the observed number of deaths from COPD in a specified industry or occupation, divided by the expected number of deaths from COPD. The expected number of deaths was the total number of deaths in the industry or occupation of interest multiplied by a proportion defined as the number of COPD deaths in all industries or occupations, divided by the total number of deaths in all industries or occupations. The COPD PMRs were adjusted by 10-year age groups, sex, and race. A PMR >1.0 indicates that more deaths were associated with the condition in a specified occupation or industry than expected. https://wwwn.cdc.gov/eworld/Appendix/Mortality

§§ NCHS multiple cause-of-death data included 3,390,278 decedents. Foreign residents, decedents aged <15 years, persons with missing age, and decedents from the five nonparticipating or excluded jurisdictions were not included in industry and occupation coding (3,115,391). Decedents whose death certificate lacked information on industry and occupation (38,264) were excluded from the analysis, resulting in 3,077,127 records.

¶¶ Usual occupation (and corresponding business or industry) is not necessarily the occupation of the decedent at the time of death, but the occupation the person did for "most of his or her working life," based on funeral director's discussions with decedent's informant. https://www.cdc.gov/niosh/topics/noms/funeral.html; https://www.cdc.gov/niosh/docs/2012-149/default.html

*** https://www.cdc.gov/nchs/data/dvs/Industry-and-Occupation-data-mortality-2020.pdf

PMRs were significantly elevated among ever-employed persons in 10 of the 23 industries and 11 of the 26 occupations (Table 2) (Table 3). The three industries with the highest PMRs were mining (1.33), accommodation and food services (1.28), and construction (1.23). The three occupations with the highest PMRs were food preparation and serving related (1.30), healthcare support (1.29), and construction and extraction (1.29).

Discussion

In 2020, 10% of deaths among ever-employed persons aged ≥15 years in 47 jurisdictions were associated with COPD. Elevated age-adjusted COPD death rates among White and non-Hispanic persons[†††] are consistent with previous findings of increased COPD morbidity and mortality among these groups (*3*,*5*). During 2012–2018, an estimated 5.8 million (annual average) currently employed U.S. workers had COPD (*3*). An estimated 40% of adults with COPD have never smoked, and an estimated 24% of all COPD cases among never-smokers were attributed to workplace exposures (*2*–*4*), including dust, fumes, gases, vapors, and secondhand smoke (*2*). To reduce the prevalence of COPD among workers, the COPD National Action Plan[§§§] emphasizes that occupational risk factors and interventions should be included in messaging and communication campaigns. In addition, COPD should be incorporated into prevention programs that address occupational risk factors.[¶¶¶] Higher proportions of COPD deaths were observed for ever-employed persons whose usual industry

[†††] https://www.lung.org/research/trends-in-lung-disease/copd-trends-brief/data-tables/trends-in-mortality-sex-and-race; https://www.lung.org/research/trends-in-lung-disease/copd-trends-brief/copd-prevalence

[§§§] https://www.nhlbi.nih.gov/health-topics/education-and-awareness/COPD-national-action-plan

[¶¶¶] https://www.nhlbi.nih.gov/resources/copd-national-action-plan

TABLE 1. Number, percentage, and rates of deaths for chronic obstructive pulmonary disease* among ever-employed† persons aged ≥15 years, by selected characteristics — 46 states and New York City, 2020

Characteristic	No. of deaths from all causes§	COPD		
		No. of deaths (%)	Death rate	
			Unadjusted¶	Age-adjusted** (95% CI)
Total	**3,077,127**	**316,023 (10.3)**	**126.2**	**102.5 (102.5–102.9)**
Age group, yrs				
15–24	31,993	47 (0.1)	0.1	—
25–34	66,292	222 (0.3)	0.5	—
35–44	94,924	1,276 (1.3)	3.3	—
45–54	173,980	7,807 (4.5)	20.8	—
55–64	402,215	41,234 (10.3)	104.4	—
64–74	617,183	82,037 (13.3)	271.7	—
≥75	1,690,540	183,400 (10.8)	855.8	—
Sex				
Female	1,471,005	153,716 (10.4)	120.0	101.3 (100.3–101.8)
Male	1,606,122	162,307 (10.1)	132.7	99.4 (98.5–99.9)
Race††				
American Indian or Alaska Native	22,406	2,109 (9.4)	65.6	41.5 (37.5–45.5)
Asian or other Pacific Islander	96,981	4,721 (4.9)	26.9	16.3 (15.4–17.3)
Black or African American	408,549	27,422 (6.7)	84.0	62.1 (60.5–63.7)
White	2,549,191	281,771 (11.1)	143.8	116.9 (116.1–17.7)
Ethnicity				
Hispanic or Latino	277,756	13,934 (5.0)	32.4	21.1 (20.4–21.9)
Non-Hispanic or Latino	2,799,371	302,089 (10.8)	145.3	115.8 (115.0–116.6)
COPD*				
Chronic bronchitis	—	1,702	0.7	0.7 (0.5–0.7)
Emphysema	—	18,129	7.2	5.9 (5.7–6.0)
Other COPD	—	298,419	119.2	96.8 (96.1–97.4)

Source: National Vital Statistics System public use multiple cause files 2020. https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm#Mortality_Multiple

Abbreviations: COPD = chronic obstructive pulmonary disease; ICD-10 = *International Classification of Diseases, Tenth Revision*.

* Decedents with COPD (ICD-10 codes J40–J44) listed as the underlying or contributing cause-of-death.

† Decedents with information on their usual industry and occupation.

§ Among ever-employed U.S. residents aged ≥15 years from 47 jurisdiction (excluding Arizona, District of Columbia, Iowa, North Carolina, and Rhode Island) with information on their usual industry and occupation information.

¶ Death rates are per 100,000 workers, based on 2020 estimates released by U.S. Census Bureau on July 27, 2021. https://www.census.gov/programs-surveys/popest/technical-documentation/methodology.html; https://wonder.cdc.gov/single-race-population.html

** Age-adjusted death rates (per 100,000 workers) were calculated by applying age-specific death rates to the 2000 U.S. Census Bureau standard population age distribution. https://wonder.cdc.gov/wonder/help/mcd.html#Age-AdjustedRates

†† Race and Hispanic origin are reported separately on the death certificate. The American Indian or Alaska Native race category includes North, Central, and South American Indians, Eskimos, and Aleuts. The Asian or other Pacific Islander race category includes Chinese, Filipino, Hawaiian, Japanese, and other Asian or Pacific Islanders.

was mining, accommodation and food services, construction, or transportation and material moving, and among workers whose usual occupation was healthcare support, food preparation and serving related, construction and extraction, or transportation and material moving. National survey data indicates that workers in these industries and occupations have elevated prevalence of COPD, higher tobacco use, and are frequently exposed to secondhand smoke, vapors, gas, dust, and fumes in the workplace (*2*,*3*,*6*–*8*). For example, approximately one third of the workers in mining, construction, accommodation and food services, and transportation and warehousing industries, and healthcare support, construction and extraction, food preparation and serving related occupations are combustible tobacco users and are often exposed to secondhand smoke, diesel exhaust, and byproducts of machinery combustion, as well as dusts (e.g., wood and silica dusts), vapors, and fumes (*6*–*8*). In addition, a previous study among nurses and healthcare support workers found that exposure to cleaners and

Summary

What is already known about this topic?

Chronic obstructive pulmonary disease (COPD) was the sixth leading cause of death in the United States in 2020. Workplace exposures and tobacco smoking are risk factors for COPD.

What is added by this report?

In 2020, 316,023 (10.3%) deaths among ever-employed persons were associated with COPD. The COPD proportionate mortality ratios were elevated for several industries and occupations, and highest among workers in the mining industry and in food preparation and serving–related occupations.

What are the implications for public health practice?

Elevated COPD mortality among workers in certain industries and occupations underscores the importance of targeted interventions, including reduction or elimination of COPD-related risk factors and workplace smoke-free policies, to prevent COPD from developing and to intervene before illness becomes symptomatic or severe.

TABLE 2. Number and percentage of deaths from chronic obstructive pulmonary disease* and proportionate mortality ratio† among ever-employed§ persons aged ≥15 years, by industry — 46 states and New York City, 2020

Industry¶	No. of deaths from all causes**	COPD	
		No. of deaths (%)	PMR (95% CI)
Agriculture, forestry, fishing, and hunting	68,502	7,768 (11.3)	1.03 (1.00–1.05)††
Mining	22,706	3,275 (14.4)	1.33 (1.28–1.38)††
Utilities	30,236	3,209 (10.6)	0.96 (0.92–0.99)
Construction	224,353	26,673 (11.9)	1.23 (1.21–1.24)††
Manufacturing	386,796	43,509 (11.2)	1.04 (1.03–1.05)††
Wholesale trade	28,331	2,823 (10.0)	0.93 (0.90–0.97)
Retail trade	220,233	22,836 (10.4)	0.99 (0.98–1.01)
Transportation and warehousing	161,208	18,745 (11.6)	1.14 (1.12–1.16)††
Information	55,556	5,207 (9.4)	0.86 (0.84–0.88)
Finance and insurance	88,115	7,780 (8.8)	0.80 (0.79–0.82)
Real estate and rental and leasing	37,290	3,601 (3.6)	0.89 (0.87–0.92)
Professional, scientific, and technical services	113,239	9,060 (8.0)	0.75 (0.73–0.76)
Management of companies and enterprises	4,587	462 (10.1)	0.89 (0.82–0.97)
Administrative, support, and waste management and remediation services	71,284	6,798 (9.5)	1.04 (1.02–1.07)††
Education services	203,542	14,954 (7.3)	0.68 (0.67–0.68)
Healthcare and social assistance	266,570	26,857 (1.1)	1.00 (0.99–1.01)
Arts, entertainment, and recreation	40,380	3,916 (9.7)	0.98 (0.95–1.02)
Accommodation and food services	114,117	12,721 (11.1)	1.28 (1.25–1.30)††
Other services (except public administration)	145,870	15,073 (10.3)	1.03 (1.02–1.05)††
Public administration	145,493	14,511 (10.0)	0.92 (0.91–0.94)
Military	31,044	4,145 (13.4)	1.23 (1.19–1.27)††
Other-misc, missing	617,675	62,100 (13.4)	1.02 (1.01–1.03)††

Source: National Vital Statistics System (NVSS) public use multiple cause files 2020. https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm#Mortality_Multiple
Abbreviations: COPD = chronic obstructive pulmonary disease; ICD-10 = *International Classification of Diseases, Tenth Revision*; misc = miscellaneous; PMR = proportionate mortality ratio.

* Decedents with COPD (ICD-10 codes J40–J44) listed as the underlying or contributing cause of death.

† PMR was defined as the observed number of deaths from COPD in a specified industry, divided by the expected number of deaths from COPD. The expected number of deaths was the total number of deaths in an industry of interest multiplied by a proportion defined as the number of COPD deaths in all industries, divided by the total number of deaths in all industries. PMRs were adjusted for 10-year age group, sex, and race.

§ Decedents with information on their usual industry and occupation.

¶ Industry the decedent worked in "during most of his or her life, or for the longest time" and is the two-digit simple industry recode based on the 2012 North American Industry Classification System–informed codes obtained from the U.S. Census Bureau. https://www.cdc.gov/nchs/data/dvs/Industry-and-Occupation-data-mortality-2020.pdf

** Ever-employed aged ≥15 years with information on their usual industry and occupation, information from 47 jurisdictions (excluding Arizona, District of Columbia, Iowa, North Carolina, and Rhode Island).

†† Significantly elevated PMR.

disinfectants (i.e., glutaraldehyde, bleach, hydrogen peroxide, alcohol, and ammonium compounds) was associated with increased (25%–38%) risk for COPD (*9*).

Although the exact reason for the differences in high COPD death rates among certain groups is unknown, differences could be partly explained by preventable workplace exposures including secondhand smoke, vapors, dusts, and fumes (*2*,*6*,*8*). Identification of hazards in the workplace could assist with early identification and implementation of public health programs (e.g., workplace smoke-free policies and cessation programs, elimination or substitution of exposures, removing workers from exposures, and engineering controls such as ventilation or enclosure of exposure-generating processes) that support comprehensive approaches to prevention through control of workplace hazards and promotion of healthy behaviors, early interventions, and better access to health care services (*8*).

The findings in this report are subject to at least six limitations. First, COPD-related deaths were not validated using medical records. Second, no information on workplace exposures is available on death certificates. Therefore, whether workplace exposures could have led directly to the COPD death is unknown. Third, if COPD was caused by workplace exposures, the industry and occupation information reported on the death certificate might not be the industry and occupation in which workplace exposures occurred. Fourth, 38,264 decedents (1.2% of total deaths) for whom employment history was not available on the death certificate were excluded from the current study. Fifth, information on smoking status of decedents was not available; smoking is known to cause or worsen COPD. Finally, results are limited to 47 jurisdictions and might not be representative of nonparticipating jurisdictions.

TABLE 3. Number, percentage of deaths from chronic obstructive pulmonary disease* and proportionate mortality ratio† among ever-employed§ persons aged ≥15 years, by occupation — 46 states and New York City, 2020

Occupation¶	No. of deaths from all causes**	COPD	
		No. of deaths (%)	PMR (95% CI)
Management	254,603	24.301 (9.5)	0.87 (0.86–0.88)
Business and financial operations	76,100	6,622 (8.7)	0.80 (0.79–0.82)
Computer and mathematical	25,320	1,803 (7.1)	0.71 (0.69–0.74)
Architecture and engineering	70,332	5,693 (8.1)	0.71 (0.70–0.73)
Life, physical, and social science	20,039	1,448 (7.2)	0.66 (0.63–0.68)
Community and social services	42,143	3,088 (7.3)	0.70 (0.68–0.72)
Legal	18,257	1,312 (7.2)	0.64 (0.62–0.67)
Education, training, and library	133,542	8,705 (6.5)	0.60 (0.59–0.61)
Arts, design, entertainment, sports, and media	47,606	4,047 (8.5)	0.82 (0.80–0.84)
Healthcare practitioners and technical	116,891	10,734 (9.2)	0.88 (0.86–0.89)
Healthcare support	52,528	6,281 (12.0)	1.29 (1.25–1.32)††
Protective service	54,826	5,721 (10.4)	1.02 (1.00–1.04)
Food preparation and serving related	91,368	10,315 (11.3)	1.30 (1.27–1.33)††
Building and grounds cleaning and maintenance	95,098	9,718 (10.2)	1.10 (1.07–1.12)††
Personal care and service	67,952	7,267 (10.7)	1.11 (1.08–1.14)††
Sales and related	214,771	21,705 (10.1)	0.94 (0.93–0.96)
Office and administrative support	272,811	27,265 (10.0)	0.93 (0.92–0.94)
Farming, fishing, and forestry	22,299	2,595 (11.6)	1.14 (1.09–1.19)††
Construction and extraction	206,217	25,730 (12.5)	1.29 (1.27–1.31)††
Installation, maintenance, and repair	106,146	13,120 (12.4)	1.20 (1.17–1.22)††
Production	240,443	28,247 (11.7)	1.11 (1.09–1.12)††
Transportation and material moving	214,521	25,389 (11.8)	1.22 (1.20–1.24)††
Military	30,360	4,046 (13.3)	1.22 (1.18–1.27)††
Other-misc (except housewife)	215,532	20,513 (9.5)	1.14 (1.12–1.16)††
Other-housewife	387,422	40,358 (10.4)	0.96 (0.96–0.97)

Source: National Vital Statistics System (NVSS) public use multiple cause files 2020. https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm#Mortality_Multiple
Abbreviations: COPD = chronic obstructive pulmonary disease; ICD-10 = *International Classification of Diseases, Tenth Revision*; misc = miscellaneous; PMR = proportionate mortality ratio.

* Decedents with COPD (ICD-10 codes J40–J44) listed as an underlying or contributing cause-of-death.
† PMR was defined as the observed number of deaths from COPD in a specified occupation, divided by the expected number of deaths from COPD. The expected number of deaths was the total number of deaths in an occupation of interest multiplied by a proportion defined as the number of COPD deaths in all industries, divided by the total number of deaths in all industries. PMRs were adjusted for 10-year age group, sex, and race.
§ Decedents with information on their usual industry and occupation.
¶ Occupation the decedent worked in "during most of his or her life, or for the longest time" and is the two-digit simple occupation recode based on the 2010 Standard Occupation Classification–informed codes obtained from the U.S. Census Bureau. https://www.cdc.gov/nchs/data/dvs/Industry-and-Occupation-data-mortality-2020.pdf
** Ever-employed persons aged ≥15 years with information on their usual industry and occupation information from 47 jurisdictions (excluding Arizona, District of Columbia, Iowa, North Carolina, and Rhode Island).
†† Significantly elevated PMR.

Findings from this report might help physicians identify workers who should be evaluated for COPD in the industries and occupations with a higher proportion of COPD deaths. The elevated COPD mortality among ever-employed persons in certain industries and occupations underscores the importance of targeted interventions to prevent COPD from developing and intervening before it becomes symptomatic or severe. Continued surveillance, including collection of detailed industry and occupational history and etiologic research to further characterize occupational risk factors for COPD, is essential to guide interventions and policies to improve workers' health.

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Corresponding author: Girija Syamlal, gos2@cdc.gov, 304-285-5827.

[1]Respiratory Health Division, National Institute for Occupational Safety and Health, CDC.

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Safety Monitoring of JYNNEOS Vaccine During the 2022 Mpox Outbreak — United States, May 22–October 21, 2022

Jonathan Duffy, MD[1]; Paige Marquez, MPH[1]; Pedro Moro, MD[1]; Eric Weintraub, MPH[1]; Yon Yu, PharmD[1]; Peter Boersma, MPH[1]; James G. Donahue, DVM, PhD[2]; Jason M. Glanz, PhD[3]; Kristin Goddard, MPH[4]; Simon J. Hambidge, MD, PhD[5]; Bruno Lewin, MD[6]; Ned Lewis, MPH[4]; Douglas Rouse, MD[7]; Tom Shimabukuro, MD[1]

JYNNEOS (Modified Vaccinia Ankara vaccine, Bavarian Nordic) is recommended in the United States for persons exposed to or at high risk for exposure to *Monkeypox virus* during the 2022 monkeypox (mpox) outbreak (*1*). JYNNEOS is a live, nonreplicating viral vaccine licensed for the prevention of smallpox and mpox in adults aged ≥18 years, administered as a 0.5-mL 2-dose series given 28 days apart by subcutaneous injection (*2*). On August 9, 2022, the Food and Drug Administration (FDA) issued an Emergency Use Authorization (EUA) for administration of 0.1 mL doses by intradermal injection for adults aged ≥18 years as a strategy to increase vaccine supply, and administration of 0.5 mL doses subcutaneously for persons aged <18 years (*3*). During May 22–October 21, 2022, a total of 987,294 JYNNEOS vaccine doses were administered in the United States. CDC has monitored JYNNEOS vaccine safety using the Vaccine Adverse Event Reporting System (VAERS) and the Vaccine Safety Datalink (VSD) for vaccine recipients of all ages, and through single-patient emergency Investigational New Drug (EIND) procedures for persons aged <18 years vaccinated before August 9, 2022. The most common adverse health events reported to VAERS for adults were nonserious and included injection site reactions, which was consistent with the prelicensure studies. Adverse health events were reported at similar rates for doses received by intradermal and subcutaneous administration. Serious adverse events were rare in adults, and no serious adverse events have been identified among persons aged <18 years. Overall, postlicensure and postauthorization surveillance to date support JYNNEOS vaccine safety.

VAERS is a national passive surveillance system for adverse events after vaccination (*4*). VAERS accepts reports from health care providers, vaccine manufacturers, and the public. The JYNNEOS EUA requires reporting the following events to VAERS: vaccine administration errors (whether or not associated with an adverse event), serious adverse events (irrespective of attribution to vaccination), and cases of cardiac, thromboembolic, and neurovascular events.* Reported signs and symptoms are coded using Medical Dictionary for Regulatory Activities (MedDRA) terminology.† Adverse events that are serious or of special interest are followed up by obtaining medical records, information from health care providers, and, in cases of death, death certificates and autopsy reports. Adverse events of special interest include anaphylaxis (an adverse event that can occur after any vaccine), and myocarditis, which is associated with older smallpox vaccines (*5*,*6*). Reports received and processed by October 21, 2022, were included.§ Adverse event reporting rates were calculated by dividing the number of reports by the number of vaccine doses administered during May 22–October 14 (to allow a minimum of 7 days for VAERS reporting) and reported to CDC by October 24, 2022 (*7*).

VSD is a collaboration between CDC and several integrated health care systems that uses electronic health record data to perform active vaccine safety surveillance (*8*). VSD identified medical visits with *International Classification of Diseases, Tenth Revision* diagnosis codes for myocarditis or pericarditis¶ that occurred within 30 days after either dose of JYNNEOS and verified the diagnosis using medical record review. Eight VSD health care systems contributed data to this assessment. For VAERS and VSD, rates and bivariate rate ratios (RRs) with associated 95% CIs were estimated and compared using Fisher's exact test; analyses were conducted using OpenEpi software (version 3.01; OpenEpi).

CDC facilitated JYNNEOS EIND authorizations from FDA for 65 persons aged <18 years. CDC solicited information from vaccine providers about adverse events occurring during the 28 days after each dose. All activities described were reviewed by CDC and conducted consistent with applicable federal law and CDC policy.**

During the surveillance period (May 22–October 21, 2022), 987,294 JYNNEOS vaccine doses were administered in the United States, including 652,641 (66%) first doses

*The JYNNEOS EUA requires health care providers and the vaccine manufacturer to report serious adverse events (irrespective of attribution to vaccination), and cases of cardiac, thromboembolic, and neurovascular events. Health care providers are also required to report vaccine administration errors (whether or not associated with an adverse event). Based on the Code of Federal Regulations, a serious adverse event is defined as occurring if one of the following is reported: death, life-threatening illness, hospitalization or prolongation of hospitalization, permanent disability, congenital anomaly, or birth defect.

† A single VAERS report might be assigned more than one MedDRA preferred term; not all terms are medically confirmed diagnoses. https://www.meddra.org/how-to-use/basics/hierarchy

§ Processed VAERS reports are those that have been MedDRA-coded, deduplicated, and have undergone quality assurance and quality control.

¶ Myocarditis and pericarditis *International Classification of Diseases, Tenth Revision* codes included B33.22*, B33.23*, I30.*, I31.9*, I40.*, and I51.4. An asterisk indicates that any trailing digit values were included.

** 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.

and 334,568 (34%) second doses. Approximately one half (51%) of doses were administered intradermally, one third (34%) subcutaneously, and the remaining 15% by unknown or other routes. Overall, 90% of vaccinated persons were male. JYNNEOS vaccine was administered to 1,003 persons aged <18 years.

Vaccine Adverse Event Reporting System

VAERS received 1,350 reports for JYNNEOS. Most reports were for males (84%), after dose 1 (63%), and for vaccine doses administered either intradermally (54%) or subcutaneously (25%) (Table 1). Approximately one half of reports (638; 47%) documented a vaccine administration error, 624 (98%) of which did not mention an adverse health event. The administration error reporting rate was higher for intradermal (818 per million doses administered) than for subcutaneous administration (314) (RR = 2.61; 95% CI = 2.10–3.26). The most common perceived vaccination error reported for intradermal administration was absence of a wheal without vaccine leakage on the first injection attempt (220 [54%] of 410 error reports). Among all VAERS reports, 685 (51%) documented an adverse health event. The reporting rates of adverse health events were similar for intradermal and subcutaneous administration (648 and 627 reports per million doses administered, respectively) (RR = 1.03; 95% CI = 0.87–1.24). The most common types of adverse health events reported differed by route of administration (Table 2).

Fourteen reports (1%) were classified as serious. Two deaths in males aged 37 and 58 years were reported, both within 2 days of vaccination. In one case, drowning was the cause of death. The death certificate is pending for the other case. Nine reports were classified as serious because of hospitalization for the following events: myocarditis (two), pericarditis (two), appendicitis (one), aseptic meningitis (one), atrial fibrillation (one), idiopathic thrombocytopenic purpura (one), and methemoglobinemia (one). Three vaccinated persons reported the following events as representing disability or permanent damage in their own assessment: injection site discoloration (one), injection site pain (one), and injection site scar (one).

The myocarditis reporting rate was 1.53 cases per million doses within 30 days after receipt of dose 1 and 2.99 after dose 2. Three reports of anaphylaxis within 24 hours of

TABLE 1. Characteristics of JYNNEOS vaccine recipients with reports submitted to the Vaccine Adverse Event Reporting System after vaccination (N = 1,350) — United States, May 22–October 21, 2022

Characteristic	No. (%)
Sex	
Male	1,134 (84)
Female	184 (14)
Not reported	32 (2)
Age group, yrs	
0–17	13 (1)
18–49	1,013 (75)
50–64	247 (18)
≥65	68 (5)
Not reported	9 (1)
Dose in series	
First	850 (63)
Second	317 (23)
Not reported or other	183 (14)
Route of administration	
Intradermal	732 (54)
Subcutaneous	334 (25)
Intramuscular	155 (11)
Not reported or other	129 (10)
JYNNEOS administered with other vaccines the same day	
Yes	33 (2)
No	1,317 (98)
Seriousness classification*	
Nonserious	1,336 (99)
Serious	14 (1)
JYNNEOS vaccine administration error reported	
Yes	638 (47)
No	712 (53)
Adverse health event reported	
Yes	685 (51)
No	665 (49)

* Based on the Code of Federal Regulations, classification of a serious adverse event includes a report of one of the following: death, life-threatening illness, hospitalization or prolongation of hospitalization, permanent disability, congenital anomaly, or birth defect.

TABLE 2. Reporting rates for the 10 most frequently reported adverse health events* after JYNNEOS vaccine receipt, by route of administration† — Vaccine Adverse Event Reporting System, United States, May 22–October 21, 2022

Route of administration/ Health event	No. of reports	Reporting rate§ (95% CI)
Intradermal (n = 325)		
Injection site erythema	75	150 (118–188)
Dizziness	66	132 (102–168)
Urticaria	60	120 (91–154)
Injection site swelling	51	102 (76–134)
Syncope	43	86 (62–116)
Erythema	42	84 (60–113)
Loss of consciousness	41	82 (59–111)
Injection site pruritus	40	80 (57–109)
Hyperhidrosis	38	76 (54–104)
Pruritus	33	66 (45–92)
Subcutaneous (n = 212)		
Injection site erythema	36	107 (75–148)
Injection site swelling	36	107 (75–148)
Injection site pain	34	101 (70–141)
Pain	29	86 (57–123)
Erythema	28	83 (55–120)
Dizziness	27	80 (53–116)
Headache	26	77 (50–113)
Fatigue	25	74 (48–109)
Injection site pruritus	23	68 (43–102)
Pyrexia	23	68 (43–102)

* Excluding vaccination errors and deviations from recommendations.
† Licensed and authorized routes of administration only.
§ Reports per million doses administered; total number of intradermal doses administered = 501,228 and subcutaneous doses administered = 337,950.

vaccination were received (overall reporting rate = 3.04; 95% CI = 0.63–8.88 cases per million doses administered) (Table 3).

VAERS received 13 reports for persons aged <18 years, one of which included an adverse health event (syncope). The other reports for persons in this age group were related to vaccine administration errors, most commonly inadvertent intradermal rather than subcutaneous administration (six), which is the authorized route of administration for persons aged <18 years.

Vaccine Safety Datalink

As of October 21, 2022, a total of 43,253 JYNNEOS doses had been administered to persons in the VSD population, representing approximately 4.3% of all doses administered nationally. Among 25,659 males and 1,953 females who received dose 1, 58% and 37%, respectively, also received dose 2. One case of myocarditis was identified after each dose in males. The incidence among males after dose 1 was 39 per million doses (95% CI = 0.1–217.1) and after dose 2 was 67 (95% CI = 1.7–374.4).

Emergency Investigational New Drug Authorizations

Among the 65 persons aged <18 years for whom CDC obtained EIND authorization for vaccination, 55 were confirmed to have received ≥1 vaccine dose. CDC also received vaccine follow-up information for seven additional persons aged <18 years who were vaccinated under the EUA. Overall, vaccine recipients ranged in age from 4 months to 17 years, and 58% were male. Information about whether adverse events occurred was received for 57 of the 62 persons aged <18 years vaccinated. Adverse events were reported for 10 (18%) of 57 after the first dose and five (21%) of 24 after the second dose. Most were injection site reactions, including pain, erythema, swelling, and induration. Systemic adverse events included fever, fatigue, and headache. No serious adverse events were reported.

TABLE 3. Reporting rates for adverse events of special interest after JYNNEOS vaccine receipt — Vaccine Adverse Event Reporting System, United States, May 22–October 21, 2022

Adverse event/ Dose	Postvaccination risk interval	No. of reports	No. of doses administered	Reporting rate* (95% CI)
Myocarditis				
After dose 1	30 days	1	652,641	1.53 (0.04–8.54)
After dose 2		1	334,568	2.99 (0.08–16.65)
Anaphylaxis				
After dose 1	24 hours	2	652,641	3.06 (0.37–11.07)
After dose 2		1	334,568	2.99 (0.08–16.65)

* Reports per million doses administered.

Discussion

Monitoring of JYNNEOS vaccine safety in the United States during the 2022 mpox outbreak has not identified any new or unexpected safety concerns among adults or persons aged <18 years. The VAERS reporting rate of anaphylaxis after JYNNEOS is similar to rates previously published after receipt of other vaccines (*9*). JYNNEOS safety in persons aged <18 years had not been assessed before this outbreak. Pediatric vaccine safety information collected to date has not identified any concerning adverse events.

Not all adverse events that occur after vaccination are caused by the vaccine. Currently, no evidence indicates that either of the two deaths reported to VAERS after JYNNEOS administration were caused by the vaccine. These two deaths within 2 days of vaccination are less than the number expected to occur by chance alone. For example, during 2019, an average of six deaths occurred daily per 1 million men aged 35–39 years (*10*).

Myocarditis is associated with live, replicating smallpox vaccines, such as ACAM2000, with incidence point estimates for symptomatic cases ranging from 78 to 5,230 cases per million persons within 30 days after vaccination (*5*,*6*). The background myocarditis rate has been estimated to be 21.6 cases per million in a 30-day period (*5*). The VAERS myocarditis reporting rate (1.53 and 2.99 per million first and second vaccine doses administered, respectively) is at least seven times lower than the background rate. VSD myocarditis incidence estimates have wide CIs that encompass both the background rate and the lower incidence estimates for the replicating smallpox vaccines. Current data do not suggest an increased risk for myocarditis after receipt of JYNNEOS, but the possibility of a small risk cannot be excluded.

Vaccine administration errors have been reported more often following intradermal than subcutaneous administration of JYNNEOS vaccine. The most common issue reported has been a wheal not forming with the initial injection. CDC's interim clinical considerations for use of JYNNEOS state that absence of a wheal without vaccine leakage may be counted as valid administration (*1*).

The findings in this report are subject to at least three limitations. First, VAERS is a passive reporting system and is subject to underreporting and reporting biases; for example, the two myocarditis cases identified by VSD were not reported to VAERS. Common, nonserious adverse events, such as injection site reactions, are less likely to be reported compared with serious adverse events. Second, comparison of VAERS reporting rates to published background rates might not signal a potential risk if the published rate is higher than the vaccinated population's true background rate. Finally, VSD might not receive JYNNEOS vaccine administration data for all out-of-network

Summary

What is already known about this topic?

JYNNEOS vaccine has been used in a real-world setting for the first time during the 2022 monkeypox (mpox) outbreak, including intradermal administration under a Food and Drug Administration (FDA) Emergency Use Authorization.

What is added by this report?

During May 22–October 21, 2022, nearly 1 million JYNNEOS doses were administered in the United States. The vaccine safety profile was consistent with prelicensure studies. The most common adverse health events reported were nonserious and included injection site reactions. Serious adverse events were rare among adults, and no serious adverse events have been identified among persons aged <18 years.

What are the implications for public health practice?

Surveillance supports JYNNEOS vaccine safety. CDC and FDA will continue to monitor the safety of JYNNEOS.

doses; vaccination history might be recorded more often for patients with a medical visit for an adverse event, which could lead to overestimating adverse event incidence.

JYNNEOS postlicensure and postauthorization vaccine safety surveillance findings to date are consistent with those observed in the clinical trials, and support JYNNEOS vaccine safety with no new or unexpected safety concerns identified. Serious adverse events were rare among adults, and none have been identified among persons aged <18 years. CDC and FDA will continue to monitor the safety of JYNNEOS. Health care providers should continue to report adverse events after JYNNEOS to VAERS.[††]

[††] https://vaers.hhs.gov

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Corresponding author: Jonathan Duffy, jduffy@cdc.gov.

[1]CDC Mpox Emergency Response Team; [2]Marshfield Clinic Research Institute, Marshfield, Wisconsin; [3]Kaiser Permanente Colorado Institute for Health Research, Denver, Colorado; [4]Kaiser Permanente Vaccine Study Center, Kaiser Permanente Northern California, Oakland, California; [5]Community Health Services, Denver Health, Denver, Colorado and Department of Pediatrics, University of Colorado School of Medicine, Denver, Colorado; [6]Department of Research and Evaluation, Kaiser Permanente Southern California, Pasadena, California; [7]Food and Drug Administration, Silver Spring, Maryland.

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Reduced Risk for Mpox After Receipt of 1 or 2 Doses of JYNNEOS Vaccine Compared with Risk Among Unvaccinated Persons — 43 U.S. Jurisdictions, July 31–October 1, 2022

Amanda B. Payne, PhD[1]; Logan C. Ray, MPH[1]; Matthew M. Cole, MPH[1]; Michelle Canning, MPH[1]; Kennedy Houck, MPH[1]; Hazel J. Shah, MPH[1]; Jennifer L. Farrar, MPH[1]; Nathaniel M. Lewis, PhD[1]; Amy Fothergill, PhD[1,2]; Elizabeth B. White, PhD[1,2]; Leora R. Feldstein, PhD[1]; Lauren E. Roper, MPH[1]; Florence Lee, MPH[1]; Jennifer L. Kriss, PhD[1]; Emily Sims, MPH[1]; Ian H. Spicknall, PhD[1]; Yoshinori Nakazawa, PhD[1]; Adi V. Gundlapalli, MD, PhD[1]; Tom Shimabukuro, MD[1]; Adam L. Cohen, MD[1]; Margaret A. Honein, PhD[1]; Jonathan Mermin, MD[1]; Daniel C. Payne, PhD[1]

As of October 28, 2022, a total of 28,244* monkeypox (mpox) cases have been reported in the United States during an outbreak that has disproportionately affected gay, bisexual, and other men who have sex with men (MSM) (*1*). JYNNEOS vaccine (Modified Vaccinia Ankara vaccine, Bavarian Nordic), administered subcutaneously as a 2-dose (0.5 mL per dose) series (with doses administered 4 weeks apart), was approved by the Food and Drug Administration (FDA) in 2019 to prevent smallpox and mpox disease (*2*); an FDA Emergency Use Authorization issued on August 9, 2022, authorized intradermal administration of 0.1 mL per dose, increasing the number of persons who could be vaccinated with the available vaccine supply† (*3*). A previous comparison of mpox incidence during July 31–September 3, 2022, among unvaccinated, but vaccine-eligible men aged 18–49 years and those who had received ≥1 JYNNEOS vaccine dose in 32 U.S. jurisdictions, found that incidence among unvaccinated persons was 14 times that among vaccinated persons (95% CI = 5.0–41.0) (*4*). During September 4–October 1, 2022, a total of 205,504 persons received JYNNEOS vaccine dose 2 in the United States.§ To further examine mpox incidence among persons who were unvaccinated and those who had received either 1 or 2 JYNNEOS doses, investigators analyzed data on 9,544 reported mpox cases among men¶ aged 18–49 years during July 31–October 1, 2022, from 43 U.S. jurisdictions,** by vaccination status. During this study period, mpox incidence (cases per 100,000 population at risk) among unvaccinated persons was 7.4 (95% CI = 6.0–9.1) times that among persons who received only 1 dose of JYNNEOS vaccine ≥14 days earlier and 9.6 (95% CI = 6.9–13.2) times that among persons who received dose 2 ≥14 days earlier. The observed distribution of subcutaneous and intradermal routes of administration of dose 1 among vaccinated persons with mpox was not different from the expected distribution. This report provides additional data suggesting JYNNEOS vaccine provides protection against mpox, irrespective of whether the vaccine is administered intradermally or subcutaneously. The degree and durability of such protection remains unclear. Persons eligible for mpox vaccination should receive the complete 2-dose series to optimize strength of protection†† (*5*).

Aggregate weekly numbers of confirmed and probable mpox cases§§ among men aged 18–49 years with illness onset (i.e., earliest date available¶¶) during July 31–October 1, 2022, were analyzed across 43 public health jurisdictions.*** These jurisdictions routinely ascertain patient vaccination status (receipt of ≥1 dose of JYNNEOS vaccine) and route of vaccine administration through interviews and immunization registries and submit deidentified vaccine administration data to CDC. Persons with mpox were categorized as 1) unvaccinated†††; 2) vaccinated, with illness onset ≥14 days after administration of dose 1 and before or <14 days after receipt of dose 2; or 3) vaccinated with illness onset ≥14 days after dose 2. Persons with illness onset <14 days after receipt of dose 1, potentially

* https://www.cdc.gov/poxvirus/monkeypox/response/2022/us-map.html

† https://www.hhs.gov/about/news/2022/06/28/hhs-announces-enhanced-strategy-vaccinate-protect-at-risk-individuals-from-current-monkeypox-outbreak.html

§ https://www.cdc.gov/poxvirus/monkeypox/response/2022/vaccines_data.html

¶ Persons who reported male sex assigned at birth or male gender identity.

** Alabama, Alaska, California, Colorado, Connecticut, District of Columbia, Florida, Georgia, Hawaii, Idaho, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nevada, New Hampshire, New Mexico, New York (excluding New York City), North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Puerto Rico, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming.

†† https://www.cdc.gov/poxvirus/monkeypox/clinicians/vaccines/vaccine-considerations.html

§§ Confirmed (presence of *Monkeypx virus* DNA by polymerase chain reaction [PCR] testing or next-generation sequencing of a clinical specimen or isolation of *Monkeypox virus* in culture from a clinical specimen) and probable (presence of *Orthopoxvirus* DNA by PCR testing, or *Orthopoxvirus* using immunohistochemical or electron microscopy or detectable levels of anti-*Orthopoxvirus* immunoglobulin M antibody) mpox cases.

¶¶ Dates available for selection varied by how the case was reported to the system: illness onset, specimen collection, laboratory test completion, admission, diagnosis, discharge, case investigation start date, or date first electronically submitted or reported to county, state, or public health department.

*** Jurisdictions were included if age and sex assigned at birth or gender identity was available for ≥70% of cases reported, vaccination status was available for ≥50% of cases, or jurisdiction-confirmed cases were linked to immunization registry entries, and deidentified vaccination administration data were submitted to CDC.

††† No evidence in case record of receipt of JYNNEOS vaccine or vaccination date after illness onset, including records for which vaccination information was unknown.

vaccinated persons (possibly vaccinated but without dose number or documented date of vaccination), and persons vaccinated before 2022 were excluded.

One- and 2-dose vaccination coverage was estimated as the total number of persons vaccinated as of 2 weeks before the end date of a week divided by the estimated vaccine-eligible population aged 18–49 years, including persons in each jurisdiction who might benefit from vaccination in the context of the outbreak (estimated as the number of men who are either MSM living with HIV acquired through male-to-male sexual contact, injection drug use, or both, or who are eligible for HIV preexposure prophylaxis [HIV-PrEP])[§§§] (*6*). The number of eligible unvaccinated persons was obtained by subtracting the number of vaccinated persons from jurisdiction-specific estimates of the vaccine-eligible population. Weekly incidence[¶¶¶] by vaccination status was estimated as the number of cases divided by the number of persons either eligible but unvaccinated as of that week or vaccinated as of 2 weeks earlier.[****] Weekly incidence among persons receiving dose 2 was estimated for September 4–October 1, 2022, when population coverage with 2 vaccine doses among the total eligible population was nearly 5%. The incidence rate ratio (IRR) during the study period was calculated using negative binomial regression, controlling for week in the model using an indicator variable, which is a modified approach to that used in previous analyses (*4*).

A supplementary analysis was conducted estimating the effect of dose 1 and dose 2. A Cox proportional hazards regression analysis that accounted for follow-up time among unvaccinated persons compared with that among persons known to have received either 1 or both vaccine doses was used.

The observed distribution of subcutaneous and intradermal routes of administration of dose 1 among vaccinated persons with mpox was compared with the expected distribution[††††] among all vaccinated persons, based on vaccine administration records in 14 jurisdictions with complete route of administration data for ≥80% of reported vaccinated persons with mpox.

SAS (version 9.4; SAS Institute) and R (version 4.0.3; R Foundation) were used to conduct all analyses. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[§§§§]

During July 31–October 1, 2022, in 43 jurisdictions reporting 11,581 mpox cases (range across jurisdictions = 2–3,424 cases), a total of 9,544 (82.4%) were reported among men aged 18–49 years (Table 1). Among these cases, 8,320 (87.2%) occurred in unvaccinated persons and 1,224 (12.8%) in vaccinated persons, including 218 (17.8%) in persons without a known vaccination date. Among cases in vaccinated persons whose vaccination date was known, 614 (61%) were in persons whose illness onset occurred ≤13 days after receipt of dose 1 and 392 (39%) in persons with illness onset ≥14 days after receipt of dose 1; among this group, 48 cases (12.2%) (0.5% of all cases) were among persons with illness onset ≥14 days after receipt of dose 2. Population coverage with ≥1 vaccine dose received ≥14 days before the end of each week increased from 5.7% (July 31) to 45.5% (September 25); 2-dose coverage increased from 0.1% to 17%.

Mpox incidence estimates were higher among unvaccinated persons than among persons known to have received only 1 dose of JYNNEOS vaccine ≥14 days earlier (IRR = 7.4; 95% CI = 6.0–9.1) and among those who received dose 2 ≥14 days earlier (IRR = 9.6; 95% CI = 6.9–13.2) (Figure). A supplementary analysis using a Cox proportional hazards model to account for follow-up time also indicated that incidence was higher among unvaccinated persons than among persons known to have only received dose 1 (hazard ratio = 4.3; 95% CI = 3.9–4.8) and those who received 2 doses (hazard ratio = 7.6; 95% CI = 5.7–10.2), although the strength of the effect was somewhat attenuated compared with the primary analysis (Supplementary Table, https://stacks.cdc.gov/view/cdc/122452).

[§§§] The number eligible for HIV-PrEP was estimated as the ratio of the jurisdiction-specific number of MSM receiving HIV-PrEP and the jurisdiction-specific HIV-PrEP coverage. The number of MSM with HIV or who are HIV-PrEP–eligible aged 18–49 years was estimated by aggregating 2021 U.S. Census Bureau estimates for males aged 0–12, 13–17, 18–49, and ≥50 years, calculating the state proportion for each age group, and multiplying by the estimated number of MSM with HIV or who are eligible for HIV-PrEP in each state to obtain proportional distributions. Estimates of the number of MSM with HIV infection were obtained from 2020 HIV prevalence estimates. https://www.cdc.gov/nchhstp/atlas/index.htm

[¶¶¶] Cases and vaccine doses administered are aggregated by *MMWR* week (Sunday–Saturday).

[****] Because most vaccine administered during the study period was postexposure prophylaxis (PEP) or expanded PEP, this time point was chosen to account for the incubation period after exposure. FDA immunogenicity data indicated antibody titers 2 weeks after dose 1 were similar to titers 4 weeks after dose 1 and were significantly higher than prevaccination antibody titers.

[††††] Jurisdiction-specific distributions of cases in vaccinated persons by route of administration were obtained by summarizing the cumulative number of first vaccine doses administered to men aged 18–49 years by route of administration as of a given surveillance week. The expected number of cases in vaccinated persons by route of administration was obtained by applying the jurisdiction-specific distribution to the number of cases reported from that jurisdiction within a given *MMWR* week (e.g., expected number of cases with vaccine administered intradermally = [cumulative number of vaccines administered intradermally/total number of vaccines administered] × number of cases in vaccinated persons). The number of expected cases by route of administration was summed across jurisdictions and *MMWR* weeks.

[§§§§] 5 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.

Among persons with illness onset ≥14 days after vaccine dose 1, 263 (87.1%) and 39 (12.9%) had received subcutaneous and intradermal administration, respectively. The proportion of vaccinated persons with mpox known to have received dose 1 subcutaneously or intradermally was not statistically different from that of the overall vaccinated population (83% and 17%, respectively) (p = 0.28) (Table 2).

Discussion

In this evaluation of mpox among men aged 18–49 years, incidences were lower among those who were vaccinated than among unvaccinated, vaccine-eligible persons. A proportional hazards model that accounted for time-varying risk supported the finding of a larger risk reduction among persons who had received 2 vaccine doses than among those who had received only 1 dose. Compared with a previous report (*4*), this analysis expands knowledge about mpox incidence by vaccination status by including more jurisdictions during a longer observation period, resulting in the addition of the equivalent of >1 million person-weeks of follow-up. Further, increased completeness of vaccination administration date (from 43% to 82% completeness) and a better-fitting statistical model yielded more precise effect estimates. These findings are consistent with those of the previous analysis as well as recent studies reporting some protection (*7*) and modest induction of antibody levels (*8*,*9*) after the first JYNNEOS vaccine dose.

The analysis also suggested no difference in vaccine performance between subcutaneous and intradermal administration. This supports previous clinical trial data that indicated similar immune responses to JYNNEOS vaccination over time after intradermal or subcutaneous administration (*10*).

The findings in this report are subject to at least five limitations. First, linkage of mpox case surveillance and vaccination administration data might have resulted in misclassifications that could influence estimates. This approach assumed that persons with unknown vaccination status were unvaccinated and excluded those with unknown date of vaccination, because timing between vaccination and illness onset could not be established, potentially underestimating incidence among

TABLE 1. Mpox cases among men* aged 18–49 years, by vaccination status,† and JYNNEOS vaccination coverage, by week (N = 9,544) — 43 U.S. jurisdictions,§,¶ July 31–October 1, 2022

Characteristic	No. (%) by week beginning									Total
	Jul 31	Aug 7	Aug 14	Aug 21	Aug 28	Sep 4	Sep 11	Sep 18	Sep 25	
Total mpox cases**	**1,823**	**1,649**	**1,450**	**1,250**	**1,035**	**854**	**605**	**494**	**384**	**9,544**
Vaccination status										
Unvaccinated	1,621 (88.9)	1,422 (86.2)	1,250 (86.2)	1,068 (85.4)	889 (85.9)	744 (87.1)	546 (90.2)	440 (89.1)	340 (88.5)	**8,320 (87.2)**
Vaccinated	202 (11.1)	227 (13.8)	200 (13.8)	182 (14.6)	146 (14.1)	110 (12.9)	59 (9.8)	54 (10.9)	44 (11.5)	**1,224 (12.8)**
Vaccination date known (n = 1,224)										
No	40 (19.8)	30 (13.2)	31 (15.5)	36 (19.8)	25 (17.1)	24 (21.8)	9 (15.3)	10 (18.5)	13 (29.5)	**218 (17.8)**
Yes	162 (80.2)	197 (86.8)	169 (84.5)	146 (80.2)	121 (82.9)	86 (78.2)	50 (84.7)	44 (81.5)	31 (70.5)	**1,006 (82.2)**
Illness onset relative to dose 1 of vaccination†† (n = 1,006)										
0–13 days after dose 1	141 (87)	145 (73.6)	112 (66.3)	86 (58.9)	62 (51.2)	30 (34.9)	24 (48)	9 (20.5)	5 (16.1)	**614 (61)**
≥14 days after dose 1	21 (13)	52 (26.4)	57 (33.7)	60 (41.1)	59 (48.8)	56 (65.1)	26 (52)	35 (79.5)	26 (83.9)	**392 (39)**
Illness onset relative to dose 2 of vaccination†† (n = 392)										
Before dose 2	21 (100)	48 (92.3)	50 (87.7)	46 (76.7)	47 (79.7)	36 (64.3)	13 (50)	18 (51.4)	16 (61.5)	**295 (75.3)**
0–13 days after dose 2	0 (—)	4 (7.7)	4 (7.0)	11 (18.3)	8 (13.6)	8 (14.3)	7 (26.9)	6 (17.1)	1 (3.8)	**49 (12.5)**
≥14 days after dose 2	0 (—)	0 (—)	3 (5.3)	3 (5.0)	4 (6.8)	12 (21.4)	6 (23.1)	11 (31.4)	9 (34.6)	**48 (12.2)**
JYNNEOS vaccination coverage (%)										
1 dose§§	5.7	10.4	16.9	24.6	30.9	36.2	40.2	42.9	45.5	**NA**
2 dose¶¶	0.1	0.2	0.3	0.8	2.1	4.7	8.4	12.7	17	**NA**

Abbreviations: mpox = monkeypox; NA = not applicable; PCR = polymerase chain reaction.

* Sex assigned at birth or gender identity.

† Vaccinated is defined as receipt of ≥1 dose of JYNNEOS vaccine (1-dose = receipt of dose 1 ≥14 days earlier; 2-dose = receipt of dose 2 ≥14 days earlier).

§ Alabama, Alaska, California, Colorado, Connecticut, District of Columbia, Florida, Georgia, Hawaii, Idaho, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nevada, New Hampshire, New Mexico, New York (excluding New York City), North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Puerto Rico, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming.

¶ Jurisdictions were included if age and sex assigned at birth or gender identity was available for ≥70% of cases reported, vaccination status was available for ≥50% of cases, or jurisdiction confirmed cases were linked to immunization registry entries, and deidentified vaccination administration data were submitted to CDC.

** Confirmed (presence of *Monkeypox virus* DNA by PCR testing or next-generation sequencing of a clinical specimen or isolation of *Monkeypox virus* in culture from a clinical specimen) and probable (presence of *Orthopoxvirus* DNA by PCR testing, or *Orthopoxvirus* using immunohistochemical or electron microscopy or detectable levels of anti-*Orthopoxvirus* immunoglobulin M antibody) mpox cases.

†† Among those with known vaccination date.

§§ Proportion of population eligible for vaccination who had received 1 dose of JYNNEOS vaccine as of 2 weeks before the end of the week. This underlying population included persons in each jurisdiction who might benefit from expanded vaccination in the context of the outbreak and was estimated as the number of gay, bisexual, and other men who have sex with men who have HIV infection or who are eligible to receive HIV preexposure prophylaxis.

¶¶ Proportion of population eligible for vaccination who had received 2 doses of JYNNEOS vaccine as of 2 weeks before the end of the week. This underlying population included persons in each jurisdiction who might benefit from expanded vaccination in the context of the outbreak and was estimated as the number of gay, bisexual, and other men who have sex with men who have HIV infection or who are eligible to receive HIV preexposure prophylaxis.

vaccinated persons. Second, this analysis was unable to control for possible differences in testing or behaviors that affect the risk for *Monkeypox virus* exposure (e.g., reducing number of sexual partners), or possible differences in risk of infection because of patient characteristics (e.g., age, underlying medical conditions, and HIV-associated immune suppression); consequently, causal attribution of these results to vaccination cannot be definitively inferred from these data. Third, temporality of exposures that result in infection is not known, nor was it possible to determine whether vaccination was administered as postexposure or preexposure prophylaxis. Fourth, confirmation that all identified persons with mpox were members of the population eligible for vaccination was not possible. Finally, considering persons vaccinated as of 2 weeks before the end date of a surveillance week could overestimate the number of persons vaccinated each week and, thus, underestimate the weekly incidence among vaccinated persons.

Monitoring mpox incidence by vaccination status using currently available surveillance data provides an indication of the real-world impact of JYNNEOS vaccine on prevention of mpox to guide rapid public health decision-making, subject to the limitations noted. Although the findings suggest a protective effect of JYNNEOS vaccination, additional epidemiologic studies that better account for potential biases will provide additional data on the magnitude and duration of protection by JYNNEOS against mpox. These findings also suggest that JYNNEOS vaccination provides protection against mpox infection, irrespective of route of administration. Persons who are eligible for mpox vaccination should receive the complete recommended 2-dose series to optimize their protection against mpox (*5*).

Summary

What is already known about this topic?

Real-world data on the magnitude and durability of protection by JYNNEOS vaccine against monkeypox (mpox) remain limited.

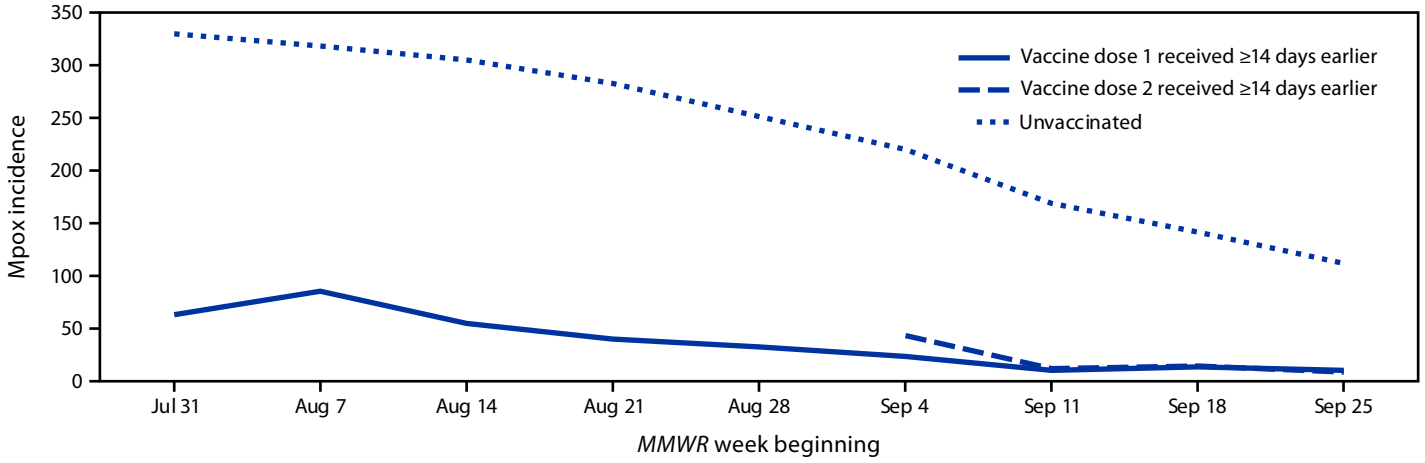
What is added by this report?

Among JYNNEOS vaccine-eligible men aged 18–49 years in 43 U.S. jurisdictions, mpox incidence among unvaccinated persons was 9.6 times as high as that among persons who had received 2 vaccine doses and 7.4 times as high as that among persons who had received only the first dose. Preliminary evidence indicates no difference in protection between subcutaneous and intradermal administration routes.

What are the implications for public health practice?

Although further study is needed to determine the magnitude and durability of protection, evidence indicates that JYNNEOS vaccination provides protection against mpox. Vaccine-eligible persons should complete the 2-dose vaccination series.

FIGURE. Weekly mpox incidence* among vaccine-eligible† men aged 18–49 years, by vaccination status§ — 43 U.S. jurisdictions,¶, July 31–October 1, 2022**



Abbreviation: IRR = incidence rate ratio.

* Cases per 100,000 population. Rate in vaccinated persons = number of probable or confirmed cases reported to CDC with date of illness onset, specimen collection, lab test completion, admission, diagnosis, discharge, case investigation start date, or date first electronically submitted or reported to the county, state, or public health department (earliest available date) ≥14 days after receiving dose 1 or dose 2 of JYNNEOS vaccine among total vaccinated population as of 2 weeks previously. Rate in unvaccinated persons = number of probable or confirmed cases reported to CDC without evidence of vaccination among total unvaccinated population.

† Gay, bisexual, and other men who have sex with men who have HIV infection or who are eligible to receive HIV preexposure prophylaxis were considered eligible for vaccination.

§ IRR comparing unvaccinated persons with those who received only 1 dose of vaccine ≥14 days earlier was 7.4. IRR comparing unvaccinated persons with those who received dose 2 of vaccine ≥14 days earlier was 9.6.

¶ Alabama, Alaska, California, Colorado, Connecticut, District of Columbia, Florida, Georgia, Hawaii, Idaho, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nevada, New Hampshire, New Mexico, New York (excluding New York City), North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Puerto Rico, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming.

** Jurisdictions were included if age and sex assigned at birth or gender identity was available for ≥70% of cases reported, vaccination status was available for ≥50% of cases, or jurisdiction-confirmed cases were linked to immunization registry entries, and deidentified vaccination administration data were submitted to CDC.

TABLE 2. Route of JYNNEOS vaccine administration among persons with mpox* vaccinated† ≥14 days before illness onset§ compared with expected proportions¶ — 14 U.S. jurisdictions,,†† July 31–October 1, 2022**

Route of vaccine administration§§	Observed no. (%)	Expected no. (%)	p-value¶¶
Subcutaneous	263 (87.1)	253 (83.0)	0.28
Intradermal	39 (12.9)	52 (17.0)	

Abbreviations: mpox = monkeypox; PCR = polymerase chain reaction.

* Confirmed (presence of *Monkeypox virus* DNA by PCR testing or next-generation sequencing of a clinical specimen or isolation of *Monkeypox virus* in culture from a clinical specimen) and probable (presence of *Orthopoxvirus* DNA by PCR testing, or *Orthopoxvirus* using immunohistochemical or electron microscopy or detectable levels of anti-*Orthopoxvirus* immunoglobulin M antibody) mpox cases.

† Receipt of ≥1 dose of JYNNEOS vaccine.

§ Earliest date available for each case; might include illness onset, specimen collection, laboratory test completion, admission, diagnosis, discharge, case investigation start date, or date first electronically submitted or reported to the county, state, or public health department.

¶ Based on vaccine administration data submitted by participating jurisdictions. The distribution of route of administration among vaccinated persons was summarized by week and applied to weekly case counts.

** California, Connecticut, District of Columbia, Florida, Illinois, Kansas, Louisiana, Massachusetts, Minnesota, New Mexico, New York (excluding New York City), Tennessee, Utah, and Wisconsin.

†† Jurisdictions were included if age and sex assigned at birth or gender identity was available for ≥70% of cases reported, vaccination status was available for ≥50% of cases in men (defined by either sex assigned at birth or gender identity) aged 18–49 years or the jurisdiction confirmed cases are linked to immunization registry entries, route of administration was complete for >80% of cases occurring ≥14 days after receipt of dose 1, and deidentified vaccine administration data were submitted to CDC.

§§ Limited to persons vaccinated ≥14 days before illness onset with recorded route of administration as subcutaneous or intradermal. One person with mpox who was vaccinated ≥14 days before illness onset was reported to have another route of vaccine administration. Route of administration was unknown for 39 persons with mpox who were vaccinated ≥14 days before illness onset; 33 persons who received dose 1 on or before August 9, 2022, were assumed to have received subcutaneous vaccination.

¶¶ Pearson's chi-square test comparing observed and expected proportions of route of administration among cases with approved or authorized route of administration.

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Corresponding author: Amanda B. Payne, ABPayne@cdc.gov.

[1]CDC Mpox Emergency Response Team; [2]Epidemic Intelligence Service, CDC.

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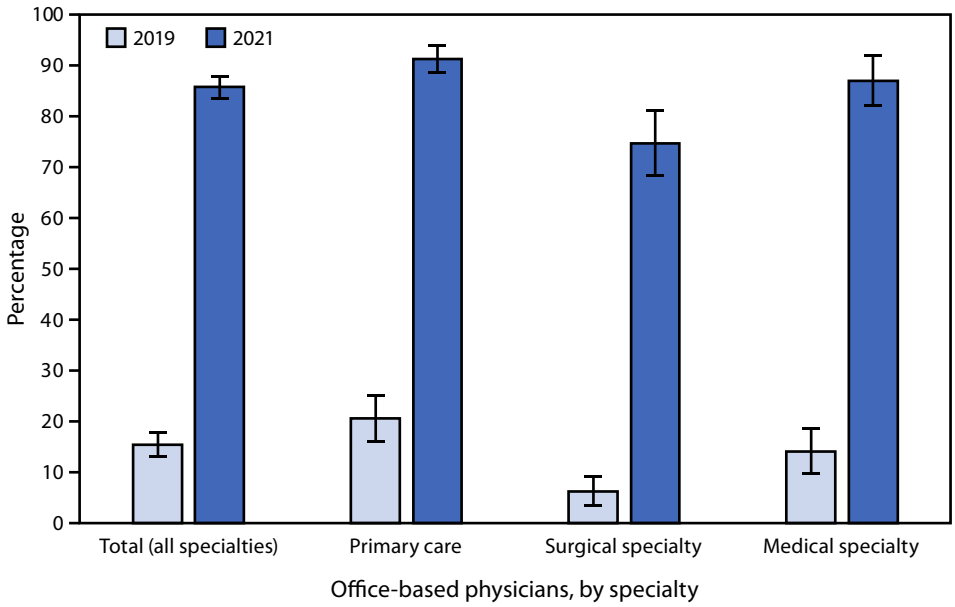
QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Office-Based Physicians Using Telemedicine Technology,† by Specialty§ — United States, 2019 and 2021



* With 95% CIs indicated by error bars.
† Telemedicine technology was defined as the use of audio with video or web videoconference for patient visits.
§ Primary care physicians are defined as physicians in the following specialties: general and family practice, internal medicine, obstetrics and gynecology, and pediatrics. Surgical specialty physicians are defined as physicians in general surgery, obstetrics and gynecology surgery, ophthalmology, orthopedic surgery, other, otolaryngology, and urology. Medical specialty physicians are defined as physicians in cardiovascular diseases, dermatology, neurology, other, and psychiatry.

From 2019 to 2021, the use of telemedicine technology increased for office-based physicians from 15.4% to 85.9%. In both 2019 and 2021, the use of telemedicine technology was higher among primary care physicians and medical specialty physicians than it was among surgical specialty physicians. In 2021, 91.4% of primary care physicians, 87.2% of medical specialty physicians, and 74.8% of surgical specialty physicians used telemedicine technology.

Sources: National Center for Health Statistics, National Electronic Health Records Surveys, 2019 and 2021. https://www.cdc.gov/nchs/nehrs/about.htm

Reported by: Kelly L. Myrick, PhD, kmyrick@cdc.gov, 301-458-4498; Malikah McNeal, MPH; Carol DeFrances, PhD.

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