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Unexpected Hepatitis B Virus Infection After Liver Transplantation — United States, 2014–2019

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Unexpected donor-derived hepatitis B virus (HBV) infection is defined as a new HBV infection in a recipient of a transplanted organ from a donor who tested negative for total antihepatitis B core antibody (total anti-HBc), hepatitis B surface antigen (HBsAg), and HBV DNA* before organ procurement. Such infections are rare and are associated with injection drug use among deceased donors (*1*). During 2014–2019, CDC received 20 reports of HBV infection among recipients of livers from donors who had no evidence of past or current HBV infection. Investigation included review of laboratory data and medical records. Fourteen of these new HBV infections were detected during 2019 alone; infections were detected a median of 38 (range = 5–116) weeks after transplantation. Of the 14 donors, 13 were hepatitis C virus (HCV)–seropositive† and had a history of injection drug use within the year preceding death, a positive toxicology result, or both. Because injection drug use is the most commonly reported risk factor for hepatitis C,§ providers caring for recipients of organs from donors who are HCV-seropositive or recently injected drugs should maintain awareness of infectious complications of injection drug use and monitor recipients accordingly (*2*). In addition to testing for HBV DNA at 4–6 weeks after transplantation, clinicians caring for liver transplant recipients should consider testing for HBV DNA 1 year after transplantation or at any time if signs and symptoms of viral hepatitis develop, even if previous tests were negative (*2*).

All suspected unexpected cases of donor-derived hepatitis B in the United States are reported to the Organ Procurement and Transplantation Network for review by the Ad Hoc Disease Transmission Advisory Committee. Suspected cases are referred to CDC to investigate whether donor-derived disease transmission occurred and identify interventions to prevent transmission and improve outcomes (*1*,*2*). Confirmed cases were defined as unexpected, new,¶ reproducible laboratory evidence of HBV infection (HBsAg or HBV DNA) occurring in liver recipients after transplantation that were reported to CDC during 2014–2019. All recipients who received organs from the same donor as the liver recipient were evaluated for donor-derived HBV infection using the same criteria. Available

* HBsAg and HBV DNA are laboratory evidence of current infection with HBV. Total anti-HBc indicates past or current infection with HBV. Recipients of a liver from a donor with isolated total anti-HBc positive results can develop reactivation of hepatitis B after transplantation.

† Donors who are HCV-seropositive include both HCV-viremic (anti-HCV–seropositive and HCV RNA–positve) and HCV-nonviremic (anti-HCV–seropositive and HCV RNA–negative) donors as described in https://pubmed.ncbi.nlm.nih.gov/28556422/.

§ https://www.cdc.gov/hepatitis/statistics/SurveillanceRpts.htm

¶ New infection with HBV is defined as a positive viral detection test (HBsAg or HBV DNA) in an organ recipient without evidence for HBV infection (anti-HBc, HBsAg, or HBV DNA) preceding transplantation.

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archived donor serum, plasma, or liver biopsy samples were tested for HBV DNA. State and local health departments shared information about recipient behavioral risk factors and outbreaks of health-care–associated HBV infection.

During 2014–2019, CDC investigated 30 suspected cases of unexpected, donor-derived HBV infection among liver recipients. Ten suspected cases were excluded because the recipients had nonreproducible HBV DNA (six), or false-positive total anti-HBc (two) or HBsAg (two) results. Twenty confirmed cases were included.

Median age at death of the 20 donors was 31 years (range = 20–46 years); 11 were male, and 19 were White. The most common cause of death was drug intoxication. Injection drug use and positive toxicology were each reported for 18 donors (Table). Sixteen donors, including 13 of 14 reported in 2019, were HCV antibody (anti-HCV)–seropositive; among these 13 donors, 12 had positive drug toxicology, 12 had a history of injection drug use, and 11 had both. Stimulants (cocaine or amphetamines) were the most common substances identified by toxicology screening. HBV DNA was detected in one archived donor serum sample and one archived liver biopsy specimen.

New HBV infection was identified in 18 liver and two liver-kidney recipients at a median of 41 weeks after transplantation (range = 5–116 weeks). Among cases reported during 2019, hepatitis B test conversion was first identified at a median of 38 weeks after transplantation (Figure). None of 31 recipients of nonliver organs** from the 20 donors developed a new infection with hepatitis B. No behavioral risk factors or health care–associated hepatitis B outbreaks were reported in association with any case. Hepatitis B vaccination status was unavailable for the majority of recipients.

Discussion

HBV infection among transplant recipients can occur from reactivation of previous HBV infection (*3*), primary infection after transplantation, or donor-derived transmission (*1*). This report provides evidence that transmission of HBV from donors occurred despite negative organ donor HBV DNA, HBsAg, and total anti-HBc results before organ procurement. Among 14 cases reported during 2019, all donors but one were HCV-seropositive with a history of injection drug use, a positive toxicology result, or both. Clinicians caring for liver recipients, particularly those from donors with positive anti-HCV serology or a history of injection drug use, should maintain awareness of delayed HBV presentation and consider testing for HBV DNA at 1 year after transplantation or at any time if signs and symptoms of viral hepatitis develop, even if prior tests were negative (*2*).

** Analysis included nonliver organ recipients without evidence of hepatitis B infection (total anti-HBc, HBsAg, or HBV DNA) before transplantation. Twenty single kidney, six heart, and four bilateral lung recpients and one kidney-pancreas recipient received negative test results for HBsAg or HBV DNA after transplantation at the time of the investigation. Seven nonliver organ recipients with previous evidence of hepatitis B infection were excluded from this analysis, including six single kidney recipients and one bilateral lung recipient.

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TABLE. Demographic and clinical characteristics and risk behaviors of deceased organ donors* reported to CDC because of hepatitis B virus infection in liver transplant recipients after transplantation — United States, 2014–2019

Characteristic	Yr of report to CDC, no. (%)	
	2014–2018 (N = 6)	2019 (N = 14)
Age		
Mean age, yrs (median)	27 (23)	33 (32)
Age range, yrs	20–43	20–46
Age, interquartile range, yrs	21–29	27–41
Year, no. of deaths		
2013	1	0
2014	0	0
2015	1	0
2016	3	0
2017	0	2
2018	1	10
2019	0	2
Sex		
Male	4 (67)	7 (50)
Female	2 (33)	7 (50)
Race		
White	6 (100)	13 (93)
Black or African American	0 (—)	1 (7)
Risk factor for hepatitis B† within the 12 mos before organ donation		
Injection drug use	6 (100)	12 (86)
Incarceration (lockup, jail, prison, or a juvenile correctional facility) for >72 hours	5 (83)	8 (57)
Sex with a person who injected drugs by intravenous, intramuscular, or subcutaneous route for nonmedical reasons	4 (67)	3 (21)
Sex with a person who had sex in exchange for money or drugs	3 (50)	0 (—)
Sex with a person who had a positive test for, or was suspected of having, hepatitis B, hepatitis C, or HIV	1 (17)	0 (—)
Sex in exchange for money or drugs	1 (17)	0 (—)
Diagnosis or treatment for syphilis, gonorrhea, chlamydia, or genital ulcers during the preceding 12 months	1 (17)	0 (—)
Men who have sex with men, no. (% of males)	0 (—)	1 (14)
No history from next-of-kin	0 (—)	1 (7)
Developmental disabilities and long-term group home residence	0 (—)	1 (7)
Toxicology screening		
Amphetamines	4 (67)	6 (43)
Opiates	5 (83)	7 (50)
Benzodiazepines	4 (67)	4 (29)
Cannabinoids or Delta-9 tetrahydrocannabinol	1 (17)	7 (50)
Cocaine	1 (17)	8 (57)
Barbiturates	1 (17)	1 (7)§
PCP (phencyclidine)	0 (—)	1 (7)
Positive screen for any substance	5 (83)	13 (93)¶
Positive screen for any stimulant (cocaine or amphetamines)	4 (67)	11 (79)
Cause of death		
Drug intoxication	3 (50)	11 (79)
Trauma	1 (17)	2 (14)
Asphyxiation	1 (17)	1 (7)
Cardiovascular disease	1 (17)	0 (—)
Antemortem test results**		
Anti-HCV–positive (serum) (i.e., seropositive)	3 (50)	13 (93)
HCV RNA–positive (serum) (i.e., viremic)	0 (—)	9 (64)
Archived specimen testing††		
Plasma/serum tested for HBV DNA	5 (83)	9 (64)
Plasma/serum positive for HBV DNA	0 (—)	1 (7)§§
Splenocytes tested for HBV DNA	1 (17)	4 (29)
Splenocytes positive for HBV DNA	0 (—)	0 (—)
Liver biopsy specimen tested for HBV DNA	1 (17)¶¶	1 (7)***
Liver biopsy specimen positive for HBV DNA	1 (17)	0 (—)

See table footnotes on the next page.

TABLE. (*Continued*) Demographic and clinical characteristics and risk behaviors of deceased organ donors* reported to CDC because of hepatitis B virus infection in liver transplant recipients after transplantation — United States, 2014–2019

Abbreviations: anti-HCV = antibody (IgG) to hepatitis C virus; HBsAg = hepatitis B surface antigen; HBV = hepatitis B virus; HCV = hepatitis C virus; total anti-HBc = total antibody to hepatitis B core antigen.

* Donors were included in the study if they had been reported to CDC during 2014–2019 and had negative total anti-HBc, HBsAg, and HBV DNA, and a liver recipient experienced new, reproducible laboratory evidence of HBV infection after transplantation.

† Includes risk behaviors and other risk factors as defined in https://www.cdc.gov/mmwr/volumes/67/rr/rr6701a1.htm and https://pubmed.ncbi.nlm.nih.gov/23814319/. Behavioral risk factors were identified through next-of kin interviews or review of medical records. No donor met any of the following United States Public Health Service criteria: a woman who had sex with a man with a history of having had sex with men during the preceding 12 months; a child who was aged <18 months and born to a mother known to be infected with, or at increased risk for, HBV, or HCV infection; a child who had been breastfed within the preceding 12 months and the mother was known to be infected with, or at increased risk for, HIV infection; persons who had been on hemodialysis during the preceding 12 months (for hepatitis C only); or hemodilution.

§ Barbiturates had been prescribed for one included donor.

¶ Includes one donor with only prescribed barbiturates and 12 donors with a median of three substances (range = one to four).

** Routine antemortem donor test results as recommended in https://pubmed.ncbi.nlm.nih.gov/23814319/. All HIV test results were negative.

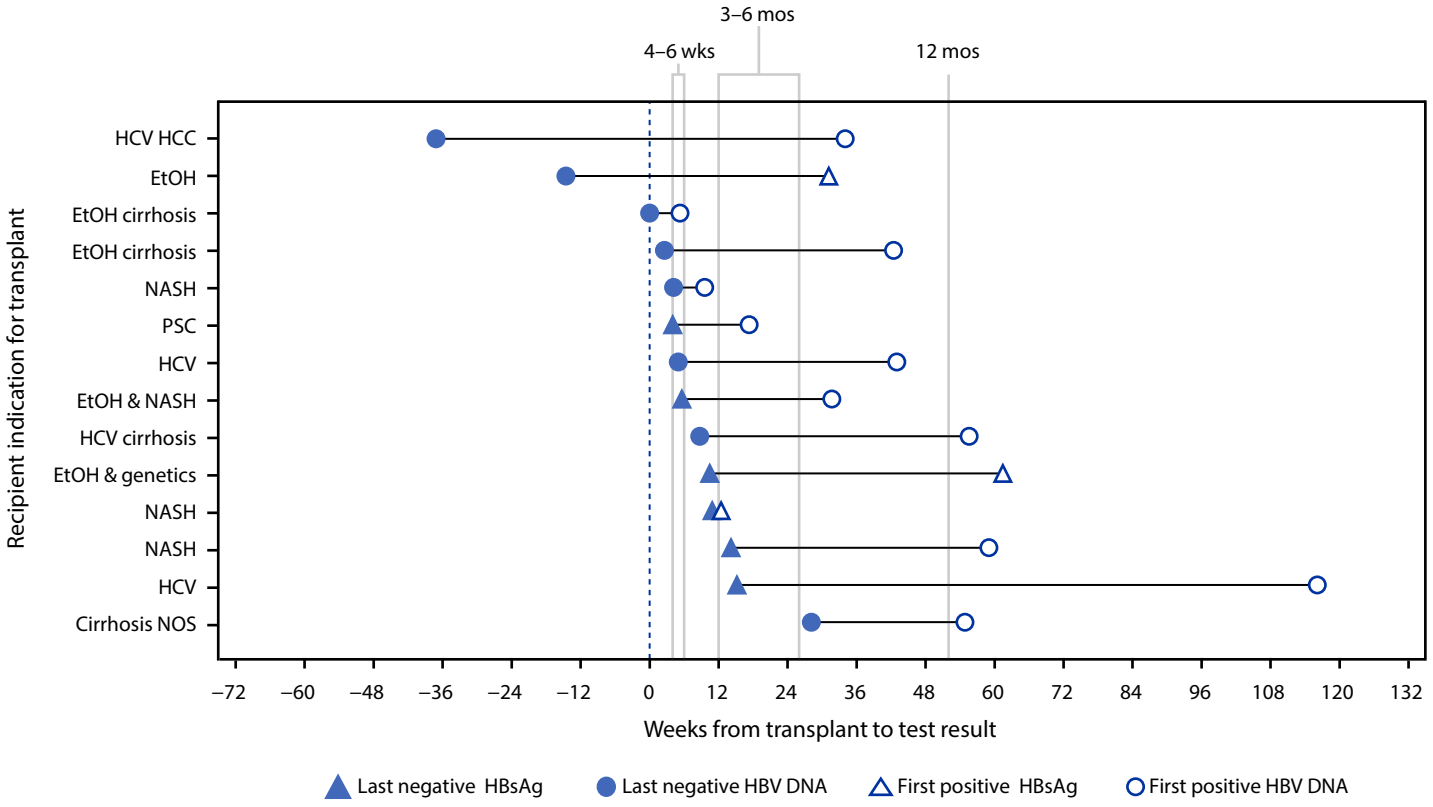
†† All archived specimens were tested during investigation of suspected donor-derived transmission of HBV infection. Testing was performed at CDC's Division of Viral Hepatitis Laboratory, unless otherwise specified.

§§ The positive result was obtained by the Public Health Ontario Laboratory, Ontario, Canada.

¶¶ Archived liver biopsy specimen taken from the recipient 1 week after transplantation.

*** Archived reperfusion liver biopsy specimen.

FIGURE. Timing of last negative and first positive test for hepatitis B virus among liver recipients with hepatitis B virus test conversion after transplantation reported to CDC — United States, 2019



Abbreviations: EtOH = alcohol(ic); HBsAg = hepatitis B surface antigen; HBV = hepatitis B virus; HCC = hepatocellular carcinoma; HCV = hepatitis C virus; NASH = nonalcoholic steatohepatitis; NOS = not otherwise specified; PSC = primary sclerosing cholangitis.

Donors might have been exposed to HBV through injection drug use shortly before death; thus, organ procurement might have occurred during the eclipse period,†† before HBV DNA was detectable in donor serum. During the eclipse period, HBV enters the hepatocyte nucleus and forms covalently closed circular DNA, which endures throughout the life of the nondividing hepatocyte (*4*). Therefore, liver recipients should be more likely than nonliver organ recipients to experience HBV infection from donors with eclipse period infection. An alternative hypothesis is that HCV coinfection suppressed

†† Eclipse period is defined as the 1–12 weeks between exposure to HBV and first detection of HBV DNA in serum.

Summary

What is already known about this topic?

Unexpected donor-derived hepatitis B virus (HBV) infection after organ transplantation is rare and is associated most commonly with donor injection drug use.

What is added by this report?

During 2019, the Organ Procurement and Transplantation Network and CDC received an increased number of reports of HBV infection among liver recipients from HBV-negative donors; 12 of 14 implicated donors had evidence of recent injection drug use, and 13 donors were hepatitis C virus (HCV)–seropositive.

What are the implications for public health practice?

Providers caring for recipients of organs from donors who are HCV–seropositive or who recently injected drugs should maintain awareness of infectious complications of drug use and monitor recipients accordingly.

HBV replication in certain donors, resulting in occult HBV infection. In 20% of HBV/HCV coinfections, patients can test negative for all HBV serum markers (*5*). Subsequent immunosuppression or treatment for HCV infection among liver recipients might lead to reactivation of HBV infection (*5*) after transplantation. The observed interval (median = 41 weeks) between transplantation and diagnosis of HBV infection in these cases is similar to the prolonged interval between transplantation and reactivation of hepatitis B infection among recipients of a liver from a donor who was total anti-HBc seropositive(*3*).

In the United States, liver transplants from HCV-seropositive donors increased from 308 in 2014 to 644 in 2018, and liver transplants from HCV RNA-positive donors increased from 236 in 2015 to 418 in 2018 (*6*). The national rate of drug overdose deaths per 100,000 population[§§] increased during 2012–2018 from 1.4 to 4.5 for cocaine, and from 0.8 to 3.9 for psychostimulants, including amphetamines (*7*). Deaths related to synthetic opioids also increased during that time frame (*7*).[¶¶] Injection of cocaine (*8*) or methamphetamine (*9*) and high-risk sexual behavior (*8*) have been reported in association with hepatitis B outbreaks. These data indicate that the increased number of unexpected donor-derived HBV infections among liver recipients during 2019 might be related to changes in patterns of stimulant use and associated behaviors, or to increased transplantation of organs from anti-HCV–seropositive donors who injected drugs. The most common risk factor for hepatitis B and hepatitis C is injection drug use.

[§§] Adjusted to the 2000 U.S. standard population.

[¶¶] The trend toward increasing deaths from stimulants and opioids continued into 2019. https://www.cdc.gov/mmwr/volumes/70/wr/mm7006a4.htm?s_cid=mm7006a4_w

The findings in this report are subject to at least four limitations. First, detection of infection after transplantation is dependent on testing and reporting by transplant centers. The 2013 Public Health Service guidelines (*10*) recommended risk-based recipient screening for hepatitis B after transplantation. However, the timing and frequency of recipient testing after transplantation might have varied during the timeframe of this study by year, transplant center, organ type, or the donor's hepatitis C status. The impact on these findings cannot be quantified but might result in underestimation of donor-derived HBV infections. Second, previous recommendations (*10*) did not specify how hepatitis B testing of recipients should be accomplished before transplantation. Because of incomplete test results before transplantation, the presence of resolved or occult HBV infection before transplantation cannot be ruled out for certain recipients. Third, archived liver biopsy specimens were unavailable for the majority of donors. If stored correctly, liver tissue is the most likely specimen to have detectable HBV DNA during the eclipse period, which might confirm donor-derived infection. Finally, despite efforts to ascertain risk factors, risk behaviors for organ recipients might have been underreported, resulting in overestimation of donor-derived infections.

Early detection of donor-derived HBV infection is important for preventing hepatitis B–related complications among organ recipients and unintended transmission to their contacts. Recipients should be offered hepatitis B vaccination and hepatitis B testing (including total anti-HBc, HBsAg, and HBV surface antibody) before transplantation and HBV DNA testing at 4–6 weeks after transplantation (*2*). Additional testing for HBV DNA 1 year after transplantation (*2*) should be considered for liver transplant recipients, especially if the donor had risk factors for hepatitis B, including injection drug use or positive HCV serology. Recipients with signs or symptoms of liver injury after transplantation should be tested for viral hepatitis, even if previous hepatitis B or hepatitis C testing was negative (*2*). More broadly, providers caring for recipients of organs from donors who recently injected drugs or are HCV-seropositive should maintain awareness of infectious complications of drug use and monitor recipients accordingly.

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Outcomes Among Patients Referred to Outpatient Rehabilitation Clinics After COVID-19 diagnosis — United States, January 2020–March 2021

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As of June 30, 2021, 33.5 million persons in the United States had received a diagnosis of COVID-19 (*1*). Although most patients infected with SARS-CoV-2, the virus that causes COVID-19, recover within a few weeks, some experience post–COVID-19 conditions. These range from new or returning to ongoing health problems that can continue beyond 4 weeks. Persons who were asymptomatic at the time of infection can also experience post–COVID-19 conditions. Data on post–COVID-19 conditions are emerging and information on rehabilitation needs among persons recovering from COVID-19 is limited. Using data acquired during January 2020–March 2021 from Select Medical* outpatient rehabilitation clinics, CDC compared patient-reported measures of health, physical endurance, and health care use between patients who had recovered from COVID-19 (post–COVID-19 patients) and patients needing rehabilitation because of a current or previous diagnosis of a neoplasm (cancer) who had not experienced COVID-19 (control patients). All patients had been referred to outpatient rehabilitation. Compared with control patients, post–COVID-19 patients had higher age- and sex-adjusted odds of reporting worse physical health (adjusted odds ratio [aOR] = 1.8), pain (aOR = 2.3), and difficulty with physical activities (aOR = 1.6). Post–COVID-19 patients also had worse physical endurance, measured by the 6-minute walk test† (6MWT) ($p<0.001$) compared with control patients. Among patients referred to outpatient rehabilitation, those recovering from COVID-19 had poorer physical health and functional status than those who had cancer, or were recovering from cancer but not COVID-19. Patients recovering from COVID-19 might need additional clinical support, including tailored physical and mental health rehabilitation services.

Data were obtained from electronic health records (EHRs) of patients referred to Select Medical's outpatient rehabilitation clinics during January 2020–March 2021. Epidemiologic, clinical, and functional data from 1,295 post–COVID-19 patients and 2,395 control patients were examined. Post-COVID-19 patients were defined as those who were referred to a Select Medical facility for post–COVID-19 physical rehabilitation. Control patients, defined as those needing rehabilitation for a current or previous diagnosis of cancer with no history of an *International Classification of Diseases, Tenth Revision* (ICD-10) COVID-19 diagnosis code,§ were referred to a Select Medical cancer rehabilitation program. This control population was chosen because patients in this group completed the same initial evaluations as patients referred for post–COVID-19 rehabilitation. Information on type of cancer or interval since diagnosis was not available. Patient data were collected from EHRs and initial clinical evaluation, which included self-reported health measures and a 6MWT. At intake, self-reported measures and clinical evaluations were administered for health, physical endurance, and health care use.

Using validated scales, CDC assessed patients' mental and physical health, functional health, social participation ability, applied cognition, and physical endurance with Patient-Reported Outcomes Measurement Information System (PROMIS) Global Health (version 1.2; National Institutes of Health), PROMIS Physical Function, PROMIS Ability,¶ Quality of Life in Neurologic Disorders (Neuro-QoL),** and the 6MWT,†† respectively. For self-reported item-level data, five-point Likert scales were recoded to proportions. T-scores

* Data used were from Select Medical, a network of rehabilitation clinics in 36 states and the District of Columbia. https://www.selectmedical.com/

† https://www.thoracic.org/statements/resources/pfet/sixminute.pdf

§ *International Classification of Diseases, Tenth Revision* codes used to examine potential post-COVID condition were J96.01, M62.81, R.26.2, R26.89 R53, R53.1, and R53.83.

¶ PROMIS items use a Likert-type response scale (https://commonfund.nih.gov/promis/index). The 10 PROMIS items used in this analysis included overall self-rated health; overall quality of life; overall physical health; overall mental health; and individual items on fatigue, pain, emotional distress, and social activities and roles. Most questions asked about a person's experience "in general," with items on fatigue, pain, and emotional problems experienced during the past 7 days. Psychometric evaluation of the PROMIS global health items were based on two global physical health (GPH) and global mental health (GMH) scales. The PROMIS GPH scale included four items that rated overall physical health (physical functioning, physical activities, pain, and fatigue). GPH and GMH total raw scores were computed by summing item scores that ranged from 1 to 5, such that higher scores reflected better functioning and are then rescaled to a mean of 50 and an SD of 10 using nationally normative data from the U.S. general population. The estimated correlation between the GPH and GMH was 0.63.

** Neuro-QoL is a set of self-report measures that assesses the health-related quality of life of adults with neurologic disorders. Neuro-QoL AC-GC assesses perceived difficulties in everyday cognitive abilities, such as memory, attention, and decision-making. https://www.healthmeasures.net/explore-measurement-systems/neuro-qol

†† Physical endurance was assessed using the 6-minute walk test. A poor 6-minute walk distance (e.g., <300 m) might have prognostic value (i.e., usually associated with an increased risk of mortality), and a change of 14.0 to 30.5 m might be clinically relevant.

were computed for composite measures of physical and mental health, social participation ability, and applied cognition, where the summed raw scores were converted to T-scores based on standardized scoring tables; T-scores were designed to have a mean of 50 and a standard deviation (SD) of 10 for the general adult population Logistic regression analysis, adjusted for age and sex, was used to examine differences in patient-reported measures of health, physical endurance, and health care use between post–COVID-19 and control patients.[§§] All analyses were conducted using SAS (version 9.4; SAS Institute). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[¶¶]

Post–COVID-19 patients referred for rehabilitation services differed from control patients by several characteristics, including sex, age, race, ethnicity, employment status, health insurance coverage, and U.S. Census region (Table 1). Compared with control patients, post–COVID-19 patients were more likely to be male, younger, in the labor force, insured by a commercial plan or a worker's compensation plan, and less likely to be covered by Medicaid or Medicare (Table 1). Post–COVID-19 patients were more likely to have received a diagnosis of generalized muscle weakness or fatigue (72.7% versus 42.3%) and patient-reported symptoms of generalized muscle weakness, malaise, and fatigue (69.0% versus 59.7%) (Table 2).

Compared with control patients, post–COVID-19 patients had higher prevalences of reported fair or poor general health (32.9% versus 25.4%), poorer physical health (44.1% versus 32.6%), pain level ≥7 (on a scale of 0–10) (40.4% versus 24.8%), and difficulty with physical activities (32.3% versus 24.2%) (Table 3). Post–COVID-19 patients also reported a higher prevalence of fair or poor overall mental health than control patients (19.1% versus 15.3%). Post–COVID-19 patients and control patients reported more challenges with applied cognition as indicated by T-scores (42.2 versus 41.2), both approximately one SD below the normative sample with which the scale was developed. Post–COVID-19 patients also demonstrated reduced physical endurance on the 6MWT compared with control patients (distance of 303 m versus 377 m; p<0.001) and reported increased difficulty completing chores (38.2% versus 25.2%), navigating stairs (40.2% versus 18.3%), running errands or shopping (34.3% versus 16.0%), and walking for 15 minutes (38.2% versus 16.6%). Compared with control patients, post–COVID-19 patients also reported more difficulty doing usual work or work at home (37.2% versus 20.4%) and challenges in ability to participate in activities with friends (33.0% versus 18.8%). For measures of health care use, post–COVID-19 patients required significantly more visits (median = 9, interquartile range [IQR] = 4–20) than control patients (median = 5, IQR 1–11; p<0.001) and longer therapy duration (median = 35 days, IQR = 15–71 days versus median = 27 days, IQR = 0–57 days; p<0.001).

[§§] Other demographic variables besides sex and age had substantial proportions of missing data (26%–75%); therefore, these variables were not included in the analysis.

[¶¶] 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.

Summary

What is already known about this topic?

COVID-19 patients might experience symptoms that persist months after initial infection.

What is added by this report?

Compared with control patients enrolled in a cancer rehabilitation program, adult post–COVID-19 patients referred for rehabilitation services reported poorer physical health and being less able to engage in physical activities and activities of daily living. Patients recovering from COVID-19 also had significantly higher health care use than control patients.

What are the implications for public health practice?

Patients recovering from COVID-19 might require tailored physical and mental health rehabilitation services.

Discussion

Among patients referred to Select Medical's outpatient rehabilitation clinics during January 2020–March 2021 (during the COVID-19 pandemic), patients who previously had COVID-19 reported poorer general, mental, and physical health (i.e., overall physical health, physical activities, and pain), and functioning (i.e., physical and social, such as ability to do chores, usual work, or activities with friends) compared with patients with no previous diagnosis of COVID-19 referred for cancer rehabilitation. Also, post–COVID-19 patients did not perform as well as control patients on a measured assessment of physical functioning (6MWT). Finally, post–COVID-19 patients used more rehabilitative services than control patients. These findings indicate that among patients referred to outpatient rehabilitation, those recovering from COVID-19 might have poorer physical health and functional status than do patients with cancer but not COVID-19 and could benefit from additional clinical support, including tailored physical and mental health rehabilitation services.

The identification of poorer physical health among post–COVID-19 patients is consistent with a previous study that found that 92% of post–COVID-19 patients had diagnoses potentially related to post–COVID-19 conditions, including weakness, malaise, fatigue, respiratory failure with hypoxia, and gait abnormalities (*2*,*3*). Poorer self-reported physical and mental health is associated with long-term negative health outcomes including chronic diseases (e.g., diabetes and cardiovascular

TABLE 1. Baseline characteristics of post–COVID-19 patients and control patients* who received care in outpatient rehabilitation clinics — United States,† January 2020–March 2021

Characteristic	No. (%) Post–COVID-19 patients (n = 1,295)	Control patients (n = 2,395)	p-value§
Sex			
Male	560 (43.2)	610 (25.5)	<0.001
Female	735 (56.8)	1,785 (74.5)	
Age, median (IQR), yrs	56 (44–65)	61 (51–70)	<0.001
Age group, yrs			
18–39	233 (18.0)	155 (6.5)	<0.001
40–49	197 (15.2)	325 (13.6)	
50–59	355 (27.4)	611 (25.5)	
60–69	282 (21.8)	665 (27.8)	
70–79	163 (12.6)	499 (20.8)	
≥80	65 (5.0)	140 (5.8)	
Race¶			
White	320 (24.7)	814 (34.0)	<0.001
Black or African American	101 (7.8)	173 (7.2)	
Other	36 (2.8)	51 (2.1)	
Missing	838 (64.7)	1,357 (56.7)	
Ethnicity			
Hispanic or Latino	92 (7.1)	75 (3.1)	<0.001
Missing	1,203 (92.9)	2,320 (96.9)	
Marital status			
Married	624 (48.2)	1,209 (50.5)	0.122
Single	250 (19.3)	413 (17.2)	
Other (not specified)	81 (6.3)	119 (5.0)	
Missing	340 (26.3)	654 (27.3)	
Employment status			
In labor force	271 (20.9)	415 (17.3)	<0.001
Not in labor force	48 (3.7)	488 (20.4)	
Missing	976 (75.4)	1,492 (62.3)	
Health insurance coverage			
Medicaid/Medicare	433 (33.4)	1,074 (44.8)	<0.001
Private/Commercial	746 (57.6)	1,291 (53.9)	
Other**	116 (9.0)	30 (1.3)	
U.S. Census region			
Midwest	230 (17.8)	380 (15.9)	<0.001
Northeast	410 (31.7)	438 (18.3)	
South	568 (43.9)	1,304 (54.4)	
West	86 (6.6)	273 (11.4)	
Missing	1 (<0.01)	0 (—)	

Abbreviations: ICD-10 = *International Classification of Diseases, Tenth Revision*; IQR = interquartile range.

* Post–COVID-19 patients in this analysis were patients referred to Select Medical's Recovery and Reconditioning program that includes post–COVID-19 care. In addition, patient history of COVID-19 was assessed to validate that each patient had either 1) an ICD-10 code for COVID-19 or 2) clinical notes documenting COVID-19 history. Control patients were patients referred for cancer rehabilitation and confirmed with no history of COVID-19 diagnoses by ICD-10 code in the same network and time frame.

† Select Medical's Recovery and Reconditioning clinics are located in Alabama, Alaska, Arizona, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nevada, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

§ P-value from chi square test.

¶ Other race = non-Hispanic Asian or Pacific Islander, American Indian or Native Alaskan, and multiracial.

** Other health insurance coverage categories included self-pay and workers' compensation.

TABLE 2. Most common diagnoses and symptoms potentially related to COVID-19* among post–COVID-19 patients and control patients† receiving care in outpatient rehabilitation clinics — United States,§ January 2020–March 2021

Diagnoses¶ (ICD-10 code)	No. (%) Post-COVID-19 patients (n = 1,295)	Control patients (n = 2,395)
Most common diagnoses		
Neoplasms (C code 189.0; D code I97.2)	17 (1.3)	2,767 (100)
Muscle weakness (generalized), malaise and fatigue (M62.81, R53.0, R53.1, R53.8)	941 (72.7)	1,014 (42.3)
COVID-19 (G93.3, U07.1, Z86.19)	970 (74.9)	12 (0.5)
Symptoms potentially related to COVID-19		
Muscle weakness (generalized), malaise and fatigue (M62.81, R53, R53.1, R53.8, R53.81, R53.83)	894 (69.0)	1,430 (59.7)
Muscle weakness (generalized) (M62.81)	572 (44.2)	929 (38.8)
Malaise and fatigue (R53, 53.1, R53.8, R53.81, R53.83)	522 (40.4)	566 (23.6)
Abnormalities of gait and mobility (R26.2, R26.89)	266 (20.5)	205 (8.6)
Acute respiratory failure with hypoxia (J96.01)	26 (2.0)	0 (—)

Abbreviation: ICD-10 = *International Classification of Diseases, Tenth Revision.*

* ICD-10 codes at first evaluation in outpatient rehabilitation clinic.

† Post-COVID-19 patients were defined as those who were referred for post–COVID-19 care to Select Medical's Recovery and Reconditioning program. In addition, patient history of COVID-19 was assessed by validating whether a patient had either 1) an ICD-10 code for COVID-19 or 2) clinical notes documenting COVID-19 history. Control patients were defined as patients referred for cancer rehabilitation and confirmed with no history of COVID-19 diagnoses by ICD-10 code in the same network and time frame.

§ Select Medical's outpatient rehabilitation clinics are located in Alabama, Alaska, Arizona, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nevada, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

¶ This list is not exhaustive and is based on nonmutually exclusive ICD-10 codes.

disease), functional decline (*4*), and mortality (*5*). The lower scores on applied cognitive ability tasks suggest more subtle deficits in cognitive functioning, which might indicate the need for further evaluation and additional need for health care resources and services (*6*). Further, physical function, as measured by the 6MWT, has been shown to be an important outcome for assessing impact of COVID-19 (*4*). Additional studies have shown that patients recovering from COVID-19 have higher incidences of negative health outcomes, including poorer physical health and functional status, and might need additional clinical support such as tailored physical and mental health rehabilitation services (*7*,*8*). These findings have implications for health care systems during and after the COVID-19 pandemic (*9*). Postacute sequalae associated with COVID-19 have not been comprehensively described, and data from studies of long-term follow-up to provide reliable estimates of the long-term sequelae associated with COVID-19 are still emerging (*6*–*8*). Continued assessments

TABLE 3. Measures of mental and physical health, functioning, and treatment among post-COVID-19 patients and control patients* — United States,† January 2020–March 2021

Characteristic	% (95% CI)		
	Post–COVID-19 patients	Control patients	aOR§
General health fair or poor¶	32.9 (28.8 to 36.9)	25.4 (23.6 to 27.1)	1.64 (1.32 to 2.04)
Mental health**			
Quality of life, fair or poor	19.9 (16.5 to 23.4)	19.3 (17.7 to 20.9)	1.17 (0.91 to 1.50)
Mental health, fair or poor	19.1 (15.7 to 22.6)	15.3 (13.9 to 16.8)	1.34 (1.04 to 1.73)
Satisfaction with social activities, fair or poor	17.4 (14.1 to 20.7)	19.2 (17.6 to 20.7)	0.98 (0.76 to 1.27)
Emotional problems, often or always	12.8 (9.9 to 15.7)	15.0 (13.6 to 16.5)	0.91 (0.68 to 1.22)
Physical health**			
Physical health, fair or poor	44.1 (39.8 to 48.4)	32.6 (30.7 to 34.4)	1.76 (1.43 to 2.15)
Physical activities, little or none at all	32.3 (28.3 to 36.3)	24.2 (22.5 to 25.9)	1.64 (1.32 to 2.03)
Pain, ≥7	40.4 (36.2 to 44.7)	24.8 (23.1 to 26.5)	2.30 (1.86 to 2.83)
Fatigue, severe or very severe	15.7 (12.5 to 18.8)	14.1 (12.7 to 15.5)	1.03 (0.79 to 1.36)
Physical functional status (with much difficulty or unable to do)††			
Able to do chores such as vacuuming or yard work	38.2 (28.6 to 47.8)	25.2 (23.0 to 27.4)	2.17 (1.42 to 3.35)
Able to go up and down stairs at a normal pace	40.2 (30.5 to 49.9)	18.3 (16.4 to 20.3)	4.12 (2.62 to 6.48)
Able to go for a walk of at least 15 minutes	38.2 (28.6 to 47.8)	16.6 (14.7 to 18.5)	4.60 (2.90 to 7.30)
Able to run errands and shop	34.3 (24.9 to 43.7)	16.0 (14.1 to 17.9)	3.43 (2.17 to 5.42)
Social participation ability (usually or always)§§			
Trouble doing all of my regular leisure activities with others	22.3 (13.8 to 30.9)	17.3 (15.3 to 19.2)	1.48 (0.88 to 2.50)
Trouble doing all of the family activities that I want to do	23.4 (14.7 to 32.1)	17.4 (15.5 to 19.3)	1.52 (0.91 to 2.54)
Trouble doing all of my usual work (include work at home)	37.2 (27.3 to 47.2)	20.4 (18.3 to 22.4)	2.43 (1.54 to 3.84)
Trouble doing all of the activities with friends that I want to do	33.0 (23.3 to 42.7)	18.8 (16.8 to 20.8)	2.27 (1.41 to 3.64)
Applied cognition (often or very often)¶¶			
Have to read something several times to understand it	15.7 (11.6 to 19.9)	20.3 (9.8 to 30.9)	0.73 (0.36 to 1.52)
Trouble keeping track of what I was doing if I was interrupted	20.1 (15.5 to 24.6)	18.6 (8.4 to 28.9)	1.09 (0.52 to 2.26)
Difficulty doing more than one thing at a time	22.7 (18.0 to 27.5)	23.7 (12.5 to 34.9)	0.91 (0.46 to 1.80)
Trouble remembering new information, like phone numbers or simple instructions	17.4 (13.1 to 21.7)	18.6 (8.4 to 28.9)	1.12 (0.53 to 2.35)
Trouble thinking clearly	18.7 (14.3 to 23.2)	16.9 (7.1 to 26.8)	1.04 (0.49 to 2.24)
Thinking was slow	18.4 (14.0 to 22.8)	20.3 (9.8 to 30.9)	0.86 (0.42 to 1.77)
Have to work really hard to pay attention or I would make a mistake	20.1 (15.5 to 24.6)	16.9 (7.1 to 26.8)	1.23 (0.58 to 2.62)
Trouble concentrating	20.1 (15.5 to 24.6)	20.3 (9.8 to 30.9)	0.90 (0.44 to 1.83)
Summary scale T-score,* mean SD, mean difference**			
Mental health	46.7 (47.2 to 48.7)	47.6 (48.4 to 49.1)	−0.96 (−1.83 to −0.09)
Physical health	40.6 (40.0 to 41.2)	43.8 (43.4 to 44.2)	−3.54 (−4.40 to −2.67)
Physical functional status	37.1 (35.4 to 38.8)	43.5 (43.0 to 44.0)	−7.43 (−9.37 to −5.50)
Social participation ability	52.6 (45.6 to 59.7)	53.0 (51.8 to 54.2)	−0.53 (−5.72 to 4.67)
Applied cognition	42.2 (41.1 to 43.4)	41.2 (38.5 to 43.8)	1.23 (−1.64 to 4.11)
Physical endurance,††† mean IQR, mean difference			
6-minute walk test, meters	303.0 (276.6 to 329.4)	377.4 (360.3 to 394.5)	−94.21 (−124.92 to −63.51)
Health care use, median (IQR) and p-value			
Days in therapy	35 (15 to 71)	27 (0 to 57)	<0.001
Total number of visits	9 (4 to 20)	5 (1 to 11)	<0.001

Abbreviations: aOR = adjusted odds ratio; CI = confidence interval; ICD-10 = *International Classification of Diseases, Tenth Revision*; IQR = interquartile range; Neuro-QoL = Quality of Life in Neurologic Disorders; PROMIS = Patient Reported Outcomes Measurement Information System; SD = standard deviation.

* Post–COVID-19 patients were defined as those who were referred for post–COVID-19 care to Select Medical's Recovery and Reconditioning program. In addition, patient history of COVID-19 was assessed by validating whether a patient had either 1) an ICD-10 code for COVID-19 or 2) clinical notes documenting COVID-19 history. Control patients were defined as patients referred for cancer rehabilitation and confirmed with no history of COVID-19 diagnoses by ICD-10 code in the same network and time frame.

† Select Medical's outpatient rehabilitation clinics are located in Alabama, Alaska, Arizona, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nevada, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

§ Adjusted for age (years, continuous) and sex.

¶ Proportions of patients reporting "fair" or "poor" general health.

** Mental and physical health were assessed with PROMIS Scale v1.2 – Global Health (National Institutes of Health). PROMIS items all use a Likert-type response scale. Most questions ask about a person's experience "in general," with items on fatigue, pain, and emotional problems referencing the past 7 days. The PROMIS global mental health scale includes four items that rate overall mental health (quality of life, mental health, emotional distress, and social activities and roles). The PROMIS global physical health scale includes four items that rate overall physical health (physical functioning, physical activities, pain, and fatigue). Proportions of patients reporting "fair" or "poor" health were calculated for each measure, with the exceptions of emotional problems, physical activities, pain, and fatigue. Proportions of patients reporting "often" or "always" were calculated for emotional problems; "little" or "none at all" for physical activities; and "severe" or "very severe" for fatigue. Pain was measured using a scale of 0–10 and the proportion of patients reporting ≥7 was calculated.

†† Physical functional status was assessed with PROMIS Item Bank v2.0 – Physical Function–Short Form 4a. Proportions of patients reporting "with much difficulty" or "unable to do with much difficulty" were calculated for each measure.

§§ Social participation ability was assessed with PROMIS Item Bank v2.0 - Ability to Participate in Social Roles and Activities–Short Form 4a. Proportions of patients reporting "usually" or "always" were calculated for each measure.

¶¶ Applied cognition was assessed with Neuro-QOL Item Bank v1.0 – Applied Cognition – General Concerns (AC-GC)–Short Form. Neuro-QoL AC-GC assesses perceived difficulties in everyday cognitive abilities such as memory, attention, and decision-making. Proportions of patients reporting "often (once a day)" or "very often (several times a day)" were calculated for each measure.

*** Total raw scores were computed by summing items scores that range from 1 to 5, such that higher scores reflect better functioning and are then rescaled to a mean of 50 and SD of 10 using nationally normative data from the U.S. general population.

††† Physical endurance was assessed using the 6-minute walk test. A poor 6-minute walk distance (e.g., <300 m) might have prognostic value (i.e., usually associated with an increased risk of mortality), and a change of 14.0 to 30.5 m might be clinically relevant.

of self-reported health data are important to characterize the sequelae of novel infectious diseases and are critical for developing cost-effectiveness estimates for lifesaving interventions, such as vaccines and other potentially important rehabilitation therapies and interventions, including physical therapy, occupational therapy, and services and therapies associated with cognitive and functional decline (*9*,*10*).

The findings in this report are subject to at least six limitations. First, date of infection was not available; therefore, time-varying effects associated with infection date could not be examined. Second, data on severity of illness, including hospitalization status, were not available, precluding assessment of the impact of illness severity on post–COVID-19 conditions. Third, given the large amount of missing data (>50%) for many demographic variables (e.g., race, ethnicity, employment status, and occupation), which are common limitations in large EHR data sets, it was not possible to control for additional demographic differences. Fourth, the absence of pre–COVID-19 assessments did not permit controlling for premorbid function. Fifth, the types of cancer diagnoses and treatments were not available, which is an important consideration given heterogeneity of cancer sequelae. Similarly, assessing other comorbidities was not possible; post–COVID-19 patients might have had more underlying medical conditions (e.g., diabetes or obesity) than did control patients, which could explain poorer physical and mental health measures. However, given that patients in the post–COVID-19 group were younger and more commonly employed than were those in the control group, it is likely that these two populations are different with regard to demographic factors and the prevalence of comorbid chronic conditions. Finally, referral to physical rehabilitation depended on nonstandardized clinical judgment, which might have led to differences in patient population by group. Therefore, these results should not be interpreted to mean that post–COVID-19 patients overall had poorer physical and mental health than patients with cancer. Instead, results indicate that post–COVID-19 patients specifically referred to a large physical rehabilitation network had poorer health measures than those referred for cancer, which indicates that some patients recovering from COVID-19 had substantial rehabilitation needs.

Patients recovering from COVID-19 might experience continued poor health and could benefit from additional support and tailored physical and mental health rehabilitation services. Health care systems and providers should be prepared to recognize and meet the ongoing needs of this patient population. Efforts to increase COVID-19 vaccination could include messaging that states that preventing COVID-19 also prevents post–COVID-19 conditions with potential effects on long-term health.

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Efficacy of Portable Air Cleaners and Masking for Reducing Indoor Exposure to Simulated Exhaled SARS-CoV-2 Aerosols — United States, 2021

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SARS-CoV-2, the virus that causes COVID-19, can be spread by exposure to droplets and aerosols of respiratory fluids that are released by infected persons when they cough, sing, talk, or exhale. To reduce indoor transmission of SARS-CoV-2 between persons, CDC recommends measures including physical distancing, universal masking (the use of face masks in public places by everyone who is not fully vaccinated), and increased room ventilation (*1*). Ventilation systems can be supplemented with portable high efficiency particulate air (HEPA) cleaners* to reduce the number of infectious particles in the air and provide enhanced protection from transmission between persons (*2*); two recent reports found that HEPA air cleaners in classrooms could reduce overall aerosol particle concentrations by ≥80% within 30 minutes (*3*,*4*). To investigate the effectiveness of portable HEPA air cleaners and universal masking at reducing exposure to exhaled aerosol particles, the investigation team used respiratory simulators to mimic a person with COVID-19 and other, uninfected persons in a conference room. The addition of two HEPA air cleaners that met the Environmental Protection Agency (EPA)–recommended clean air delivery rate (CADR) (*5*) reduced overall exposure to simulated exhaled aerosol particles by up to 65% without universal masking. Without the HEPA air cleaners, universal masking reduced the combined mean aerosol concentration by 72%. The combination of the two HEPA air cleaners and universal masking reduced overall exposure by up to 90%. The HEPA air cleaners were most effective when they were close to the aerosol source. These findings suggest that portable HEPA air cleaners can reduce exposure to SARS-CoV-2 aerosols in indoor environments, with greater reductions in exposure occurring when used in combination with universal masking.

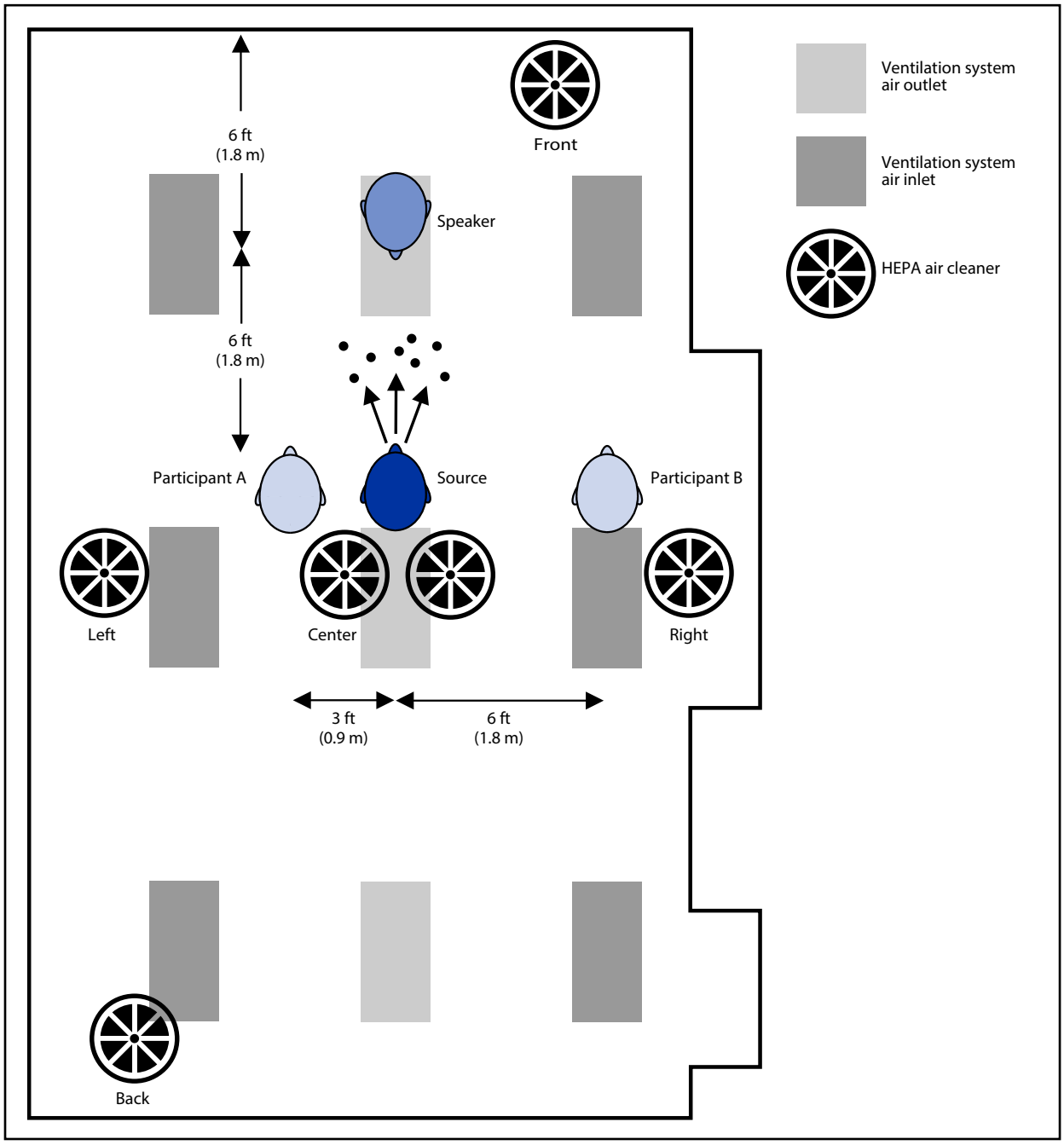
A breathing aerosol source simulator was used to mimic a meeting participant exhaling infectious particles (source), and three breathing simulators were used to mimic a speaker and two participants exposed to these aerosol particles (receivers) (Figure 1). The methods used were similar to those used in previous studies of aerosol dispersion and transport in indoor spaces (*3*,*4*,*6*). The simulators were placed in a 584–ft^2 (54–m^2) conference room with a heating, ventilation, and air conditioning (HVAC) system that provided 0.1 m^3 per second of air flow (202 ft^3 per minute; two air changes per hour) with no air recirculation. Two HEPA air cleaners (Honeywell 50250-S, Kaz Inc.) were used, each rated to provide 250 ft^3 per minute (0.12 m^3 per second) of air filtration for a combined total of 5.2 air changes per hour. The two air cleaners were used in four different locations: 1) center of the room on the floor behind the source simulator; 2) left and right sides of the room on the floor; 3) left and right sides of the room and elevated 32 in (0.8 m); and 4) front and back of the room on the floor. Control experiments used no air cleaners.

The source simulator (*6*) breathed continuously at 15 L/min. Two participant simulators (participant receivers) similar in design to the respiratory aerosol source simulator breathed continuously at 15 L/min. The speaker simulator (speaker receiver) was a commercial simulator (Warwick Technologies Ltd.) that breathed at 28 L/min. To mimic human heads, all simulators had headforms with elastomeric skin (source simulator headform, Hanson Robotics; receiver simulator headforms, Respirator Testing Head Form 1–Static, Crawley Creatures Ltd.). The face masks used on the headforms were three-ply cotton cloth face masks with ear loops (Defender, HanesBrands Inc.). Experiments were conducted either with all simulators unmasked or all simulators masked (universal masking).

The concentrations of 0.3 μm to 3 μm aerosol particles were measured at the mouth of each receiver using optical particle counters (Model 1.108, Grimm Technologies, Inc.) to determine the exposure of each receiver simulator to aerosol particles. When the simulators were masked, the particle counters collected aerosol samples from inside the masks (i.e., the particle counter measured the concentration of the aerosol being inhaled by the receiver simulator). For each optical particle counter, the total aerosol mass concentration was averaged over 60 minutes to determine the mean aerosol mass concentration (mean aerosol exposure) to which each receiver was exposed. Each experiment was repeated four times for a total of 20 tests. All data were analyzed using the Kruskal Wallis test to assess overall significance, followed by a Wilcoxon Rank Sum pairwise comparison with a Benjamini and Hochberg adjusted p-value for multiple comparisons. R software (version 3.6.0; R Foundation) was used to conduct all analyses.

* HEPA air cleaners consist of a filter capable of removing ≥99.97% of particles from the air and a fan or blower to draw air through the filter. HEPA air cleaners are commercially available, relatively inexpensive, and easy to use.

FIGURE 1. Representation of conference room* containing a breathing aerosol source simulator† used to mimic a meeting participant exhaling infectious particles (source),§ and three breathing simulators used to mimic a speaker and two participants exposed to these aerosol particles (receivers) — United States, 2021¶



Abbreviation: HEPA = high efficiency particulate air.

* The room is 21 ft (6.3 m) x 31 ft (9.3 m) x 10 ft (3 m).

† The mouths of the participant source and participant receiver simulators were 40 in (1 m) above the floor, simulating persons sitting in a meeting or classroom. The mouth of the speaker receiver was 5 ft (1.5 m) above the floor, simulating a speaker standing in the front of the room. The air cleaners were placed either side-by-side in the center of the room on the floor, in the front and back of the room on the floor, on the left and right sides of the room on the floor, or on the left and right sides of the room and elevated 30 in (0.8 m). The room ventilation system air inlets and outlets were located in the ceiling as part of the light fixtures.

§ The source simulator breathed continuously at 15 liters per minute, and the aerosol generator was repeatedly cycled on for 20 seconds and off for 40 seconds to avoid exceeding the range of the aerosol instruments.

¶ Two participant breathing simulators (participant receivers) had a design based on the respiratory aerosol source simulator and breathed continuously at 15 liters per minute. The speaker breathing simulator (speaker receiver) was a commercial simulator that breathed at 28 liters per minute.

The mean aerosol concentrations for the two participant receivers and the speaker receiver were generally similar during each experiment, indicating that the air in the room was well mixed over the 60-minute test period (Table). For all assessed scenarios, use of the HEPA air cleaners significantly reduced the aerosol exposures for the two participant receivers and speaker receiver ($p = 0.001$) (Figure 2). Without masks, the combined mean aerosol concentrations for the two participant receivers and speaker receiver were reduced by 49% with the air cleaners in the left and right elevated positions, 52% in the left and right floor positions, 55% in the front and back floor positions, and 65% in the center floor positions. The reductions with the air cleaners in the center floor position were higher than those with the air cleaners in the left/right or front/back positions ($p<0.01$). The aerosol concentrations when the air cleaners were in the left and right floor, left and right elevated, and front and back floor position results did not differ significantly from one another. Without the HEPA air cleaners, universal masking reduced the combined mean aerosol concentration by 72% ($p<0.001$). When both universal masking and the HEPA air cleaners were used, the combined mean concentrations for the two participant receivers and the speaker decreased by as much as 90% ($p<0.001$) (Table).

Summary

What is already known about this topic?

Ventilation systems can be supplemented with portable high efficiency particulate air (HEPA) cleaners to reduce the number of airborne infectious particles.

What is added by this report?

A simulated infected meeting participant who was exhaling aerosols was placed in a room with two simulated uninfected participants and a simulated uninfected speaker. Using two HEPA air cleaners close to the aerosol source reduced the aerosol exposure of the uninfected participants and speaker by up to 65%. A combination of HEPA air cleaners and universal masking reduced exposure by up to 90%.

What are the implications for public health practice?

Portable HEPA air cleaners can reduce exposure to simulated SARS-CoV-2 aerosols in indoor environments, especially when combined with universal masking.

Discussion

In this study, the use of HEPA air cleaners in a conference room significantly reduced the exposure of nearby participants and a speaker to airborne particles produced by a simulated infected participant. The air cleaners were most effective when they were located in the center of the room close to the aerosol source. Moreover, the combination of HEPA air cleaners and universal masking was more effective than was either intervention alone. The use of masks without air cleaners reduced the aerosol exposure of the receivers by 72%, and the use of air cleaners without masks reduced the exposure by up to 65%. When used together, the HEPA air cleaners and masks reduced exposure to respiratory aerosols by up to 90%. These findings suggest that the use of portable HEPA air cleaners and universal masking can each reduce exposure to simulated SARS-CoV-2 aerosols in indoor environments, with larger reductions occurring when air cleaners and masking are used together.

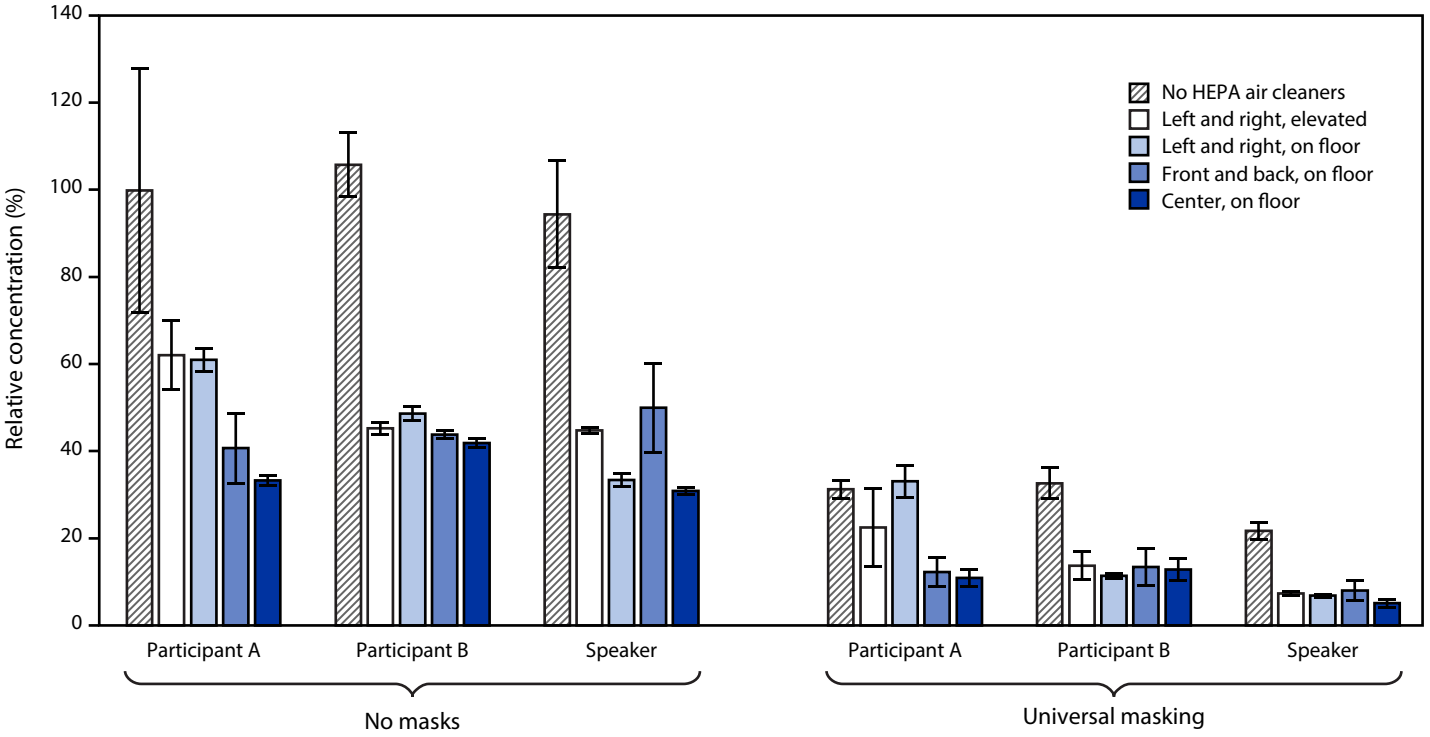
Ventilation is a well-established method for reducing potential exposures to infectious aerosols (*7*). By removing airborne particles from a room, ventilation systems can reduce exposures that occur by inhalation of infectious aerosols, deposition on susceptible mucous membranes, or conveyance to mucous membranes by contaminated hands. However, in most nonclinical settings, ventilation systems are designed only with sufficient airflow to provide fresh air while maintaining comfortable temperature and humidity levels; these systems

TABLE. Mean aerosol concentrations and standard deviations measured at the mouth of each simulator over 60 minutes at varying HEPA air cleaner locations, by masking status — United States, 2021

	Mean aerosol concentrations at four HEPA air cleaner locations, % (SD)				
Simulator/Masking status	No air cleaner	Left and right (elevated)	Left and right (floor)	Front and back (floor)	Center of room (floor)
No masks					
Participant A	99.8 (28.3)	62.1 (8.2)	61.0 (2.9)	40.7 (8.4)	33.3 (1.5)
Participant B	105.8 (7.7)	45.2 (1.7)	48.6 (1.9)	43.8 (1.2)	41.9 (1.4)
Speaker	94.4 (12.6)	44.7 (0.9)	33.4 (1.8)	50.0 (10.5)	30.8 (1.1)
Participants and speaker combined*	**100.0 (12.1)**	**50.7 (3.3)**	**47.7 (1.6)**	**44.8 (5.7)**	**35.3 (1.3)**
Universal masking					
Participant A	31.2 (2.4)	22.5 (9.2)	33.1 (4.0)	12.2 (3.6)	10.9 (2.3)
Participant B	32.7 (3.9)	13.7 (3.5)	11.4 (0.9)	13.4 (4.5)	12.8 (2.7)
Speaker	21.7 (2.2)	7.3 (0.7)	6.8 (0.7)	8.1 (2.7)	5.1 (1.2)
Participants and speaker combined*	**28.5 (2.8)**	**14.5 (4.3)**	**17.1 (1.7)**	**11.2 (3.6)**	**9.6 (2.1)**

Abbreviations: HEPA = high efficiency particulate air; SD = standard deviation.
* The values for participants and speaker combined represent the average of the results for the two participant receivers and the speaker receiver.

FIGURE 2. Concentrations* of aerosol particles at mouths of two participants and speaker relative to the combined average concentration measured for participants and speaker when high efficiency particulate air cleaners were not used and masks were not worn† — United States, 2021



Abbreviation: HEPA = high efficiency particulate air.

* The aerosol concentrations were measured at the mouths of two simulated participant receivers and simulated speaker receiver for 60 minutes while the simulated infected participant source exhaled aerosols into the room.

† The legend indicates the locations of the HEPA air cleaners in the room. Each bar is the mean of four experiments. Error bars show the standard deviations.

typically are not designed to have the much higher airflow rates that are needed to reduce disease transmission (*8*). During the ongoing pandemic, public health and professional organizations have provided guidance for increasing ventilation and air filtration to decrease the spread of SARS-CoV-2 (*2*,*9*,*10*). One recommended option, especially when existing HVAC systems might be insufficient, is adding portable HEPA air cleaners to rooms (*2*). The results of this study support the use of portable HEPA air cleaners to reduce exposure to airborne particles.

The findings in this report are subject to at least five limitations. First, the dispersion of aerosols in a room depends upon air currents, which are unique to each setting. In this study, the conference room air was well mixed, which helped transport aerosols to the air cleaners. In rooms with poor air mixing and potential stagnation zones, air cleaners might be less effective. Airflow patterns in real-world settings such as classrooms will vary among buildings and rooms, and rooms of different dimensions and with different ventilation rates will also have different airflow patterns. Second, the aerosol source manikin in this study was kept in one fixed location. In reality, potentially infectious occupants could be anywhere in the room and might move around the room occasionally. Third, this study only used one source manikin and three receiver manikins; additional sources and receivers could change the dynamics of aerosol dispersion within a room. Fourth, the study was limited to aerosol particles of 0.3 μm to 3 μm in size, which are small enough to remain airborne for an extended time but large enough to carry pathogens. However, particles outside this size range would behave differently. Finally, the study only assessed aerosol exposure; it did not directly examine disease transmission. Although the study provides useful information about the dynamics of respiratory aerosol particles and the effects of HEPA air cleaners and universal masking, many other factors are also important for disease transmission, including the amount of virus in the particles, how long the virus survives in air, and the vaccination status of the room occupants.

Portable HEPA air cleaners offer a simple means to increase the filtration of aerosol particles from a room without modifying the existing building ventilation system (*2*). The optimal location for HEPA air cleaners will depend upon the unique conditions in each room, but they are likely to be most effective when they are placed as close to the occupants as is practicable. Larger reductions in exposure occur when air cleaners are used in combination with universal masking. These

findings support the utility of portable HEPA air cleaners and universal masking for reducing exposure to indoor aerosols containing SARS-CoV-2. Efforts to reduce SARS-CoV-2 aerosol exposure could help limit transmission of the virus and decrease incidences of COVID-19 illness and death.

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Use of mRNA COVID-19 Vaccine After Reports of Myocarditis Among Vaccine Recipients: Update from the Advisory Committee on Immunization Practices — United States, June 2021

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In December 2020, the Food and Drug Administration (FDA) issued Emergency Use Authorizations (EUAs) for the Pfizer-BioNTech COVID-19 (BNT162b2) vaccine and the Moderna COVID-19 (mRNA-1273) vaccine,† and the Advisory Committee on Immunization Practices (ACIP) issued interim recommendations for their use in persons aged ≥16 years and ≥18 years, respectively.§ In May 2021, FDA expanded the EUA for the Pfizer-BioNTech COVID-19 vaccine to include adolescents aged 12–15 years; ACIP recommends that all persons aged ≥12 years receive a COVID-19 vaccine. Both Pfizer-BioNTech and Moderna vaccines are mRNA vaccines encoding the stabilized prefusion spike glycoprotein of SARS-CoV-2, the virus that causes COVID-19. Both mRNA vaccines were authorized and recommended as a 2-dose schedule, with second doses administered 21 days (Pfizer-BioNTech) or 28 days (Moderna) after the first dose. After reports of myocarditis and pericarditis in mRNA vaccine recipients,¶ which predominantly occurred in young males after the second dose, an ACIP meeting was rapidly convened to review reported cases of myocarditis and pericarditis and discuss the benefits and risks of mRNA COVID-19 vaccination in the United States. Myocarditis is an inflammation of the heart muscle; if it is accompanied by pericarditis, an inflammation of the thin tissue surrounding the heart (the pericardium), it is referred to as myopericarditis. Hereafter, myocarditis is used to refer to myocarditis, pericarditis, or myopericarditis. On June 23, 2021, after reviewing available evidence including that for risks of myocarditis, ACIP determined that the benefits of using mRNA COVID-19 vaccines under the FDA's EUA clearly outweigh the risks in all populations, including adolescents and young adults. The EUA has been modified to include information on myocarditis after receipt of mRNA COVID-19 vaccines. The EUA fact sheets should be provided before vaccination; in addition, CDC has developed patient and provider education materials about the possibility of myocarditis and symptoms of concern, to ensure prompt recognition and management of myocarditis.

Since June 2020, ACIP has convened 15 public meetings to review data on COVID-19 epidemiology and use of COVID-19 vaccines. The ACIP COVID-19 Vaccines Work Group, comprising experts in infectious diseases, vaccinology, vaccine safety, public health, and ethics, has held weekly meetings since April 2020 to review COVID-19 surveillance data, evidence for vaccine efficacy and safety, and implementation considerations for COVID-19 vaccination programs. After reports of myocarditis, the work group met twice to review clinical trial and postauthorization safety data for myocarditis after receipt of mRNA COVID-19 vaccines. The work group also reviewed a benefit-risk assessment of myocarditis events after receipt of mRNA COVID-19 vaccines, considering recent epidemiology of COVID-19 and sequelae of COVID-19, including myocarditis and multisystem inflammatory syndrome in children (MIS-C).** The ACIP COVID-19 Vaccines Safety Technical (VaST) Work Group, comprising independent vaccine safety expert consultants, had also reviewed safety data on myocarditis after receipt of mRNA COVID-19 vaccines at its weekly meetings. The findings from the VaST and the ACIP COVID-19 Vaccines Work Group assessments, including a summary of the data reviewed, were presented to ACIP during its meeting on June 23, 2021.

Myocarditis typically occurs more commonly in males than in females, and incidence is highest among infants, adolescents, and young adults (*1*,*2*). The clinical presentation and severity of myocarditis vary among patients. Symptoms typically include chest pain, dyspnea, or palpitations, although other symptoms might be present, especially in younger children (*3*). Diagnostic evaluation might reveal an elevated troponin level or abnormal findings on electrocardiogram, echocardiogram, or cardiac magnetic resonance imaging (Table 1). Supportive therapy is

* These authors contributed equally to this work.
† All EUA documents for COVID-19 vaccines, including fact sheets, are available at https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/covid-19-vaccines.
§ ACIP recommendations for all COVID-19 vaccines are available at https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/covid-19.html.
¶ COVID-19 Vaccine Safety Technical Work Group Reports are available at https://www.cdc.gov/vaccines/acip/work-groups-vast/index.html.
** https://www.cdc.gov/mis/hcp/index.html

a mainstay of treatment, with targeted cardiac medications or interventions as needed. Current guidelines from the American Heart Association and American College of Cardiology recommend exercise restriction until the heart recovers.[††]

As of June 11, 2021, approximately 296 million doses of mRNA COVID-19 vaccines had been administered in the United States, with 52 million administered to persons aged 12–29 years; of these, 30 million were first and 22 million were second doses. Within the Vaccine Adverse Event Reporting System (VAERS) (*4*), the national vaccine safety passive monitoring system, 1,226 reports of myocarditis after mRNA vaccination were received during December 29, 2020–June 11, 2021. Among persons with reported myocarditis after mRNA vaccination, the median age was 26 years (range = 12–94 years), with median symptom onset interval of 3 days after vaccination (range = 0–179). Among 1,194 reports for which patient age was known, 687 were among persons aged <30 years and 507 were among persons aged ≥30 years; of 1,212 with sex reported, 923 were male, and 289 were female.[§§] Among 1,094 patients with number of vaccine doses received reported, 76% occurred after receipt of dose 2 of mRNA vaccine; cases were reported after both Pfizer-BioNTech and Moderna vaccines. Informed by early reports, CDC prioritized rapid review of myocarditis in persons aged <30 years reported during May 1–June 11, 2021; the 484 patient records in this subset were evaluated by physicians at CDC, and several reports were also reviewed with Clinical Immunization Safety Assessment Project investigators,[¶¶] including cardiologists. At the time of this report, 323 of these 484 cases were determined to meet criteria in CDC's case definitions for myocarditis, pericarditis, or myopericarditis by provider interview or medical record review (Table 1). The median age of the 323 patients meeting CDC's case definitions was 19 years (range = 12–29 years); 291 were male, and 32 were female. The median interval from vaccination to symptom onset was 2 days (range = 0–40 days); 92% of patients experienced onset of symptoms within 7 days of vaccination. Of the 323 persons meeting CDC's case definitions, 309 (96%) were hospitalized. Acute clinical courses were generally mild; among 304 hospitalized patients with known clinical outcomes, 95% had been discharged at time of review, and none had died. Treatment data in VAERS are preliminary and incomplete; however, many patients have experienced resolution of symptoms with conservative treatment, such as receipt of nonsteroidal antiinflammatory drugs. Follow-up is

TABLE 1. Case definitions of probable and confirmed myocarditis, pericarditis, and myopericarditis

Condition	Definition	
Acute myocarditis	**Probable case**	**Confirmed case**
	Presence of ≥1 new or worsening of the following clinical symptoms:*	Presence of ≥1 new or worsening of the following clinical symptoms:*
	• chest pain, pressure, or discomfort • dyspnea, shortness of breath, or pain with breathing • palpitations • syncope	• chest pain, pressure, or discomfort • dyspnea, shortness of breath, or pain with breathing • palpitations • syncope
	OR, infants and children aged <12 years might instead have ≥2 of the following symptoms: • irritability • vomiting • poor feeding • tachypnea • lethargy	OR, infants and children aged <12 years might instead have ≥2 of the following symptoms: • irritability • vomiting • poor feeding • tachypnea • lethargy
	AND ≥1 new finding of • troponin level above upper limit of normal (any type of troponin) • abnormal electrocardiogram (ECG or EKG) or rhythm monitoring findings consistent with myocarditis[§] • abnormal cardiac function or wall motion abnormalities on echocardiogram • cMRI findings consistent with myocarditis[¶]	AND ≥1 new finding of • Histopathologic confirmation of myocarditis[†] • cMRI findings consistent with myocarditis[¶] in the presence of troponin level above upper limit of normal (any type of troponin)
	AND • No other identifiable cause of the symptoms and findings	AND • No other identifiable cause of the symptoms and findings
Acute pericarditis**	Presence of ≥2 new or worsening of the following clinical features: • acute chest pain[††] • pericardial rub on exam • new ST-elevation or PR-depression on EKG • new or worsening pericardial effusion on echocardiogram or MRI	
Myopericarditis	This term may be used for patients who meet criteria for both myocarditis and pericarditis.	

Abbreviations: AV = atrioventricular; cMRI = cardiac magnetic resonance imaging; ECG or EKG = electrocardiogram.

* Persons who lack the listed symptoms but who meet other criteria may be classified as subclinical myocarditis (probable or confirmed).

† Using the Dallas criteria (Aretz HT, Billingham ME, Edwards WD, et al. Myocarditis. A histopathologic definition and classification. Am J Cardiovasc Pathol 1987; 1:3–14). Autopsy cases may be classified as confirmed clinical myocarditis on the basis of meeting histopathologic criteria if no other identifiable cause.

§ To meet the ECG or rhythm monitoring criterion, a probable case must include at least one of 1) ST-segment or T-wave abnormalities; 2) Paroxysmal or sustained atrial, supraventricular, or ventricular arrhythmias; or 3) AV nodal conduction delays or intraventricular conduction defects.

¶ Using either the original or the revised Lake Louise criteria. https://www.sciencedirect.com/science/article/pii/S0735109718388430?via%3Dihub

** https://academic.oup.com/eurheartj/article/36/42/2921/2293375

†† Typically described as pain made worse by lying down, deep inspiration, or cough, and relieved by sitting up or leaning forward, although other types of chest pain might occur.

†† https://www.ahajournals.org/doi/10.1161/CIR.0000000000000239?url_ver = Z39.88-2003&rfr_id = ori:rid:crossref.org&rfr_dat = cr_pub%20%200pubmed#d3e785

§§ Age was not reported for 32 patients, and sex was not reported for 14 patients.

¶¶ https://www.cdc.gov/vaccinesafety/ensuringsafety/monitoring/cisa/index.html

ongoing to identify and understand longer-term outcomes after myocarditis occurring after COVID-19 vaccination.

Using myocarditis cases reported to VAERS with onset within 7 days after dose 2 of an mRNA vaccine, crude reporting rates (i.e., using confirmed and unconfirmed cases) per million second dose recipients were calculated using national COVID-19 vaccine administration data as of June 11, 2021. Myocarditis reporting rates were 40.6 cases per million second doses of mRNA COVID-19 vaccines administered to males aged 12–29 years and 2.4 per million second doses administered to males aged ≥30 years; reporting rates among females in these age groups were 4.2 and 1.0 per million second doses, respectively.*** The highest reporting rates were among males aged 12–17 years and those aged 18–24 years (62.8 and 50.5 reported myocarditis cases per million second doses of mRNA COVID-19 vaccine administered, respectively). Myocarditis rates from Vaccine Safety Datalink (VSD), based on electronic health records, were also evaluated. Although numbers were too small to show rates in all subgroups by age, VSD data indicated increased risk of myocarditis in the 7 days after receipt of dose 1 or dose 2 of an mRNA COVID-19 vaccine compared with the risk 22–42 days after the second dose, particularly among younger males after dose 2 (*5*).

To assess the benefit-risk balance of mRNA vaccines in adolescents and young adults, ACIP reviewed an individual-level assessment that compared the benefits (i.e., COVID-19 infections and severe disease prevented) to the risks (number of cases of myocarditis) of vaccination, using methods similar to those described previously.††† Specifically, the benefits per million second doses administered (i.e., the benefits of being fully vaccinated in accordance with the FDA EUA) were assessed, including 1) COVID-19 cases prevented based on rates the week of May 29, 2021§§§; 2) COVID-19 hospitalizations prevented based on rates the week of May 22, 2021¶¶¶; and 3) COVID-19 intensive care unit (ICU) admissions and deaths prevented based on the proportion of hospitalized patients who were admitted to the ICU or died.**** The risks were assessed as the number of myocarditis patients reported to VAERS that occurred within 7 days of receipt of a second dose of an mRNA COVID-19 vaccine per million second doses administered through the week of June 11, 2021.†††† The benefit-risk assessment was stratified by age group and sex. The analysis assumed 95% vaccine effectiveness§§§§ of 2 doses of a mRNA COVID-19 vaccine in preventing COVID-19 cases and hospitalization and assessed outcomes for a 120-day period. The 120-day period was selected because 1) no alternative vaccine options currently exist for persons aged <18 years or are expected to be available during this period, and 2) inputs regarding community transmission have high uncertainty beyond this period, particularly in the context of circulating variants.¶¶¶¶

The benefits (prevention of COVID-19 disease and associated hospitalizations, ICU admissions, and deaths) outweighed the risks (expected myocarditis cases after vaccination) in all populations for which vaccination has been recommended. However, the balance of benefits and risks varied by age and sex because cases of myocarditis were primarily identified among males aged <30 years, and the risks of poor outcomes related to COVID-19 increase with age. Per million second doses of mRNA COVID-19 vaccine administered to males aged 12–29 years, 11,000 COVID-19 cases, 560 hospitalizations, 138 ICU admissions, and six deaths due to COVID-19 could be prevented, compared with 39–47 expected myocarditis cases after COVID-19 vaccination (Table 2). Among males aged ≥30 years, 15,300 COVID-19 cases, 4,598 hospitalizations, 1,242 ICU admissions, and 700 deaths could be prevented, compared with three to four expected myocarditis cases after COVID-19 vaccination. This analysis did not include the potential benefit of preventing post-COVID-19 conditions, such as prolonged symptoms and MIS-C (*6*,*7*).

ACIP also reviewed population-level considerations regarding vaccination. No alternatives to mRNA COVID-19 vaccines for adolescents will be available for the foreseeable future, and vaccination of adolescents offers protection against COVID-19 that can be important for returning to educational, social, and extracurricular activities. Higher levels of vaccination coverage can reduce community transmission, which can protect against development and circulation of emerging variants. Regarding health equity considerations, racial and ethnic minority groups have higher rates of COVID-19 and severe disease*****; potential changes in vaccine policy, or anything that would affect vaccination coverage for adolescents or young adults, might disproportionately affect those groups with the highest rates of poor COVID-19 outcomes.

The ACIP discussion concluded that 1) the benefits of vaccinating all recommended age groups with mRNA COVID-19 vaccine clearly outweigh the risks of vaccination, including the risk of myocarditis after vaccination; 2) continuing to monitor

*** Data collection for race/ethnicity of myocarditis cases is ongoing.

††† https://www.cdc.gov/vaccines/covid-19/info-by-product/janssen/risk-benefit-analysis.html

§§§ https://covid.cdc.gov/covid-data-tracker/#demographicsovertime. Data were used for the most recent week not subject to reporting delays prior to the ACIP meeting.

¶¶¶ https://gis.cdc.gov/grasp/COVIDNet/COVID19_3.html. Data were used for the most recent week not subject to reporting delays prior to the ACIP meeting.

**** https://gis.cdc.gov/grasp/COVIDNet/COVID19_5.html

†††† Because of uncertainty in the accuracy of myocarditis reporting, given that reviews are ongoing, and some cases might not have been reported yet, myocarditis reporting rates are presented as a range of values, calculated as ±10% of the observed reporting rates.

§§§§ https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/fully-vaccinated-people.html

¶¶¶¶ https://covid.cdc.gov/covid-data-tracker/#variant-proportions

***** https://covid.cdc.gov/covid-data-tracker/#demographics

TABLE 2. Individual-level estimated number of COVID-19 cases and COVID-19–associated hospitalizations, intensive care unit admissions, and deaths prevented after use of 2-dose mRNA COVID-19 vaccine for 120 days and number of myocarditis cases expected per million second mRNA vaccine doses administered, by sex and age group* — United States, 2021

	No. per million vaccine doses administered in each age group (yrs)†				
Sex/Benefits and harms from mRNA vaccination	**12–29**	**12–17**	**18–24**	**25–29**	**≥30**
Male					
Benefit					
COVID-19 cases prevented§	11,000	5,700	12,100	15,200	15,300
Hospitalizations prevented	560	215	530	936	4,598
ICU admissions prevented	138	71	127	215	1,242
Deaths prevented	6	2	3	13	700
Harms					
Myocarditis cases expected¶	39–47	56–69	45–56	15–18	3–4
Female					
Benefit					
COVID-19 cases prevented§	12,500	8,500	14,300	14,700	14,900
Hospitalizations prevented	922	183	1,127	1,459	3,484
ICU admissions prevented	73	38	93	87	707
Deaths prevented	6	1	13	4	347
Harm					
Myocarditis cases expected¶	4–5	8–10	4–5	2	1

Abbreviations: ICU = intensive care unit; VAERS = Vaccine Adverse Event Reporting System.
* This analysis evaluated direct benefits and harms, per million second doses of mRNA COVID-19 vaccine given in each age group, over 120 days. The numbers of events per million persons aged 12–29 years are the averages of numbers per million persons aged 12–17 years, 18–24 years, and 25–29 years.
† Receipt of 2 doses of mRNA COVID-19 vaccine, compared with no vaccination.
§ Case numbers have been rounded to the nearest hundred.
¶ Ranges calculated as ±10% of crude VAERS reporting rates. Estimates include cases of myocarditis, pericarditis, and myopericarditis.

outcomes of myocarditis cases after COVID-19 vaccination is important; and 3) providers and the public should be informed about these myocarditis cases and the use of COVID-19 vaccines. Based on ACIP's conclusion regarding the benefit-risk assessment on June 23, 2021, COVID-19 vaccination continues to be recommended for all persons aged ≥12 years under the FDA's EUA. ACIP emphasized the importance of informing vaccination providers and the public about the benefits and the risks, including the risk for myocarditis after COVID-19 vaccination, particularly for males aged 12–29 years.

CDC has provided guidance regarding evaluation and management of myocarditis after mRNA COVID-19 vaccine (https://www.cdc.gov/vaccines/covid-19/clinical-considerations/myocarditis.html), as well as considerations for a second vaccine dose in persons who develop myocarditis after a first dose (https://www.cdc.gov/vaccines/covid-19/info-by-product/clinical-considerations.html). FDA has added information to the Pfizer-BioNTech††††† and Moderna§§§§§ COVID-19 vaccine EUA and fact sheets regarding myocarditis cases that have been reported among vaccine recipients. In addition, CDC has updated patient education and communication materials reflecting this information for the Pfizer-BioNTech¶¶¶¶¶ and Moderna****** COVID-19 vaccines; these are important to ensure that vaccine recipients, especially males aged 12–29 years, are aware of increased risk for myocarditis and to seek care if they develop symptoms of myocarditis. The vaccine product-specific EUA fact sheet should be provided to all vaccine recipients and their caregivers before vaccination with any authorized COVID-19 vaccine.

CDC and FDA will continue to closely monitor reports of myocarditis after receipt of the mRNA COVID-19 vaccines and will bring any additional data to ACIP for consideration. The benefit-risk analysis can be updated as needed to reflect changes in the COVID-19 pandemic and additional information on the risk for and outcomes of myocarditis after COVID-19 vaccination. The ACIP recommendation for use of mRNA COVID-19 vaccines under an EUA is interim and will be updated as additional information becomes available.

Reporting of Vaccine Adverse Events

FDA requires that vaccine providers report to VAERS vaccination administration errors, serious adverse events,†††††† cases of multisystem inflammatory syndrome, and cases of COVID-19 that result in hospitalization or death after

††††† https://www.fda.gov/media/144413/download
§§§§§ https://www.fda.gov/media/144637/download

¶¶¶¶¶ https://www.cdc.gov/vaccines/covid-19/info-by-product/pfizer/index.html
****** https://www.cdc.gov/vaccines/covid-19/info-by-product/moderna/index.html
†††††† https://vaers.hhs.gov/faq.html

administration of a COVID-19 vaccine under an EUA. CDC also encourages reporting of any additional clinically significant adverse event, even if it is not clear whether a vaccination caused the event. Information on how to submit a report to VAERS is available at https://vaers.hhs.gov/index.html or 1-800-822-7967. In addition, CDC has developed a voluntary smartphone-based online tool (v-safe) that uses text messaging and online surveys to provide near real-time health check-ins after receipt of a COVID-19 vaccine. In cases of v-safe reports that include possible medically attended health events, CDC's v-safe call center follows up with the vaccine recipient to collect additional information for completion of a VAERS report. Information on v-safe is available at https://www.cdc.gov/vsafe.

Summary

What is already known about this topic?

An elevated risk for myocarditis among mRNA COVID-19 vaccinees has been observed, particularly in males aged 12–29 years.

What is added by this report?

On June 23, 2021, the Advisory Committee on Immunization Practices concluded that the benefits of COVID-19 vaccination to individual persons and at the population level clearly outweighed the risks of myocarditis after vaccination.

What are the implications for public health practice?

Continued use of mRNA COVID-19 vaccines in all recommended age groups will prevent morbidity and mortality from COVID-19 that far exceed the number of cases of myocarditis expected. Information regarding the risk for myocarditis with mRNA COVID-19 vaccines should be disseminated to providers to share with vaccine recipients.

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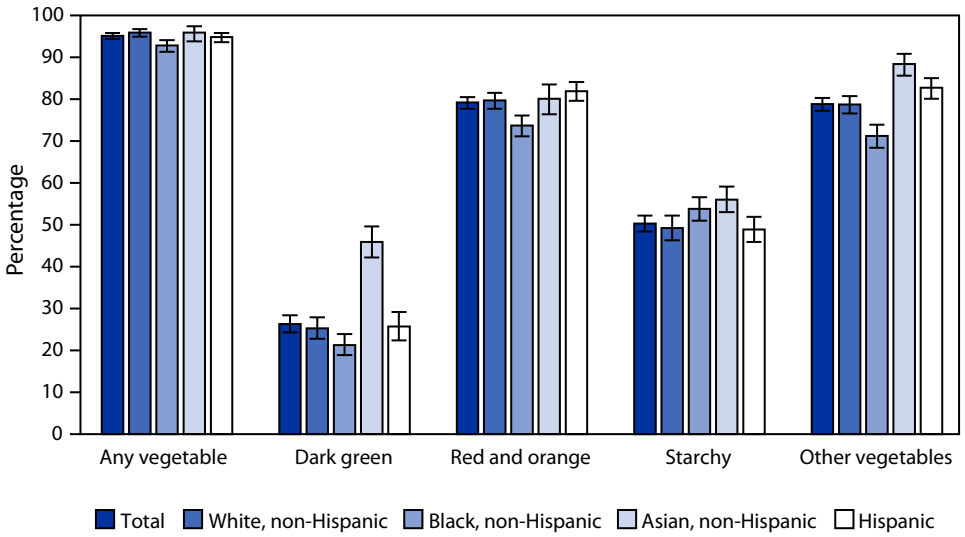
QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage*,† of Adults Aged ≥20 Years Who Consumed Vegetables on a Given Day, by Race and Hispanic Origin§ — United States, 2015–2018



* With 95% confidence intervals indicated with error bars.
† Percentages are based on vegetables reported during the Day 1 24-hour Dietary Recall. Vegetables were defined using the U.S. Department of Agriculture's Food Patterns Equivalents Database food groups (https://www.ars.usda.gov/ARSUserFiles/80400530/pdf/fped/FPED_1718.pdf), which include dark green vegetables (e.g., spinach, collard greens, and broccoli); red and orange vegetables (e.g., carrots, red peppers, and tomatoes); starchy vegetables (e.g., potatoes, plantains, and cassava); and other vegetables (e.g., cauliflower, string beans, and eggplant).
§ Estimates for persons reporting more than one race are not shown separately but are included in the total.

During 2015–2018, 95.1% of adults aged ≥20 years consumed any vegetable, 26.3% consumed dark green vegetables, 79.2% consumed red and orange vegetables, 50.3% consumed starchy vegetables, and 78.8% consumed other vegetables on a given day. Non-Hispanic Black adults were least likely to consume any vegetable (92.8%). Non-Hispanic Black adults were also least likely to consume dark green (21.3%), red and orange (73.7%), and other vegetables (71.2%), and non-Hispanic Asian adults were most likely to consume dark green (45.9%) and other vegetables (88.4%). Non-Hispanic Black (53.8%) and non-Hispanic Asian (56.0%) adults were more likely to consume starchy vegetables.

Sources: Ansai N, Wambogo EA. Fruit and vegetable consumption among adults in the United States, 2015–2018. National Center for Health Statistics (NCHS) data brief, no 397. https://www.cdc.gov/nchs/products/databriefs/db397.htm; NCHS, National Health and Nutrition Examination Survey (NHANES) data, NHANES 2017–2018. https://www.cdc.gov/nchs/nhanes.htm

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