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Predicted Heart Age Among Cancer Survivors — United States, 2013–2017

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Approximately 15.5 million cancer survivors were alive in the United States in 2016 with expected growth to 26.1 million by 2040 (*1*). Cancer survivors are living longer because of advances in early detection and treatment, but face psychosocial, cognitive, financial, and physical challenges (*1*,*2*). Physical challenges include cardiovascular complications, partly because cancer and cardiovascular disease (CVD) share some cumulative risk factors including tobacco use, physical inactivity, obesity, poor diet, hypertension, diabetes, and dyslipidemia (*3*). In addition, many cancer treatments damage the heart, and some cancer types increase risk for developing CVD (*4*). The recognition and management of heart disease in cancer survivors has given rise to the discipline of cardio-oncology, which focuses on the cardiovascular health of this population (*5*). CVD risk has been previously estimated using prediction models, and studies suggest that physician-patient communication using predicted heart age rather than predicted 10-year risk has led to a more accurate perception of excess heart age, encouraged actions to adopt a healthy lifestyle, and improved modifiable CVD risk factors (*6*,*7*). Using the nonlaboratory-based Framingham Risk Score (FRS) to estimate 10-year risk for developing CVD, predicted heart age is estimated from the 10-year risk of CVD (predicted by age, sex, diabetes status, smoking status, systolic blood pressure, hypertension treatment status, and body mass index); it is the age of an otherwise healthy person with the same predicted risk, with all other risk factors included in the prediction model at the normal level (systolic blood pressure of 125 mmHg, no hypertension treatment, body mass index of 22.5, nonsmoker, and nondiabetic) (*6*). Using data from the Behavioral Risk Factor Surveillance System (BRFSS), this study estimates predicted heart age, excess heart age (difference between predicted heart age and actual age), and racial/ethnic and sociodemographic disparities in predicted heart age among U.S. adult cancer survivors and noncancer participants aged 30–74 years using previously published methods (*7*). A total of 22,759 men and 46,294 women were cancer survivors with a mean age of 48.7 and 48.3 years, respectively. The predicted heart age and excess heart age among cancer survivors were 57.2 and 8.5 years, respectively, for men and 54.8 and 6.5 years, respectively, for women, and varied by age, race/ethnicity, education and income. The use of predicted heart age by physicians to encourage cancer survivors to improve modifiable risk factors and make heart healthy choices, such as tobacco cessation, regular physical activity, and a healthy diet to maintain a healthy weight, can engage survivors in informed cancer care planning after diagnosis.

Data were drawn from the BRFSS 2013, 2015, and 2017 survey cycles because CVD-specific modules are conducted in odd-numbered years. CDC pooled results for those years to produce stable estimates. The median combined response rate

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across states for each year was 45.9%, 47.2%, and 45.9%. The eligible sample included nonpregnant adults aged 30–74 years, who had no self-reported history of CVD, including coronary heart disease, myocardial infarction, and stroke. Among 1,362,270 BRFSS participants, the following were excluded: 337,836 participants outside the age range, 3,927 who were pregnant, 103,658 with self-reported CVD, and 70,453 with missing covariates for blood pressure prediction. Among the remaining 846,396 participants for the analysis, 69,053 (8.2%) were cancer survivors. Cancer survivors were defined as having answered "yes" to the question "(Ever told) you had any other type of cancer?" (i.e., excluding skin cancer) by a doctor, nurse, or health professional. Exclusions based on cancer type, which can be found in the cancer survivorship module (https://www.cdc.gov/brfss/questionnaires/pdf-ques/2017_BRFSS_Pub_Ques_508_tagged.pdf), were not made because the survey included that module for only 2017 and did not survey all states.

To account for the complex sampling design, CDC calculated estimates using weights and strata in SAS (version 9.4; SAS Institute) or SAS-callable SUDAAN (version 11.0; RTI International). Systolic blood pressure was calculated using a previously published method (*8*) with National Health and Nutrition Examination Survey 2011–2012, 2013–2014, and 2015–2016 cycles. Predicted heart age was capped with an upper limit of 100 years (*6*).

Age-adjusted weighted means, prevalences, and 95% confidence intervals were calculated for actual age, predicted heart age, and excess heart age. Prevalence of excess heart age of ≥5 years was calculated by age group, race/ethnicity, educational attainment, and annual household income stratified by sex and cancer-survivor status. Adjusted differences in predicted heart age for cancer-survivor versus noncancer status and racial/ethnic differences in predicted heart age for cancer survivors were calculated using multivariate linear regression. A t-test across all age groups was used to ascertain differences within categories, and pairwise t-tests were used for education, income, and race/ethnicity.

A total of 22,759 men and 46,294 women were cancer survivors, with mean ages of 48.7 and 48.3 years, respectively. The predicted heart age and excess heart age among cancer survivors were 57.2 and 8.5 years, respectively, for men and 54.8 and 6.5 years, respectively, for women. The prevalence of excess heart age ≥5 years was 52.4% for men and 43.6% for women. Among cancer survivors, groups with the highest average excess heart age were those in which persons were aged 60–74 years, were non-Hispanic Black, had less than a high school education, and had <$35,000 annual household income (excess heart age range = 11.6–14.9 years for men and 9.8–14.0 years for women). Prevalence of excess heart age ≥5 years was highest for those aged 60–74 years among both men and women; excess heart age ≥5 years was 3.0 percentage points higher for men and

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6.5 percentage points higher for women among cancer survivors than among noncancer participants (Table 1).

Among men, adjusted difference in excess heart age was higher among lower income cancer survivors and non-Hispanic Black cancer survivors than among noncancer participants. Among women, the adjusted difference in excess heart age decreased with age and was higher among lower education, lower income, non-Hispanic Black, and Hispanic cancer survivors than among noncancer participants (Table 2).

The difference in predicted heart age between Hispanic and non-Hispanic White cancer survivors was small and not statistically significant for most subgroups, as opposed to a much larger and mostly statistically significant difference between Hispanic and non-Hispanic Black survivors. In addition, disparities were larger among female cancer survivors than among male cancer survivors. The adjusted difference in excess heart age between non-Hispanic Black and non-Hispanic White female cancer survivors increased with age, education level, and income (Table 3). Disparities between non-Hispanic Black and non-Hispanic White persons were greater for women (7.4 years) than for men (4.3 years). The largest differences in excess heart age between non-Hispanic

TABLE 1. Age-adjusted and weighted mean actual age, predicted heart age, and excess heart age; and prevalence of excess heart age ≥5 years, by sex, age, race/ethnicity, education level, and annual household income among cancer survivors aged 30–74 years — Behavioral Risk Factor Surveillance System, United States, 2013, 2015, and 2017

Characteristic	No. of persons	Age, yrs (95% CI)			Prevalence of average excess heart age ≥5 yrs % (95% CI)
		Actual age	Predicted heart age	Average excess heart age	
Men					
Cancer status					
Cancer	22,759	48.7 (48.5–48.8)	57.2 (56.8–57.6)	8.5 (8.2–8.9)	52.4 (50.2–54.6)
No cancer	345,173	47.8 (47.8–47.8)	55.7 (55.7–55.8)	7.9 (7.9–8.0)	49.4 (49.1–49.7)
Age group, yrs					
30–39	632	35.0 (34.6–35.4)	37.9 (37.0–38.8)	2.9 (2.2–3.6)	27.4 (22.4–33.2)
40–49	1,289	44.9 (44.6–45.1)	52.5 (51.6–53.4)	7.6 (6.7–8.5)	51.6 (46.8–56.3)
50–59	4,400	55.1 (55.0–55.3)	66.6 (66.0–67.2)	11.5 (10.9–12.0)	66.1 (63.5–68.7)
60–74	16,438	67.2 (67.1–67.3)	82.1 (81.7–82.5)	14.9 (14.6–15.3)	75.3 (74.0–76.6)
Race/Ethnicity					
White, non-Hispanic	19,440	48.7 (48.5–48.8)	56.7 (56.3–57.2)	8.1 (7.7–8.5)	50.2 (47.8–52.7)
Black, non-Hispanic	1,553	48.7 (48.3–49.1)	60.9 (59.6–62.3)	12.3 (11.1–13.4)	70.4 (61.6–77.9)
Hispanic	700	48.6 (48.2–49.0)	56.9 (55.5–58.3)	8.3 (7.0–9.5)	51.2 (44.3–58.1)
Other	1,066	48.7 (48.2–49.2)	58.1 (56.8–59.5)	9.5 (8.1–10.8)	57.6 (49.1–65.7)
Education					
Less than HS	1,226	48.7 (47.9–49.4)	61.1 (59.1–63.0)	12.4 (10.9–14.0)	68.5 (58.2–77.2)
HS	5,657	48.6 (48.4–48.9)	58.7 (58.0–59.4)	10.1 (9.4–10.7)	60.9 (56.5–65.1)
More than HS	15,876	48.7 (48.5–48.9)	55.8 (55.4–56.3)	7.1 (6.7–7.5)	45.7 (43.2–48.3)
Annual household income ($)					
<35,000	5,922	48.6 (48.3–48.9)	60.2 (59.3–61.1)	11.6 (10.8–12.3)	65.7 (61.0–70.0)
≥35,000	14,355	48.7 (48.5–48.9)	55.8 (55.4–56.3)	7.1 (6.7–7.5)	46.2 (43.7–48.7)
Women					
Cancer status					
Cancer	46,294	48.3 (48.2–48.4)	54.8 (54.5–55.0)	6.5 (6.2–6.7)	43.6 (42.3–44.9)
No cancer	430,699	47.9 (47.9–47.9)	53.2 (53.1–53.2)	5.3 (5.2–5.3)	37.1 (36.8–37.4)
Age group, yrs					
30–39	2,522	34.5 (34.3–34.7)	36.0 (35.5–36.4)	1.5 (1.1–1.9)	24.0 (21.4–26.7)
40–49	4,726	44.8 (44.7–45.0)	49.4 (48.9–49.9)	4.6 (4.1–5.0)	40.4 (37.4–43.4)
50–59	11,408	54.6 (54.5–54.7)	63.5 (62.9–64.0)	8.9 (8.3–9.4)	51.4 (49.4–53.3)
60–74	27,638	66.8 (66.6–66.9)	80.7 (80.4–81.1)	14 (13.6–14.3)	68.5 (67.3–69.8)
Race/Ethnicity					
White, non-Hispanic	39,085	48.4 (48.3–48.4)	54.2 (53.9–54.4)	5.8 (5.6–6.1)	42.2 (40.9–43.5)
Black, non-Hispanic	2,977	48.5 (48.2–48.8)	60.6 (59.7–61.5)	12.1 (11.3–12.9)	62.6 (57.9–67.2)
Hispanic	1,786	48.0 (47.7–48.3)	54.7 (53.8–55.7)	6.8 (5.8–7.7)	39.4 (34.5–44.5)
Other	2,446	48.2 (47.9–48.5)	54.8 (53.5–56.1)	6.6 (5.4–7.8)	44.0 (38.7–49.5)
Highest education attained					
Less than HS	2,879	48.1 (47.9–48.4)	59.4 (58.6–60.2)	11.3 (10.5–12)	58.9 (54.6–63.1)
HS	12,163	48.2 (48.0–48.4)	56.2 (55.8–56.7)	8.0 (7.6–8.4)	50.1 (47.6–52.7)
More than HS	31,252	48.4 (48.3–48.5)	53.3 (53.0–53.6)	4.9 (4.6–5.2)	37.9 (36.4–39.3)
Annual household income ($)					
<35,000	16,219	48.2 (48.1–48.3)	58.0 (57.6–58.4)	9.8 (9.4–10.2)	56.1 (54.0–58.3)
≥35,000	23,609	48.4 (48.3–48.5)	52.5 (52.2–52.9)	4.1 (3.8–4.4)	34.2 (32.7–35.8)

Abbreviations: CI = confidence interval; HS = high school.

TABLE 2. Adjusted difference in excess heart age and 95% confidence intervals (CIs) comparing cancer versus noncancer group by sex, age, race/ethnicity, education level, and annual household income for adults aged 30–74 years—Behavioral Risk Factor Surveillance System, United States, 2013, 2015, and 2017

	Difference* in excess heart age, yrs (95% CI)	
Characteristic	**Men**	**Women**
Total[†]	0.7 (0.4 to 1.0)	0.6 (0.3 to 0.8)
Age group, yrs[§]		
30–39	−0.3 (−1.0 to 0.4)	1.5 (1.1 to 1.9)
40–49	1.6 (0.8 to 2.5)	1.3 (0.8 to 1.8)
50–59	0.8 (0.3 to 1.4)	0.6 (0.1 to 1.2)
60–74	0.6 (0.2 to 0.9)	0.1 (−0.3 to 0.4)
P-value[¶]	0.16	<0.001
Highest education attained[**,††]		
Less than HS	1.6 (0.4 to 2.7)	1.4 (0.5 to 2.3)
HS	0.8 (0.3 to 1.3)	0.4 (−0.1 to 0.8)
More than HS	0.5 (0.2 to 0.8)	0.5 (0.2 to 0.8)
Annual household income ($)[§§]		
<35,000	1.5 (0.9 to 2)	1.1 (0.7 to 1.5)
≥35,000	0.4 (0.1 to 0.7)	0.3 (−0.1 to 0.6)
P-value[¶¶]	<0.001	0.001
Race/Ethnicity[***,†††]		
White, non-Hispanic	0.4 (0.1 to 0.7)	0.2 (0.0 to 0.4)
Black, non-Hispanic	1.8 (0.9 to 2.7)	2.3 (1.3 to 3.3)
Hispanic	0.9 (−0.5 to 2.2)	1.2 (0.1 to 2.3)
Other, non-Hispanic	2.1 (0.6 to 3.6)	1.9 (0.4 to 3.4)

Abbreviation: HS = high school.

* Difference was calculated as excess heart age among noncancer participants subtracted from excess heart age among cancer survivors.

† Adjusted for age, education, and annual household income.

§ Adjusted for age, education, and annual household income, with an interaction term of age-by-cancer status to estimate cancer status difference in excess heart age by age group.

¶ P-value based on t-tests across the age group.

** Adjusted for age, education, and annual household income, with an interaction term of education-by-cancer status to estimate cancer status difference in excess heart age by education group.

†† Based on pairwise t-tests, the following comparisons were significantly different: less than high school versus high school (p = 0.25 for men; p = 0.04 for women); less than high school versus more than high school (p = 0.07 for men; p = 0.06 for women).

§§ Adjusted for age, education, and annual household income, with an interaction term of annual household income-by-cancer status to estimate cancer status difference in excess heart age by household income level.

¶¶ P-value based on pairwise t-tests.

*** Adjusted for age, education, and annual household income, with an interaction term of race/ethnicity-by-cancer status to estimate cancer status difference in excess heart age by race/ethnicity.

††† Based on pairwise t-tests, statistical significance was established as p<0.05. The p-values for each comparison were as follows: White, non-Hispanic versus Black, non-Hispanic (p = 0 for men; p = <0.001 for women); White, non-Hispanic versus Hispanic (p = 0.53 for men; p = 0.08 for women); White, non-Hispanic versus other (p = 0.03 for men and p = 0.02 for women); Black, non-Hispanic versus Hispanic: (p = 0.24 for men; p = 0.14 for women); Black, non-Hispanic versus other (p = 0.76 for men; p = 0.70 for women); Hispanic versus other: (p = 0.23 for men; p = 0.43 for women).

Black and non-Hispanic White women were among those aged 50–59 years (9.2 years) and 60–74 years (8.8 years). Excess heart age differences for each education level were greater for non-Hispanic Black women, with the largest difference occurring for the highest education level (more than high school). Among non-Hispanic Black and non-Hispanic White women with annual household income >$35,000, the difference in excess heart age was 2.4 years higher than that among those with lesser income. Overall, excess heart age is similar among Hispanic and non-Hispanic White cancer survivors, and higher for non-Hispanic Black survivors (Table 3).

Summary

What is already known about this topic?

Cancer and cardiovascular disease (CVD) share long-term risk factors. Physician-patient communication using heart age has been effective in motivating patients to improve modifiable CVD risk factors.

What is added by this report?

The predicted heart age and excess heart age among cancer survivors were 57.2 and 8.5 years, respectively, for men and 54.8 and 6.5 years, respectively, for women, and varied by age, race/ethnicity, education, and income. The prevalence of excess heart age ≥5 years was higher among men, cancer survivors with lower income and lower educational attainment, and non-Hispanic Black cancer survivors, particularly women.

What are the implications for public health practice?

Health care providers should counsel cancer survivors about ways to reduce modifiable shared risk factors such as tobacco use, physical inactivity, poor diet, hypertension, and obesity that contribute to excess heart age.

Discussion

In this study, both excess heart age and prevalence of excess heart age ≥5 years were higher among cancer survivors than among noncancer participants. Consistent with previous findings, the prevalence of excess heart age was larger among men than among women; however, racial disparities among women were larger than those among men (*7*).

This study also confirms previous findings that few adults meet ideal cardiovascular health metrics, such as not smoking, having normal body mass index, being physically active, eating a healthy diet, and having normal levels of total cholesterol and blood pressure, resulting in excess heart age ≥5 years (*9*). As cancer survivors live longer, more attention can be focused on modifiable risk factors that affect both cancer and CVD (*1*,*2*,*5*). In this study, the prevalence of excess heart age ≥5 years was higher among the following groups: men, cancer survivors with lower income and lower educational attainment, and non-Hispanic Black cancer survivors, particularly women. The findings indicate that wellness plans for all cancer survivors, and particularly the most affected groups, should include a focus on cardiovascular risk.

The findings in this report are subject to at least six limitations. First, BRFSS data are self-reported and thus are subject to recall and social desirability biases (*10*), which might underestimate predicted heart age in all persons. Second, the

TABLE 3. Adjusted difference in excess heart age and 95% confidence intervals (CIs) comparing different race/ethnicity groups, by sex, age, education level, and annual household income for cancer survivors aged 30–74 years—Behavioral Risk Factor Surveillance System, United States, 2013, 2015, and 2017.

	Difference in excess heart age, yrs (95% CI)					
	Men			Women		
Characteristic	Black, non-Hispanic versus White, non-Hispanic	Hispanic versus White, non-Hispanic	Black, non-Hispanic versus Hispanic	Black, non-Hispanic versus White, non-Hispanic	Hispanic versus White, non-Hispanic	Black, non-Hispanic versus Hispanic
Total*	4.3 (3.4 to 5.2)	−0.7 (−2.1 to 0.6)	5.0 (3.4 to 6.6)	7.4 (6.5 to 8.4)	−0.7 (−1.8 to 0.4)	8.2 (6.7 to 9.6)
Age group, yrs†						
30–39	2.5 (−0.3 to 5.2)	−0.7 (−2.9 to 1.5)	3.1 (−0.2 to 6.5)	0.7 (−0.9 to 2.2)	−3.5 (−4.6 to 2.5)	4.2 (2.5 to 5.9)
40–49	2.6 (0.4 to 4.8)	−1.7 (−4.4 to 1)	4.3 (1.1 to 7.5)	4.0 (2.2 to 5.7)	−2.3 (−4.1 to 0.4)	6.2 (3.8 to 8.7)
50–59	3.8 (2.0 to 5.7)	−0.4 (−2.7 to 1.9)	4.3 (1.5 to 7.0)	9.2 (7.0 to 11.5)	−0.1 (−2.7 to 2.4)	9.4 (6.0 to 12.7)
60–74	4.8 (3.6 to 6.0)	−0.7 (−3.0 to 1.6)	5.5 (2.9 to 8.0)	8.8 (7.6 to 10.0)	0.8 (−1.3 to 3.0)	8.0 (5.5 to 10.4)
P-value§	0.09	0.81	0.31	<0.001	<0.001	<0.001
Highest education attained¶,**						
Less than HS	2.4 (−0.2 to 5.0)	−3.1 (−6.3 to 0.1)	5.5 (1.9 to 9.1)	4.6 (2.1 to 7.1)	−2.6 (−4.8 to 0.3)	7.2 (4.1 to 10.3)
HS	4.2 (2.5 to 5.8)	−1.4 (−3.8 to 1)	5.6 (2.7 to 8.4)	6.3 (4.7 to 7.9)	−1.5 (−3.2 to 0.1)	7.8 (5.6 to 10.0)
More than HS	4.9 (3.6 to 6.1)	1.0 (−0.8 to 2.9)	3.9 (1.7 to 6.1)	8.6 (7.3 to 10.0)	0.8 (−0.8 to 2.4)	7.8 (5.8 to 9.9)
Annual household income ($)††						
<35, 000	4.1 (2.7 to 5.5)	−0.5 (−2.7 to 1.8)	4.6 (2.1 to 7.1)	6.2 (4.6 to 7.8)	−1.6 (−3 to 0.2)	7.8 (5.8 to 9.8)
≥35,000	4.7 (3.5 to 5.9)	−0.8 (−2.7 to 1.1)	5.5 (3.3 to 7.7)	8.6 (7.3 to 9.9)	0.3 (−1.6 to 2.3)	8.3 (6.0 to 10.5)
P-value	0.55	0.81	0.59	0.02	0.11	0.76

Abbreviation: HS = high school.
* Adjusted for age, education, and annual household income.
† Adjusted for age, education, annual household income, with an interaction term of age-by-race/ethnicity to estimate racial difference in excess heart age by age group.
§ P-value based on t-tests across the age group.
¶ Adjusted for age, education, annual household income, with an interaction term of education-by-race/ethnicity to estimate racial difference in excess heart age by education groups.
** Based on pairwise t-tests, statistical significance was established as p<0.05. The p-values for each comparison were as follows: less than high school versus high school (p = 0.26 for Black, non-Hispanic men versus White, non-Hispanic men; p = 0.40 for Hispanic men versus White, non-Hispanic men; p = 0.98 for Black, non-Hispanic men versus Hispanic men; p = 0.26 for Black, non-Hispanic women versus White, non-Hispanic women; p = 0.46 for Hispanic women versus White, non-Hispanic women; p = 0.74 for Black, non-Hispanic women versus Hispanic women); less than high school versus more than high school (p = 0.09 for Black, non-Hispanic men versus White, non-Hispanic men; p = 0.03 for Hispanic men versus White, non-Hispanic men; p = 0.44 for Black, non-Hispanic men versus Hispanic men; p = 0.01 for Black, non-Hispanic women versus White, non-Hispanic women; p = 0.02 for Hispanic women versus White, non-Hispanic women; p = 0.73 for Black, non-Hispanic women versus Hispanic women).
†† Adjusted for age, education, annual household income, with an interaction term of annual household income-by-race/ethnicity to estimate racial difference in excess heart age by household income level.

predicted heart age calculation used model-estimated systolic blood pressure rather than measured systolic blood pressure, which might introduce bias in predicted heart age estimates (*7*). Third, the nonlaboratory-based FRS used in the study might overestimate predicted heart age compared with the laboratory-based FRS (*7*). Fourth, several lifestyle choices such as sodium consumption, physical activity, and diet are not included in the FRS heart age calculation (*7*). Physical activity and diet are specifically linked to both heart disease and cancer, and their exclusion is likely to cause underestimates of predicted heart age in cancer survivors. Fifth, specific risks for some cancer survivors such as cardiotoxic treatment are not considered in the model and are likely to result in further underestimates. Finally, the definition of cancer in this study was nonspecific and could result in misclassification of some study participants.

Adult cancer survivors aged 30–74 years had higher predicted heart age than did noncancer participants, and the degree of excess heart age varied by racial/ethnic and sociodemographic groups. Cancer survivors are living longer and are more likely to experience long-term side effects from therapy that require treatment from multiple types of physicians (*5*). The management of cardiovascular complications and involvement of cardiologists in the integrated approach of cardio-oncology is becoming more important given the steady increase in cancer survival, and the literature suggests the use of a low threshold for referral to a cardio-oncologist or cardiologist (*4*,*5*). The use of predicted heart age by physicians to encourage cancer survivors to improve modifiable risk factors and make heart-healthy choices, such as tobacco cessation, regular physical activity, and a healthy diet to maintain a healthy weight, can engage survivors in informed cancer care planning after diagnosis. In addition, physicians can consider additional components and complications of cancer survivorship, such as mental, social, and financial issues, when formulating a survivorship plan. Cancer survivors might experience numerous macro-level challenges and barriers, which can be included in future analyses to determine potential effect on heart age. By determining and communicating predicted heart age of cancer survivors at a personal level, cancer care teams can provide education to prevent long-term cardiovascular complications and improve quality of life and heart outcomes for cancer survivors.

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Time from Start of Quarantine to SARS-CoV-2 Positive Test Among Quarantined College and University Athletes — 17 States, June–October 2020

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To safely resume sports, college and university athletic programs and regional athletic conferences created plans to mitigate transmission of SARS-CoV-2, the virus that causes coronavirus disease 2019 (COVID-19). Mitigation measures included physical distancing, universal masking, and maximizing outdoor activity during training; routine testing; 10-day isolation of persons with COVID-19; and 14-day quarantine of athletes identified as close contacts* of persons with confirmed COVID-19. Regional athletic conferences created testing and quarantine policies based on National Collegiate Athletic Association (NCAA) guidance (*1*); testing policies varied by conference, school, and sport. To improve compliance with quarantine and reduce the personal and economic burden of quarantine adherence, the quarantine period has been reduced in several countries from 14 days to as few as 5 days with testing (*2*) or 10 days without testing (*3*). Data on quarantined athletes participating in NCAA sports were used to characterize COVID-19 exposures and assess the amount of time between quarantine start and first positive SARS-CoV-2 test result. Despite the potential risk for transmission from frequent, close contact associated with athletic activities (*4*), more athletes reported exposure to COVID-19 at social gatherings (40.7%) and from roommates (31.7%) than they did from exposures associated with athletic activities (12.7%). Among 1,830 quarantined athletes, 458 (25%) received positive reverse transcription–polymerase chain reaction (RT-PCR) test results during the 14-day quarantine, with a mean of 3.8 days from quarantine start (range = 0–14 days) until the positive test result. Among athletes who had not received a positive test result by quarantine day 5, the probability of having a positive test result decreased from 27% after day 5 to <5% after day 10. These findings support new guidance from CDC (*5*) in which different options are provided to shorten quarantine for persons such as collegiate athletes, especially if doing so will increase compliance, balancing the reduced duration of quarantine against a small but nonzero risk for postquarantine transmission. Improved adherence to mitigation measures (e.g., universal masking, physical distancing, and hand hygiene) at all times could further reduce exposures to SARS-CoV-2 and disruptions to athletic activities because of infections and quarantine (*1*,*6*).

CDC partnered with representatives of the NCAA conferences to analyze retrospective data collected by participating colleges and universities. A request for participation was sent to all NCAA members regardless of whether athletics programs had resumed. Colleges and universities were provided with a data dictionary to standardize data collection (Supplementary Table, https://stacks.cdc.gov/view/cdc/99431). Deidentified, individual-level retrospective testing and exposure data from quarantined, SARS-CoV-2–exposed collegiate athletes across the United States were provided to CDC for analysis. Information on the types of exposure was collected by athletic staff members or public health professionals and categorized as sports settings (e.g., game, practice, team workouts, scrimmage, shared equipment, or team travel), roommate, social gatherings (e.g., party, shared car, or friends), unspecified or other (e.g., class, meetings, work, or travel unrelated to sports). Data cleaning and analyses were conducted in duplicate using SAS (version 9.4; SAS Institute) and R (version 3.6.3; The R Foundation). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.†

For this analysis, athletes were excluded if they 1) had not received testing using RT-PCR during their 14-day quarantine period; 2) had received a positive SARS-CoV-2 RT-PCR test result before starting quarantine; 3) were still under quarantine and had not had positive test results at the time of data submission (October 27–November 17); or 4) were missing data on quarantine start date, test date, test type (i.e., antigen or RT-PCR), or RT-PCR test result (positive, negative, or indeterminate). For all athletes who received a positive SARS-CoV-2 RT-PCR test result during quarantine, time-to-event analyses were conducted by separately calculating the interval from the exposure date or the quarantine start date to the positive specimen collection date. Quarantined athlete data were excluded from time-to-event analyses if the exposure date or the quarantine start date was missing or if the athlete had positive test results >14 days after commencing quarantine. Kaplan-Meier survival analysis estimated the probability and 95% confidence intervals (CIs) of athletes receiving a first positive SARS-CoV-2 RT-PCR test result after days 5, 7, and 10 of quarantine.

* Close contact is defined as being <6 feet apart for >15 minutes with an infected person.

† 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.

Twenty-four colleges and universities contributed data on 2,257 quarantined athletes, irrespective of test result; data from 427 athletes were excluded based on the described exclusion criteria. Among the remaining 1,830 quarantined athletes, the most common sports played were football (46.2%, 846), track and field or cross-country (10.4%, 190), and soccer (6.6%, 121) (Table). The most commonly reported exposures were at social gatherings (40.7%, 745) or from roommates (31.7%, 580); overall, 232 (12.7%) quarantined athletes reported exposure associated with athletic activities. Athletes received a total of 3,345 RT-PCR tests (mean = 1.8 per athlete, range = 1–14) while in quarantine. A total of 458 (25.0%) quarantined athletes ever received a positive test result, including 137 (29.9%) who never reported symptoms. Among 386 quarantined athletes who became symptomatic, 321 (83.2%) ever received a positive test result.

Three colleges and universities contributed data only on quarantined athletes who received positive test results during quarantine (193); after exclusion of 31 who did not meet inclusion criteria, 162 athletes remained. Therefore, a total of 620 athletes with positive SARS-CoV-2 test results during quarantine were included in a time-to-event analysis. Among 436 (73.4%) of these athletes with available exposure date, quarantine commenced a mean of 1.1 days after reported exposure (range = 0–11 days). Among these athletes, 302 (48.7%) reported symptoms before collection of the specimen that returned positive; the mean interval from symptom onset to positive specimen collection date was 1.1 days (range = 0–12 days). Among the 620 athletes with positive test results, the positive test results occurred by day 2 of quarantine for 303 (48. 9%) (Figure 1) and by day 5 for 453 (73.1%) with a mean of 3.8 days from quarantine start (range 0–14 days) until the positive test (Supplementary Figure, https://stacks.cdc.gov/view/cdc/99765). Among all SARS-CoV-2 RT-PCR tests administered, the positivity rate decreased over the quarantine period (Figure 2). The median interval between the start of quarantine and collection of a positive specimen was 2 days (range = 0–14 days). Among those whose test results remained negative at day 5, the estimated probability of having a positive test result was 26.9% (95% CI = 23.7–30.7) after day 5, 14.2% (95% CI = 11.7–17.2) after day 7, and 4.7% (95% CI = 3.3–6.7) after day 10. Among the 29 athletes who received positive test results during days 11–14, 26 (89.7%) had not been tested previously during their quarantine period.

TABLE. Sports played, symptoms, and exposure type among quarantined college and university athletes with COVID-19 exposure — 17 states, June–October 2020

Sport, symptom, and type of exposure	RT-PCR test results, no. (%)		
	Total	Positive	Negative
Total athletes*	**1,830 (100.0)**	**458 (100.0)**	**1,372 (100.0)**
Sport played			
Football	846 (46.2)	249 (54.4)	597 (43.5)
Track and field/Cross country	190 (10.4)	23 (5.0)	167 (12.2)
Soccer	121 (6.6)	24 (5.2)	97 (7.1)
Basketball	116 (6.3)	23 (5.0)	93 (6.8)
Volleyball	107 (5.9)	25 (5.5)	82 (6.0)
Swimming and diving	78 (4.3)	31 (6.8)	47 (3.4)
Baseball	72 (3.9)	8 (1.8)	64 (4.7)
Wrestling	60 (3.3)	18 (3.9)	42 (3.1)
Golf	46 (2.5)	7 (1.5)	39 (2.8)
Gymnastics	44 (2.4)	7 (1.5)	37 (2.7)
Softball	37 (2.0)	5 (1.1)	32 (2.3)
Lacrosse	26 (1.4)	13 (2.8)	13 (1.0)
Tennis	21 (1.2)	10 (2.2)	11 (0.8)
Rowing	19 (1.0)	5 (1.1)	14 (1.0)
Multiple sports†	6 (0.3)	1 (0.2)	5 (0.4)
Other§	41 (2.2)	9 (2.0)	32 (2.3)
Symptoms consistent with COVID-19¶			
No	1,444 (78.9)	137 (29.9)	1,307 (95.3)
Yes	386 (21.1)	321 (70.1)	65 (4.7)
Type of exposure			
Sports setting	232 (12.7)	54 (11.8)	178 (13.0)
Roommates	580 (31.7)	134 (29.3)	446 (32.5)
Social gatherings	745 (40.7)	195 (42.6)	550 (40.1)
Multiple exposure types**	64 (3.5)	16 (3.5)	48 (3.5)
Other††	61 (3.3)	20 (4.4)	41 (3.0)
Unspecified exposure	148 (8.1)	39 (8.5)	109 (7.9)

Abbreviations: COVID-19 = coronavirus disease 2019; RT-PCR = reverse transcription–polymerase chain reaction.

* Three colleges or universities provided data sets that only included athletes who had positive test results during quarantine. The athletes in these data sets (193) were not included in this analysis.

† Six athletes indicated playing multiple sports; one of these athletes had a positive test result and participated in football and gymnastics; the others did not have positive test results and participated in football and wrestling (two), wrestling and track (one), golf and wrestling (one), and football and volleyball (one).

§ Sports with fewer than 10 athletes each (beach volleyball, cheer, dance, equestrian, rifle, skiing, and water polo) were included in the "other" category.

¶ Shortness of breath or difficulty breathing; cough or other respiratory symptoms; headache; chills; muscle aches; sore throat; congestion or runny nose; new loss of taste or smell; nausea, vomiting or diarrhea; pain, redness, swelling or rash on toes or fingers; new rash or other skin symptoms, temperature of ≥100.4°F (38°C).

** Sixty-four athletes reported more than one type of exposure.

†† Class, meetings, shared airplane, travel not related to sports, unsanctioned workouts, or work.

Discussion

A positive SARS-CoV-2 test result was received by one quarter of quarantined athletes during June–October 2020. Once an athlete entered quarantine, the probability of a positive test result among those who had no previous positive test result decreased from 27% after day 5 to <5% after day 10. New shortened quarantine options (after day 10 without testing or after day 7 with negative test result) were based on decreasing transmission risk over the duration of quarantine (*5*). Findings from this investigation support shortened quarantine options for collegiate athletes, given the low proportion of athletes who had positive test results after day 10.

Multiple, concurrent mitigation measures can effectively lower the risk for SARS-CoV-2 transmission (*7*). The majority

FIGURE 1. Cumulative percentage of SARS-CoV-2 reverse transcription–polymerase chain reaction positive test results among quarantined collegiate athletes who ever had a positive result, by day since start of quarantine — 17 states, June–October 2020

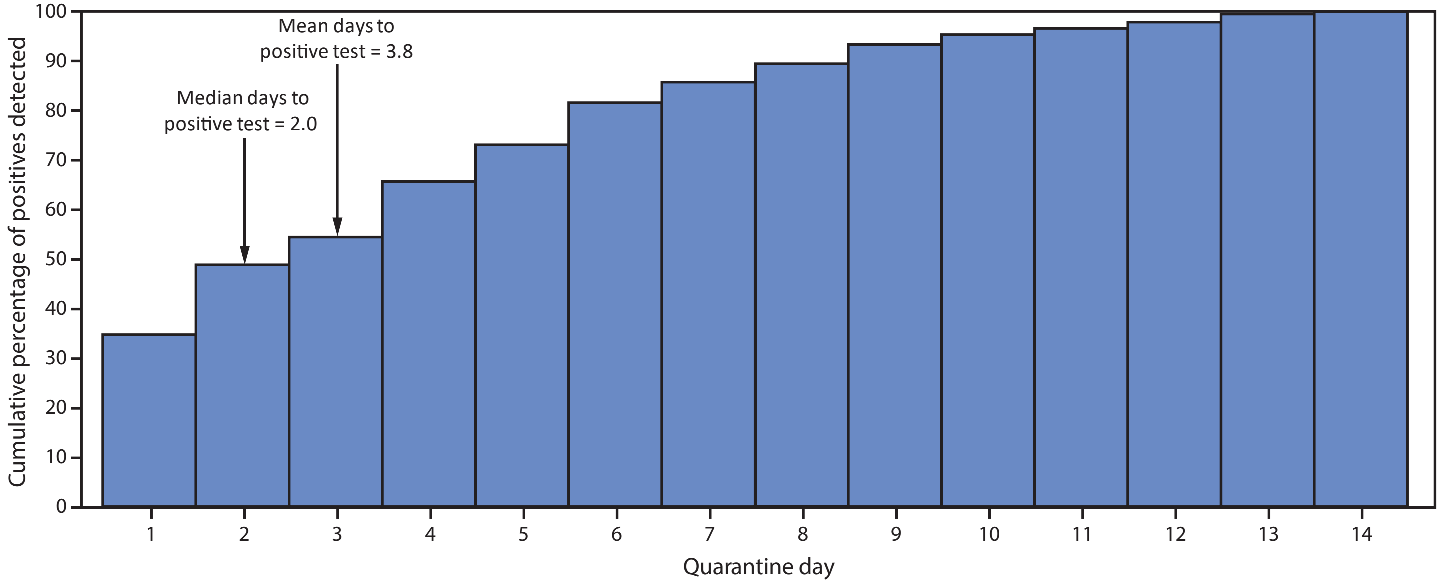
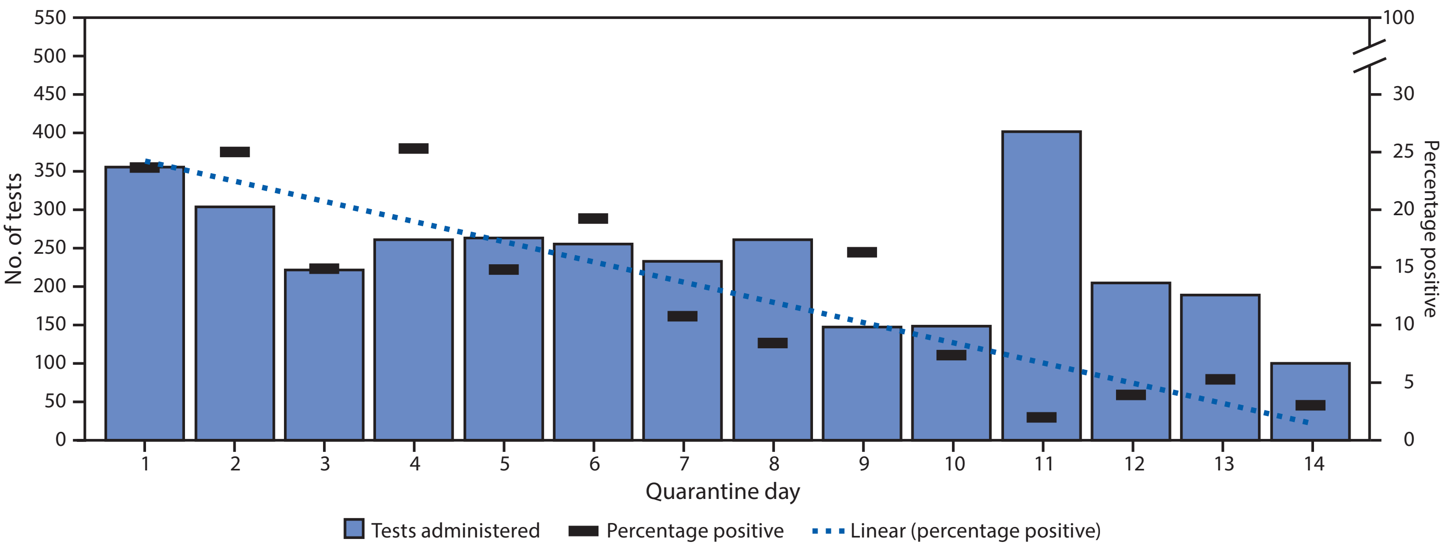


FIGURE 2. Number of SARS-CoV-2 reverse transcription–polymerase chain reaction tests performed and percentage positive* among quarantined collegiate athletes, by quarantine day — 17 states, June–October 2020



* With line of best fit for percentage positive over time.

of exposures among these athletes occurred at social gatherings and from roommates, indicating that the implementation of targeted mitigation measures helped minimize exposures associated with athletic activities. These findings underscore the need for adherence to mitigation measures (e.g., universal masking, physical distancing, and hand hygiene) at all times to reduce the risk for transmission of SARS-CoV-2 (*1*,*6*). In this cohort of collegiate athletes, fewer than one half who ultimately had a positive test result had symptoms consistent with COVID-19 before collection of the positive specimen. This finding is consistent with recent reports of asymptomatic screening programs in general university campus populations, where 51% of students with positive test results were asymptomatic (*8*). In this study, 86% of quarantined athletes who ever had positive test results did so by day 7, which is consistent with a reported median incubation period of 4.3–6.4 days (*9*,*10*).

The findings in this report are subject to at least five limitations. First, almost all athletes who had a positive specimen collected after quarantine day 10 had not been tested previously during quarantine. It is possible that those athletes might have had positive test results before day 10. Second, time-to-event analyses used quarantine start date rather than exposure date because more data were missing on exposure date than on quarantine start date; also, using exposure date was subject to validation errors. Therefore, using the quarantine start date rather than exposure date likely resulted in conservative estimates of the probability of receiving positive test results in quarantine. Third, adherence with quarantine was not assessed, and quarantined athletes possibly had additional exposures leading to infection during the 14-day quarantine. This might explain positive specimens collected after day 10 and could have overestimated the probability of a positive test result after day 10. Fourth, the data relied on self-reported exposure type. Although data were validated by case investigation and contact tracing efforts, 8.1% of athletes reported unspecified exposures, and 3.5% reported multiple exposures. Finally, this study was undertaken in a population of young, healthy athletes undergoing frequent testing. The findings might not be generalizable to other settings and populations.

Data from this report support CDC's guidance on quarantine options shorter than 14 days, with the caveat that a small residual increased risk for transmission remains with a shortened quarantine period. Persons released from quarantine before 14 days should continue daily symptom monitoring, avoid close contact and wear masks when around others. Adherence to quarantine is a known challenge (*5*) and reducing the duration of quarantine might improve adherence at a population level. Transmission of SARS-CoV-2 can be reduced through a multipronged application of evidence-based mitigation strategies (*7*), including within large congregate and crowded settings found at colleges and universities. Adherence to mitigation measures during athletic and nonathletic activities is important to protect collegiate athletes from SARS-CoV-2, lessen disruptions in play because of quarantine and isolation protocols, and reduce transmission to others in the community.

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Summary

What is already known about this topic?

Quarantine after SARS-CoV-2 exposure is critical to preventing transmission. A 14-day quarantine can prevent further transmission but might be challenging to maintain.

What is added by this report?

Among collegiate athletes exposed to COVID-19, one quarter had positive test results during quarantine. Among athletes who had not received a positive test result by day 5, the probability of testing positive decreased from 27% after day 5 to <5% after day 10.

What are the implications for public health practice?

Among young, healthy athletes, the probability of receiving positive test results after day 10 of quarantine is low. A shorter quarantine after COVID-19 exposure could increase adherence but still poses a small residual risk for transmission.

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Assessment of Day-7 Postexposure Testing of Asymptomatic Contacts of COVID-19 Patients to Evaluate Early Release from Quarantine — Vermont, May–November 2020

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On May 8, 2020, the Vermont Department of Health (VDH) issued a Health Update* recommending shortening the duration of quarantine for persons exposed to SARS-CoV-2, the virus that causes coronavirus disease 2019 (COVID-19). Exposed persons who were in quarantine could be tested by polymerase chain reaction (PCR) on or after quarantine day 7. Those who had remained asymptomatic throughout quarantine and who received a negative SARS-CoV-2 PCR test result on or after day 7 could end quarantine. This policy was based on a report suggesting that symptom onset occurs within this time frame in approximately three quarters of COVID-19 cases (*1*) and on consultation of the Vermont Health Commissioner with the U.S. Surgeon General. VDH implemented this policy to minimize restrictions on state residents, recognizing that some reduction could occur in the prevention benefit of quarantine to contain the spread of SARS-CoV-2. State-run SARS-CoV-2 testing sites were made available to increase access to no-cost testing and facilitate implementation of this policy. During August 1–December 1, among persons seeking testing at a VDH SARS-CoV-2 testing site, 36% stated that their reason for seeking testing was to end quarantine early (VDH, unpublished data, December 7, 2020), indicating that persons were aware of and following the policy and using the testing services provided. To assess the effectiveness of this policy, VDH analyzed testing data for contacts of persons with a COVID-19 diagnosis. During May 8–November 16, VDH identified 8,798 exposed contacts of COVID-19 patients; 3,983 (45%) had sought testing within 14 days of their exposure, with day 0 defined as the date of last exposure noted in the case investigation record. Among these persons, 2,200 (55%) who received testing on days 7–10 were included in this analysis; 977 (44.9%) of these contacts had a specimen collected for testing on day 7. Among these, 34 (3%) had test results that were positive, 940 (96%) had results that were negative, and three (<1%) had results that were indeterminate (Table). Among the 34 contacts who received a positive SARS-CoV-2 PCR test result on day 7 after exposure, 12 (35%) were asymptomatic. The remaining 22 contacts with positive test results were symptomatic at the time of testing; approximately one half had developed symptoms on days 4–7 after exposure. Among the 940 contacts who received negative test results on specimens collected on day 7 after exposure, 154 (16%) had a subsequent test within the next 7 days (i.e., days 8–14); among these, 152 (99%) had tests that remained negative, and two (1%) had results that were indeterminate.

* https://www.healthvermont.gov/sites/default/files/documents/pdf/HAN-COVID-19-ChangetoQuarantine.pdf.

TABLE. Polymerase chain reaction (PCR) testing results among persons tested for SARS-CoV-2 during quarantine,* by quarantine day — Vermont, May 8, 2020–November 16, 2020

	No. (%) of test results	
PCR test result	Quarantine day 7	Quarantine day 8–10
All contacts tested days 7–10	977 (100)	1,223 (100)
Positive	34 (3)	53 (4)
Negative	940 (96)	1,159 (95)
Indeterminate	3 (<1)	11 (1)
Contacts who retested after negative or indeterminate results†	154 (15.7)	108 (8.8)
Positive§	0 (—)	0 (—)
Negative§	152 (99)	107 (99)
Indeterminate§	2 (1)	1 (1)

* The quarantine period begins with the date of last exposure to a person with a positive test result for SARS-CoV-2.
† Percentage of all persons tested.
§ Percentage of persons retested.

In addition to the 977 persons who received testing on day 7 after exposure, 1,223 (55.1% of all contacts tested on days 7–10 postexposure) had a specimen collected for SARS-CoV-2 PCR testing on day 8, 9, or 10. Among those persons, 53 (4%) had test results that were positive, 1,159 (95%) had results that were negative, and 11 (1%) had results that were indeterminate. Among the 53 contacts who received a positive SARS-CoV-2 PCR result on specimens collected days 8–10 after exposure, 12 (23%) were asymptomatic (mean time since symptom onset = 6 days). Among the 1,170 contacts who received a negative or indeterminate test result on specimens collected on days 8–10 after exposure, 108 (9%) had a subsequent specimen tested; 107 (99%) remained negative, and one (1%) had a result that was indeterminate. Therefore, among all 2,200 contacts tested on days 7–10 after exposure, 87 (4%) persons had a positive test result, 24 (28%) of whom were asymptomatic.

The findings in this report are subject to at least three limitations. First, this analysis was conducted on a convenience sample that included only positive test results received electronically or by fax and negative test results received electronically. Negative test results that were received by fax were not entered into the surveillance system and so are not included in this analysis. Second, the limited demographic data on contacts of patients could hamper the matching of a contact with a laboratory result; thus, the number of contacts tested might be underreported. Although persons who were retested remained negative (1% indeterminate), they represented only 16% of the total number of persons who discontinued quarantine. Finally, asymptomatic status during quarantine until the time of testing for persons testing negative could not be verified.

These results indicate that among the persons in quarantine who tested negative at day 7 after exposure, none who were retested between day 8 and 14 were positive. Allowing asymptomatic persons to shorten quarantine with a negative test at day 7 or later has not been demonstrated to result in transmission of SARS-CoV-2, indicating that the policy has been effective. These results also indicate that 3.9% of contacts tested on days 7–10 after exposure were infected with SARS-CoV-2. In addition to reducing the duration of quarantine for exposed contacts, Vermont's policy might have provided additional benefits to the state's pandemic response by identifying some asymptomatic patients earlier in the course of their illness through enhancing statewide surveillance testing of an exposed group. This assessment supports Vermont's policy as being effective and offers data to support recommendations to shorten quarantine with testing such as those provided in CDC's updated quarantine guidance.[†]

[†] https://wwwdev.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-options-to-reduce-quarantine.html.

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Opening of Large Institutions of Higher Education and County-Level COVID-19 Incidence — United States, July 6–September 17, 2020

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During early August 2020, county-level incidence of coronavirus disease 2019 (COVID-19) generally decreased across the United States, compared with incidence earlier in the summer (*1*); however, among young adults aged 18–22 years, incidence increased (*2*). Increases in incidence among adults aged ≥60 years, who might be more susceptible to severe COVID-19–related illness, have followed increases in younger adults (aged 20–39 years) by an average of 8.7 days (*3*). Institutions of higher education (colleges and universities) have been identified as settings where incidence among young adults increased during August (*4*,*5*). Understanding the extent to which these settings have affected county-level COVID-19 incidence can inform ongoing college and university operations and future planning. To evaluate the effect of large colleges or universities and school instructional format* (remote or in-person) on COVID-19 incidence, start dates and instructional formats for the fall 2020 semester were identified for all not-for-profit large U.S. colleges and universities (≥20,000 total enrolled students). Among counties with large colleges and universities (university counties) included in the analysis, remote-instruction university counties (22) experienced a 17.9% decline in mean COVID-19 incidence during the 21 days before through 21 days after the start of classes (from 17.9 to 14.7 cases per 100,000), and in-person instruction university counties (79) experienced a 56.2% increase in COVID-19 incidence, from 15.3 to 23.9 cases per 100,000. Counties without large colleges and universities (nonuniversity counties) (3,009) experienced a 5.9% decline in COVID-19 incidence, from 15.3 to 14.4 cases per 100,000. Similar findings were observed for percentage of positive test results and hotspot status (i.e., increasing among in-person–instruction university counties). In-person instruction at colleges and universities was associated with increased county-level COVID-19 incidence and percentage test positivity. Implementation of increased mitigation efforts at colleges and universities could minimize on-campus COVID-19 transmission.

The National Center for Educational Statistics' Integrated Postsecondary Education Data System (*6*) was used to identify not-for-profit baccalaureate degree–granting colleges and universities enrolling ≥20,000 full-time and part-time students. Colleges and universities that enrolled <20,000 students or were considered for-profit were excluded. Fall class start dates and instructional formats on the first day of scheduled classes were abstracted from college and university websites during early September 2020. Counties with large colleges and universities were assigned the start date and instructional format of the school. If a county contained multiple large colleges or universities with different start dates, the earliest start date and corresponding instructional format was assigned. If a county contained multiple large schools with the same start date but different instructional formats, then in-person instruction was assigned. Among 133 counties with large colleges and universities (university counties),† the 101 (76%) in which classes started from July 27 to August 28 were included in the analysis (i.e., 32 were excluded because they included institutions that started on or after August 29 and had insufficient data for the 21 days after the start of classes at the time of analysis). County-level mean estimates of COVID-19 incidence,§ testing rates, percentage test positivity,¶ and hotspot status** were compared for university counties with remote-instruction, in-person–instruction, and nonuniversity counties during the 21 days before and after the start of classes.

* Instructional format was assigned based on the advertised method of instruction for the first day of fall 2020 classes. "Remote" format was defined as an instructional format that appeared to minimize in-person classwork on campus. This definition did allow in-person instruction for a very select number of students, including those in laboratory courses, studio courses, or courses for small groups of students with specific instructional needs. In contrast, the "in-person" format was defined for all other colleges and universities that were not considered remote, which included any instructional format that did not appear to minimize in-person classwork on campus. "Hybrid" instructional formats that had reduced, but reoccurring, in-class experiences for many college and university courses (i.e., beyond laboratory and studio courses) were considered "in-person" for this study. The assignment of instructional format was based on the advertised method of instruction and was not based on the college or university policy toward on-campus housing; therefore colleges and universities with remote instruction could have allowed students to stay in on-campus housing.

† A total of 149 large colleges and universities were identified across 133 counties.

§ Incidence was calculated using COVID-19 case counts from state and county health department websites compiled by USAFacts (https://usafacts.org/).

¶ County-level testing rates and rates of percentage positivity represent viral COVID-19 laboratory diagnostic and screening test (RT-PCR) results and exclude antibody and antigen tests. COVID-19 Electronic Laboratory Reporting state health department-reported data are used to describe county-level RT-PCR result totals when information is available on patients' county of residence or health care providers' practice location. HHS Protect laboratory data (provided directly to the federal government from public health laboratories, hospital laboratories, and commercial laboratories) are used otherwise. Total RT-PCR tests reflect the number of tests performed, not the number of persons receiving testing. RT-PCR test positivity rate is the number of positive tests divided by the total number of tests performed and for which results were available.

For all analyses, mean county population size, full-time student enrollment size, urban-rural classifications (large central metro, large fringe metro, medium metro, small metro, micropolitan, and noncore), and COVID-19 outcomes are reported and stratified by county university status and instructional format. The COVID-19 outcomes included incidence and testing rates per 100,000 population, test positivity by SARS-CoV-2 reverse transcription–polymerase chain reaction (RT-PCR) testing, and the percentage of counties identified as hotspots for ≥1 day during the observation periods. COVID-19 outcomes were reported as means for the 21 days before and after the class start date. Absolute differences (i.e., percentage point differences) are described for percentage-based measures (test positivity and hotspot detection) and relative changes described for rate-based measures (testing rate and incidence). Seven-day moving averages for testing rates, percentage test positivity, and incidence are presented as trends over the observation period (day –21 to day +21). In an unmatched analysis, remote-instruction and in-person instruction university counties were compared with nonuniversity counties. Nonuniversity counties were assigned the median start date of university counties. In the matched analysis, in-person–instruction university counties were matched with nonuniversity counties based on geographic proximity and population size. This analysis of 68 matched pairs was conducted to account for differences in population size, urbanicity, and geographic location between university and nonuniversity counties.[††] Nonuniversity counties in the matched sample were assigned the start date of their matched university-county counterpart. In the matched analysis, a regression-based difference-in-difference approach[§§] was used to quantify the impact of in-person instruction on COVID-19 incidence, with and without adjustment for transient student populations,[¶¶] and percentage test positivity. A sensitivity analysis was conducted to explore whether students' early return to campus might affect observed changes using day –7 as the demarcation between before and after periods. Statistical significance was set at $\alpha = 0.05$. Analyses were conducted using R statistical software (version 4.0.2; The R Foundation).

Among 101 university counties (3.2% of all U.S. counties, accounting for 29.4% of the U.S. population), instructional format was remote for 22 (22%) and in-person for 79 (78%). University counties had higher mean population size and were more urban than were nonuniversity counties (Table). Before the start of school, COVID-19 testing rates at the county-level were already higher in university counties than in nonuniversity counties (Figure). Comparing the time from the start of classes through day 21 with the 21 days before classes began, mean daily testing increased 4.2% and 14.1% among remote instruction and in-person instruction university counties, respectively, and decreased 1.0% among nonuniversity counties. Mean test positivity decreased among remote-instruction university counties (absolute change = –1.8%) and nonuniversity counties (–0.6%) but increased among in-person instruction university counties (1.1%). Incidence decreased in nonuniversity counties (–5.9%) and remote-instruction counties (–17.9%), whereas, incidence increased in in-person (56.2%) university counties. The percentage of counties identified at least once as a hotspot

[**] Hotspot , or rapid riser, counties met all four of the following criteria, relative to the date assessed: 1) >100 new COVID-19 cases in the most recent 7 days; 2) an increase in the most recent 7-day COVID-19 incidence over the preceding 7-day incidence; 3) a decrease of no more than 60% or an increase in the most recent 3-day COVID-19 incidence over the preceding 3-day incidence; and 4) a ratio of 7-day incidence to 30-day incidence exceeding 0.31. In addition, hotspots must have met at least one of the following criteria: 1) >60% change in the most recent 3-day COVID-19 incidence or 2) >60% change in the most recent 7-day incidence. CDC and other federal agencies that are monitoring trends in COVID-19 are collaborating to refine approaches to define and monitor hotspots. As a result, terminology or definitions used in future reports might differ from those used in this report.

[††] Matches for each in-person university county were identified by listing all candidate (county) matches without large colleges or universities that had a similar population size (± 30%) and that were located within 500 miles (805 km) of each university county. From these candidate matches, the final match was selected based on closest proximity such that no nonuniversity county was matched more than once. After matching, the average distance between counties in matched in-person university county and nonuniversity county pairs was 114 miles (183 km) with a maximum distance of 471 miles (758 km). Eleven in-person university counties were excluded from the matched analysis because there were no candidate matches meeting population size and proximity specifications. All remote university counties were excluded from the matched analysis because there were an insufficient number of nonuniversity county matches.

[§§] Difference-in-difference is a statistical technique that compares the changes in outcomes over time between two groups: those who are part of a control group and those who are part of a treatment or an intervention group. In this analysis, the intervention group was considered to be the counties with colleges and universities that had in-person instruction and the control group was considered to be nonuniversity counties. Difference-in-difference estimates used a regression model with the following specification: $Y_{ct} = \alpha + \beta_1 \cdot \text{In Person}_{ct} + \beta_2 \cdot \text{After}_{ct} + \delta_{IP} \cdot \text{After}_{ct} \cdot \text{In person}_{ct} + \theta_c + \theta_s + \theta_{week} + \theta_{weekday} + \varepsilon_{ct}$, where Y_{ct} is the outcome of interest (i.e., either COVID-19 incidence or percentage test positivity) for each county *c* and each unit of time *t* (days); In Person_{ct} is an indicator equal to 1 if the county has a college or university that started classes in an in-person format; After_{ct} is an indicator equal to 1 for all the days after the county's assigned start date (i.e., an indicator equal to 1 for days 0 to 21, where day 0 is the start date); θ_c and θ_s are county- and state-level fixed effects; θ_{week} and $\theta_{weekday}$ are fixed effects for each calendar week and each weekday; and ε_{ct} is the unobserved error term. The coefficient of interest is δ_{IP}, which captures the difference in outcome before and after the start date among in-person university counties, minus the difference in outcome before and after the assigned start date in nonuniversity counties. Standard errors were clustered at the county level. A placebo test was conducted where the college or university start date used day –21 as the demarcation of before and after periods, and no violation of the parallel trends assumption was found.

[¶¶] Because transient student populations might not be included in the population denominator for county incidence estimates, incidence is assessed two ways in the difference-in-difference models: first using county population reported by the U.S. census, then adjusting for student influx by adding full-time student enrollment to each college or university's county population for the period after classes start. The full-time student population was used for this adjustment instead of the total student population, which includes full-time and part-time students.

TABLE. COVID-19 testing, percentage positivity, incidence, and county hotspot status among counties with and without colleges and universities,* by instructional format on the first day of the fall 2020 semester — United States, 2020

Characteristic	Unmatched analysis			Matched analysis†	
	University counties§			University counties	
	Remote instruction	In-person instruction	Nonuniversity counties	In-person instruction	Nonuniversity counties
Total no. of counties	**22**	**79**	**3,009**	**68**	**68**
Mean county population	1,694,739	748,544	69,574	467,187	413,460
Total no. of large colleges/universities	31	84	—	71	—
Mean college/university full-time enrollment in county§	37,769	27,451	—	27,084	—
Mean percentage full-time college/university enrollment of total county population	7.7	11.7	—	13.3	—
Percentage of counties in each urban-rural category¶					
Large central metro	59	27	1	16	9
Large fringe metro	9	13	12	13	32
Medium metro	18	28	11	32	28
Small metro	5	25	11	29	18
Micropolitan	9	8	21	9	9
Noncore	0	0	44	0	4
County COVID-19 testing rate per 100,000 population**					
Mean daily rate from day –21 to day –1††	308	255	209	256	216
Mean daily rate from day 0 to day 21	321	291	207	304	204
Relative change, %§§	4.2	14.1	–1.0	18.8	–5.6
County COVID-19 RT-PCR test percentage positivity**					
Mean from day –21 to day –1	8.1	7.8	8.7	7.5	8.6
Mean from day 0 to day 21	6.4	8.9	8.0	9.1	7.9
Absolute change, %§§	–1.8	1.1	–0.6	1.6	–0.8
County COVID-19 incidence¶¶					
Mean incidence from day –21 to day –1	17.9	15.3	15.3	14.3	16.9
Mean incidence from day 0 to day 21	14.7	23.9	14.4	25.5	13.6
Relative change, %§§	–17.9	56.2	–5.9	78.3	–19.5
County COVID-19 hotspot activity ***					
Percentage detected as a hotspot from day –21 to day –1	9.1	8.9	4.4	8.8	13.2
Percentage detected as a hotspot from day 0 to day 21	18.2	39.2	5.9	42.6	14.7
Absolute change, %§§	9.1	30.4	1.5	33.8	1.5

Abbreviations: COVID-19 = coronavirus disease 2019; RT-PCR = reverse transcription–polymerase chain reaction.

* 133 counties had institutions of higher education (large colleges or universities). Some counties (n = 32; 24%) opened on or after August 29 and were excluded from analysis. University counties are defined as counties with a large college or university. Nonuniversity counties are defined as counties without a large college or university.

† University counties matched to geographically proximate comparison counties with similar population size. Matches for each university county were identified by first listing all candidate (county) matches without large colleges and universities (nonuniversity counties) that had a similar population size (± 30%) and that were located within 500 miles (805 km) of each university county. From these candidate matches the final match was selected based on closest proximity. After matching, the average distance between counties in matched university county and nonuniversity county pairs was 114 miles (183 km) with a maximum distance of 471 miles (758 km).

§ Colleges and universities were included in the analysis if they had ≥20,000 total enrolled students, which included full-time and part-time students. The full-time student enrollments from these included institutions were combined across each university county. The number of full-time student enrollments in the university counties ranged from 11,774 to 192,173.

¶ Urban-rural classifications are from the National Center for Health Statistics' six-level urban-rural classification scheme for U.S. counties (https://www.cdc.gov/nchs/data_access/urban_rural.htm).

** Testing rates and percentage positivity for reverse transcription–polymerase chain reaction tests were obtained from COVID-19 electronic laboratory reporting data submitted by state health departments and from data submitted directly by public health, commercial, and reference laboratories.

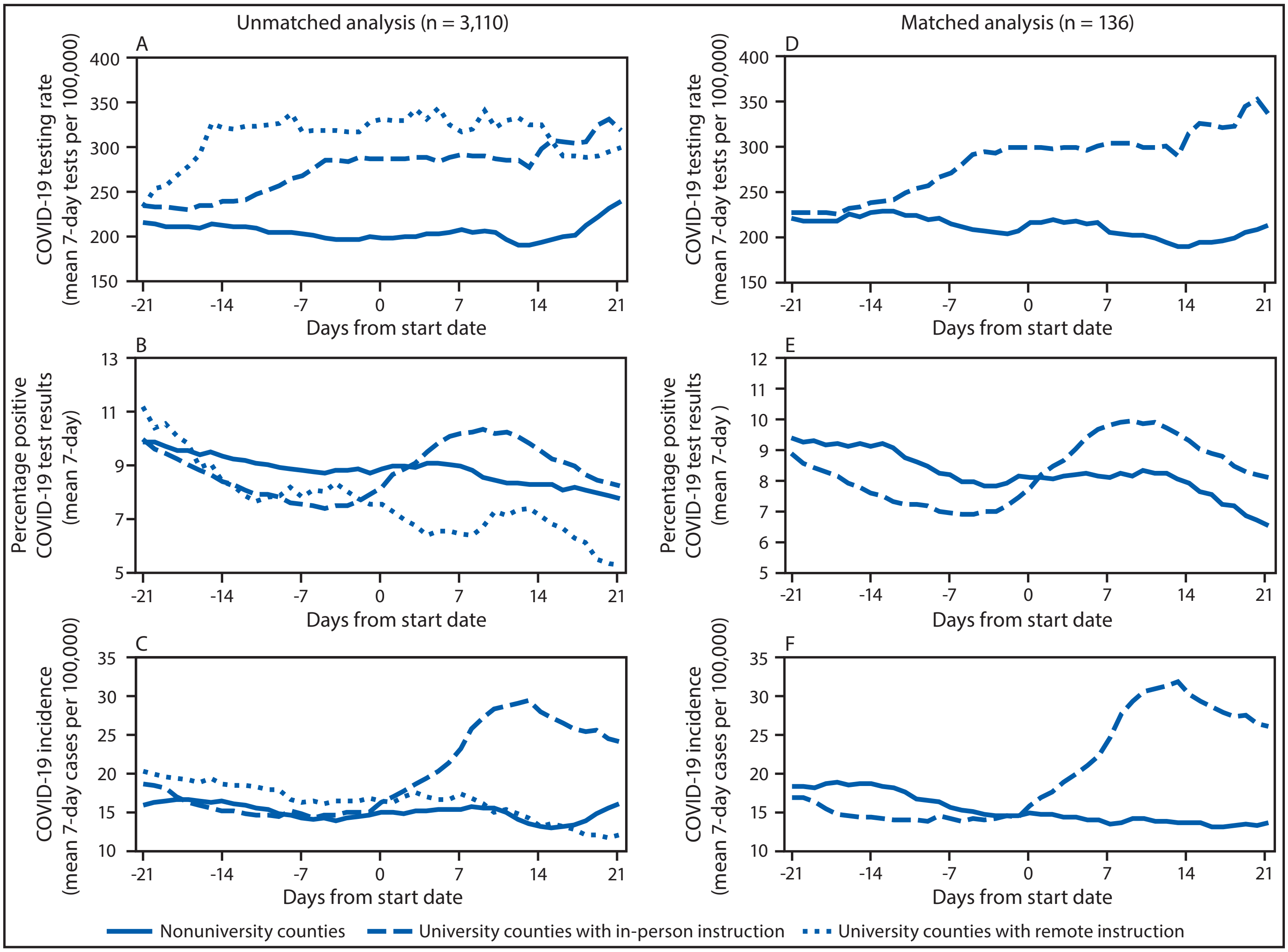
†† Day –21, –1, and 21 are relative to day 0, which indicates the start date of instruction at colleges and universities for the fall 2020 semester. The nonuniversity counties were assigned the median start date in the unmatched analysis and were assigned the start date of their matched university county counterpart in the matched analysis.

§§ Absolute differences are described for percentage-based measures (i.e., test positivity and hotspot detection) and relative changes described for rate-based measures (i.e., testing rate and incidence).

¶¶ Incidence (cases per 100,000) was calculated using daily reported COVID-19 case-counts from state and county health department websites compiled by USAFacts (https://usafacts.org/).

*** Hotspot, or rapid riser, counties met all four of the following criteria, relative to the date assessed: 1) >100 new COVID-19 cases in the most recent 7 days; 2) an increase in the most recent 7-day COVID-19 incidence over the preceding 7-day incidence; 3) a decrease of no more than 60% or an increase in the most recent 3-day COVID-19 incidence over the preceding 3-day incidence; and 4) a ratio of 7-day incidence to 30-day incidence exceeding 0.31. In addition to those four criteria, hotspots met at least one of the following criteria: 1) >60% change in the most recent 3-day COVID-19 incidence or 2) >60% change in the most recent 7-day incidence.

FIGURE. Trends* in COVID-19 testing rates (A, D), percentage test positivity (B, E), and incidence (C, F) for unmatched U.S. counties† and counties matched§ based on population size and geographic proximity, 7-day moving average — United States, 2020



Abbreviation: COVID-19 = coronavirus disease 2019.

* Trends are presented relative to the start date for fall 2020 classes for counties with large colleges and universities (university counties) and the assigned start date for nonuniversity counties.

† University counties with remote (n = 22) and in-person (n = 79) instruction versus nonuniversity (n = 3,009) counties.

§ University counties with in-person instruction versus nonuniversity counties (68 matched pairs). Matches for each in-person university county were identified by listing all candidate (county) matches without large colleges or universities that had a similar population size (± 30%) and that were located within 500 miles (805 km) of each university county. From these candidate matches, the final match was selected based on closest proximity such that no nonuniversity county was matched more than once. After matching, the average distance between counties in matched in-person university county and nonuniversity county pairs was 114 miles (183 km) with a maximum distance of 471 miles (758 km). Eleven in-person university counties were excluded from the matched analysis because there were no candidate matches meeting population size and proximity specifications. All remote university counties were excluded from the matched analysis because there was an insufficient number of nonuniversity county matches.

increased for all three groups, with the highest percentage observed in in-person instruction university counties (30.4% absolute increase), followed by remote-instruction university counties (9.1%) and nonuniversity counties (1.5%).

COVID-19 outcomes were similar in the matched analysis. Compared with nonuniversity counties, in-person instruction university counties experienced a higher relative change in testing rates (18.8% versus –5.6%), a higher absolute change in test positivity (1.6% versus –0.8%), a higher relative change in incidence (78.3% versus –19.5%) (Table) (Figure), and a higher absolute change in the percentage identified as hotspots (33.8% versus 1.5%). Based on the difference-in-difference analysis, university counties with in-person instruction were associated with an increase of 14.4 cases per 100,000 ($p<0.05$) and an increase of 2.4 percent test positivity ($p<0.05$) relative to nonuniversity counties with in-person instruction. When adjusting incidence for the influx of full-time students, in-person instruction university counties were associated with an increase of 10.6 cases per 100,000 ($p<0.05$) (Supplementary Table, https://stacks.cdc.gov/view/cdc/99533). These results did not change meaningfully in the sensitivity analysis.

Discussion

County-level COVID-19 incidence decreased in much of the United States in late summer 2020. Comparing the 21 days before and after instruction start dates, university counties with in-person instruction experienced a 56% increase in incidence and 30% increase in hotspot occurrence as well as increases in COVID-19-related testing and test percentage positivity. Results from the unmatched analysis were consistent with those from the matched analysis. If percentage positivity had been stable or declining across the observation period, then efforts on the part of many colleges and universities to conduct or require testing before students' return to campus and their ongoing surveillance efforts might explain an increase in case counts, as a result of increased case discovery. However, the concurrent increases in percentage positivity and in incidence in these counties suggest that higher levels of transmission, in addition to increased case discovery, occurred in these communities (*2*).

The findings in this report are subject to at least six limitations. First, data abstraction for schools' instructional formats was conducted in early September and focused on identifying the format used on the first day of classes; some misclassification of instructional format might have occurred because of changes during the first few weeks of instruction. Second, this study did not adjust for mitigation strategies (e.g., mask and social distancing requirements and limits on large crowds and athletic events) implemented at local or state levels or at colleges and universities, which could have affected the association between the institution's opening and county-level incidence. Similarly, whether cases in university counties were college- or university-related (i.e., through contact in classrooms, dormitories, cafeterias, or off-campus activities) or related to community transmission could not be discerned. Third, these results might not be generalizable to counties with smaller colleges and universities. Fourth, U.S. Census 2019 population estimates were used to calculate rates, which do not include all college and university enrollments. County-level rate calculations could be inflated for university counties, especially those for which the enrollment numbers are relatively large compared with the county's population size. Fifth, the longer-term implications for county incidence (i.e., beyond 21 days) were not assessed. Finally, the university counties in the unmatched analysis have larger populations and likely additional characteristics that are different from those of nonuniversity counties. This limitation prompted the decision to conduct the matched analysis, which focused on counties with more similar population levels and geographic proximity. However, broader generalizations based on the matched analysis might not be warranted because 11 university counties with in-person instruction were excluded from the matched analysis because no appropriate matches were available.

COVID-19 incidence, hotspot occurrence, COVID-19-related testing, and test positivity increased in university counties with in-person instruction. Efforts to prevent and mitigate COVID-19 transmission are critical for U.S. colleges and universities. Congregate living settings at colleges and universities were linked to transmissions (*7*). Testing students for COVID-19 when they return to campus and throughout the semester might be an effective strategy to rapidly identify and isolate new cases to interrupt and reduce further transmissions (*8*). Colleges and universities should work to achieve greater adherence to the recommended use of masks, hand hygiene, social distancing, and COVID-19 surveillance among students (*9*), including those who are exposed, symptomatic, and asymptomatic. The increase in testing rates likely reflects local efforts already underway to improve COVID-19 surveillance and response. Increasing testing capacity and engaging in other COVID-19 mitigation strategies might be especially important for colleges and universities in areas where transmission from students into the broader community could exacerbate existing disparities, including access to and utilization of health care, as well as the disproportionate morbidity and mortality of COVID-19 among populations with prevalent underlying conditions associated with more severe outcomes following infection. Some university counties might have one or more concerning factors, such as higher levels of older adult populations, high rates of obesity and cardiovascular disease,

Summary

What is already known about this topic?

Increasing COVID-19 incidence was observed among young adults in August 2020, and outbreaks have been reported at institutions of higher education (colleges and universities).

What is added by this report?

U.S. counties with large colleges or universities with remote instruction (n = 22) experienced a 17.9% decrease in incidence and university counties with in-person instruction (n = 79) experienced a 56% increase in incidence, comparing the 21-day periods before and after classes started. Counties without large colleges or universities (n = 3,009) experienced a 6% decrease in incidence during similar time frames.

What are the implications for public health practice?

Additional implementation of effective mitigation activities at colleges and universities with in-person instruction could minimize on-campus COVID-19 transmission and reduce county-level incidence.

or strained health care resources. These counties might need to consider the implications of in-person instruction on spread of COVID-19 among a student population that might have interactions with persons at higher risk in the community. College and university administrators should work with local decision-makers and public health officials to strengthen community mitigation, in addition to continuing efforts to slow the spread of COVID-19 on college and university campuses.

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Participation in Fraternity and Sorority Activities and the Spread of COVID-19 Among Residential University Communities — Arkansas, August 21–September 5, 2020

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Preventing transmission of SARS-CoV-2, the virus that causes coronavirus disease 2019 (COVID-19), in colleges and universities requires mitigation strategies that address on- and off-campus congregate living settings as well as extracurricular activities and other social gatherings (*1*–*4*). At the start of the academic year, sorority and fraternity organizations host a series of recruitment activities known as rush week; rush week culminates with bid day, when selections are announced. At university A in Arkansas, sorority rush week (for women) was held during August 17–22, 2020, and consisted of on- and off-campus social gatherings, including an outdoor bid day event on August 22. Fraternity rush week (for men) occurred during August 27–31, with bid day scheduled for September 5. During August 22–September 5, university A–associated COVID-19 cases were reported to the Arkansas Department of Health (ADH). A total of 965 confirmed and probable COVID-19 cases associated with university A were identified, with symptom onset occurring during August 20–September 5, 2020; 31% of the patients with these cases reported involvement in any fraternity or sorority activity. Network analysis identified 54 gatherings among all linkages of cases to places of residence and cases to events, 49 (91%) were linked by participation in fraternity and sorority activities accounting for 42 (72%) links among gatherings. On September 4, university A banned gatherings of ≥10 persons, and fraternity bid day was held virtually. The rapid increase in COVID-19 cases was likely facilitated by on- and off-campus congregate living settings and activities, and health departments should work together with student organizations and university leadership to ensure compliance with mitigation measures.

University A began the academic year on August 24, offering in-class and virtual instruction for approximately 20,000 students; a majority of students used virtual instruction. Before and during the start of the academic year, students might have participated in on- and off-campus fraternity or sorority activities. Cases were identified by the university during an ADH-sponsored testing event (September 1–3) or linked to the university by ADH. Case data were reported to ADH by clinic staff members at university A and stored in an electronic database (REDCap, version 8.8.0; Vanderbilt University). Using a standardized questionnaire, ADH nurses interviewed persons with university-associated COVID-19 to ascertain demographic characteristics, date of symptom onset, university status, class attendance type (in-class or virtual), place of residence, and involvement in community- and school-related activities during the 14 days preceding illness onset. Illness onset was defined as the earliest date of reported symptoms for symptomatic cases* or as date of specimen collection for asymptomatic cases (ADH followed up with cases that had testing and diagnosis before symptom onset to identify date of symptom onset). Initial case reviews by ADH identified patients who reported recent participation in sorority or fraternity activities; subsequent infections were observed among cohabitants of these persons.

A network analysis was performed to assess the relationship between participation in university fraternity or sorority activities and the spread of COVID-19 among residential communities at university A. MicrobeTrace, a network analysis and visualization tool developed by CDC,† was used to visualize and describe the full network of persons with COVID-19 and identify potential transmission-related gatherings (network analysis terminology would refer to these as "communities"), defined as one or more gatherings in which multiple cases are identified and epidemiologically linked. COVID-19 patients were included in the network if they lived on campus, participated in fraternity or sorority activities, or lived in the same off-campus dwelling as a person who participated in these activities. Case-to-residence and case-to-event networks were constructed to map residential university A transmission-related gatherings. These networks were used to infer gatherings by algorithmically partitioning the network into the most densely linked cases (nodes) (*5*,*6*). In this network analysis method, the algorithm randomly assigns nodes a "community" identifier, and community connectivity is measured. For each person in the network, community identifiers are swapped with their neighbors and then remeasured. Only changes in community affiliation that improve connectivity are preserved, reversing any swaps that do not improve connectivity. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.§

* ADH followed up with cases that had testing and diagnosis before symptom onset to identify the actual date of symptom onset.

† https://www.biorxiv.org/content/10.1101/2020.07.22.216275v1.

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

During August 22–September 5, a total of 965 university-associated COVID-19 cases with illness onset on or after August 20 were identified, including 699 (72%) confirmed cases (with positive reverse transcription–polymerase chain reaction test results) and 266 (28%) probable cases (with positive results for SARS-CoV-2 antigen test, performed at the university clinic). A 3-day, ADH-sponsored testing event, held during September 1–3 in response to an increase in university-associated cases detected by ADH, resulted in a 22% test positivity rate and identified 324 cases; overall, 34% of cases were identified through this testing event. Among the 965 confirmed and probable cases with illness onset dates during August 20–September 5, 673 (70%) occurred in women and 936 (97%) were in persons aged 18–24 years (Table). Five cases (<1%) in persons identified as faculty or staff members were reported. The number of cases with reported illness onset on a given day increased and peaked on August 31 (Figure 1). Forty-eight (5%) persons with COVID-19 had received in-class instruction, 292 (31%) participated in fraternity or sorority activities, and 149 (15%) lived in a fraternity or sorority house.

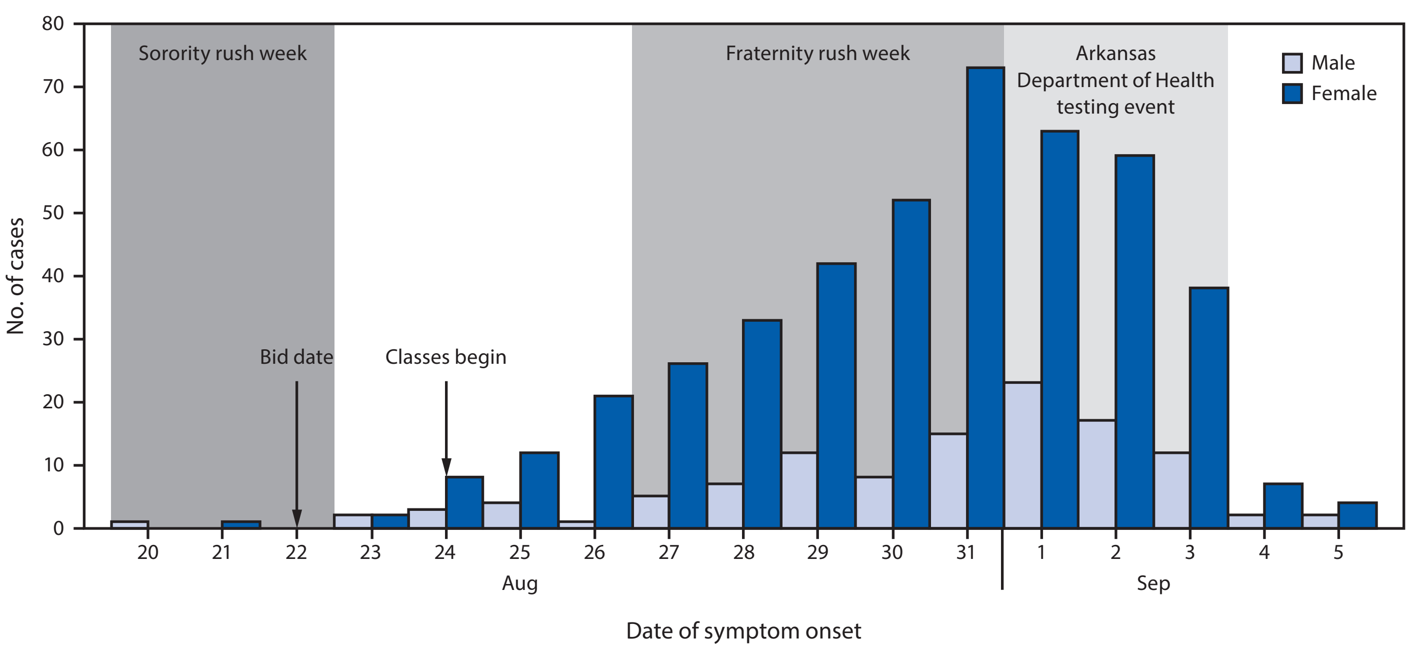
The network analysis linked 565 (59%) cases to 56 residences (16 dormitories, 20 apartments and houses, and 20 fraternity or sorority houses) and to their case-to-event associations (Figure 2). The full network consisted of one large, linked cluster of 471 (83%) cases (86% in women and 14% in men) and eight smaller, unlinked gatherings of 94 total cases (49%

TABLE. Characteristics of COVID-19 cases associated with university A — Arkansas, August 20–September 5, 2020

Characteristic	No. (%) of cases
Total	**965 (100)**
Sex	
Women	673 (70)
Men	234 (24)
Unknown	58 (6)
University status	
Student	761 (79)
Faculty/Staff member	5 (0.5)
Other/Unknown	199 (21)
Age group, yrs	
0–17	7 (1)
18–24	936 (97)
25–44	18 (2)
45–64	2 (0.2)
≥65	0 (—)
Unknown	2 (0.2)
Fraternity/Sorority activity participation	
Any	292 (31)
None	497 (52)
Unknown	176 (18)
Class attendance type	
In-class instruction only	48 (5)
Virtual instruction only	453 (47)
Mixed (in-class and virtual)	228 (24)
Unknown	236 (24)
Housing type	
On-campus (dormitory)	199 (21)
Off-campus apartment/house	499 (52)
Off-campus fraternity/sorority	149 (15)
Unknown	118 (12)

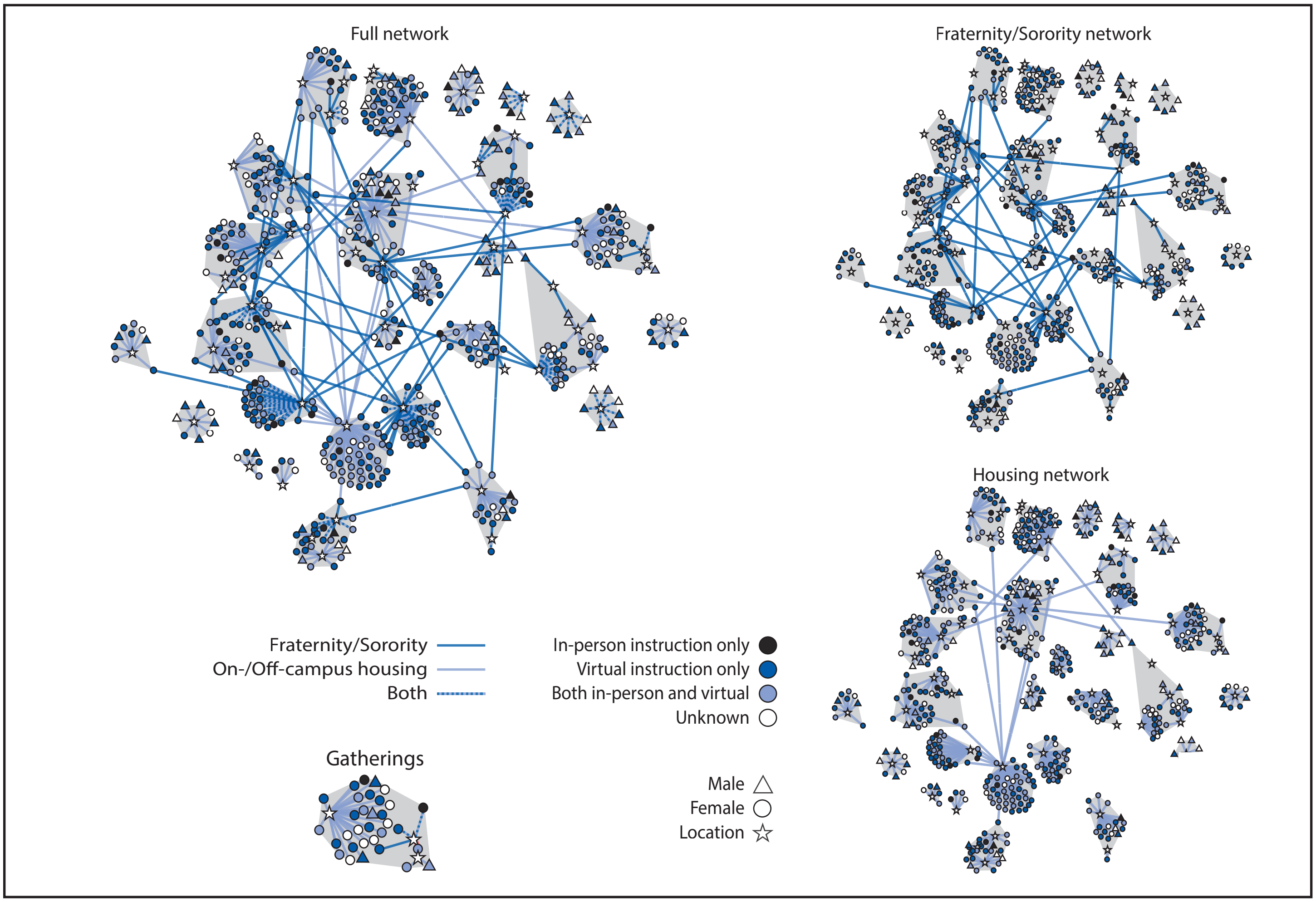
Abbreviation: COVID-19 = coronavirus disease 2019.

FIGURE 1. University-affiliated COVID-19 cases (N = 555),* by symptom onset date† and sex — Arkansas, August 17–September 5, 2020§



Abbreviation: COVID-19 = coronavirus disease 2019.
* Ten cases with onset before sorority rush week, which occurred at a frequency of ≤1 per day, are not included.
† The case report date is used as the symptom onset date for asymptomatic cases.
§ Bid date refers to date when recruitment decisions were announced.

FIGURE 2. Network diagram of 565 university-affiliated COVID-19 cases connected to the patient's place of residence or fraternity or sorority participation — Arkansas, August 20–September 5, 2020



Abbreviation: COVID-19 = coronavirus disease 2019.

in women and 51% in men; cluster size range = 4–12 cases). Fifty-four gatherings were detected, including 27 (50%) with at least five cases. Among persons in 44 (81%) gatherings, at least one member regularly attended in-person classes, and at least one member of each of the 49 gatherings (91%) reported participation in fraternity or sorority activities or events. Gatherings included an average of 20.3 cases (median = 21; range = 5–44). Among 58 links between gatherings, 42 (72%) were associated with fraternity or sorority activities, 11 (19%) with on-campus dormitories, and five (9%) with off-campus apartments and houses.

Discussion

Within 2 weeks of the start of the 2020–21 academic year, COVID-19 cases rapidly increased among persons associated with university A. Transmission was likely facilitated by on- and off-campus congregate living settings and activities, with a majority of the gatherings (91%) and links between them (72%) associated with fraternities or sororities. Most patients reported virtual instruction only, which indicates transmission likely occurred primarily outside the classroom; this finding is supported by the very small proportion of cases among faculty and staff members (0.5%). Women constitute 54% of university A's 2020 student body but accounted for 70% of university A's COVID-19 cases. Among linked gatherings, women accounted for 86% of cases, a finding that could reflect involvement in gender-specific activities, including sorority rush week, which held an in-person outdoor bid day event and occurred before fraternity rush week, which was both held later and virtually.

Understanding networks can provide insights into COVID-19 transmission dynamics and inform effective mitigation strategies. In the absence of detailed person-to-person transmission data from contact tracing, network analysis using

Summary

What is already known about this topic?

Preventing COVID-19 in colleges and universities requires mitigation strategies addressing on- and off-campus congregate living settings, extracurricular activities, and social gatherings.

What is added by this report?

At the start of the 2020–21 academic year, COVID-19 cases increased rapidly at an Arkansas university. Network analysis indicated that 91% of gatherings were associated with fraternity or sorority activities. Recruitment events held virtually were associated with fewer cases than those held in-person.

What are the implications for public health practice?

Given the potential for rapid SARS-CoV-2 transmission in on- and off-campus settings and activities, colleges and universities should work with local health departments and student organizations to ensure compliance with mitigation guidelines.

available data on place of residence and involvement in on- and off-campus activities was used to describe university A's transmission network, potential gatherings where transmission might have taken place, and links between nodes. The network visualization tool depicted algorithm-detected gatherings to identify links indicating likely recent contact. Visualized in real-time, information from such links and networks could support implementation of targeted mitigation activities, such as isolation of cases and quarantining of contacts.

The findings in this report are subject to at least four limitations. First, incomplete case investigations resulted in missing or unknown data and exclusion from the network analysis. Second, housing and event attendance might not approximate transmission histories. Third, many cases were identified during mass testing events, and event advertisement and location could have resulted in a biased sample. Finally, data were not collected from uninfected persons or on adherence to mitigation strategies, such as social distancing, mask use, and hand hygiene.

Because of the potential for rapid transmission of SARS-CoV-2 in on- and off-campus university settings, student organizations could help ensure compliance with CDC-recommended COVID-19 mitigation measures, such as limiting the size of social gatherings, adhering to social distancing recommendations, requiring mask use, improving hand hygiene, and increasing testing. Encouraging more virtual activities, including those related to fraternity and sorority rush week, might help minimize the risk for transmission on university and college campuses. To ensure compliance with mitigation measures, health departments should work together with student organizations and university leaders.

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All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Atul Kothari reports personal fees from Asun Biopharma, outside the submitted work. No other potential conflicts of interest were disclosed.

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Erratum

Vol. 69, No. 49

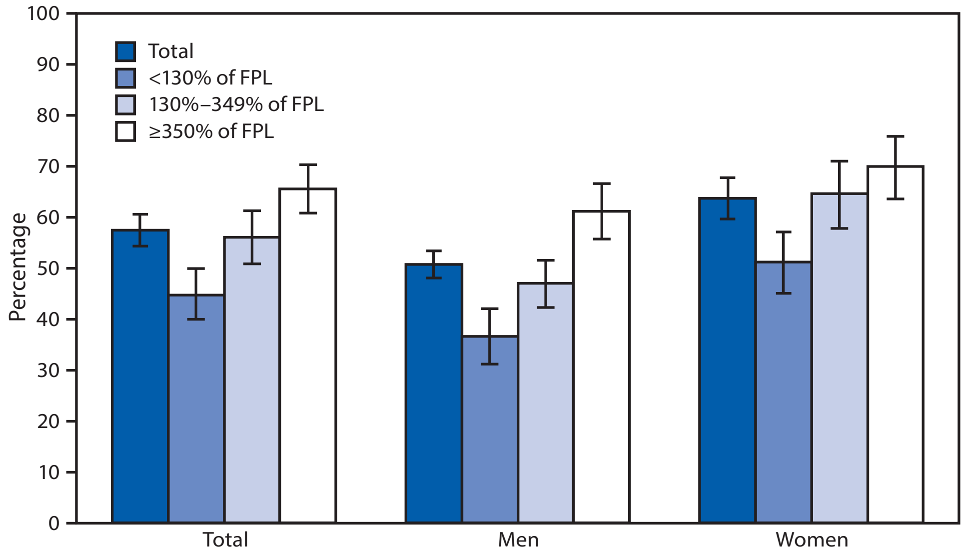
In the report "COVID-19 Mortality Among American Indian and Alaska Native Persons — 14 States, January–June 2020," on page 1853, the list of authors should have read "Jessica Arrazola, DrPH[1]; Matthew M. Masiello[1]; Sujata Joshi, MSPH[2]; Adrian E. Dominguez, MS[3]; Amy Poel, MPH[3]; Crisandra M. Wilkie, MPH[3]; Jonathan M. Bressler, MPH[4]; Joseph McLaughlin, MD[4]; Jennifer Kraszewski, MS[5]; Kenneth K. Komatsu, MPH[6]; Xandy Peterson Pompa, MPH[6]; Megan Jespersen, MPH[7]; Gillian Richardson, MPH[7]; Nicholas Lehnertz, MD[8]; Pamela LeMaster, PhD[8]; Britney Rust, MPH[9]; Alison Keyser Metobo, MPH[10]; Brooke Doman, MPH[11]; David Casey, MA[12]; Jessica Kumar, DO[12]; Alyssa L. Rowell, MA[12]; Tracy K. Miller, PhD[13]; Mike Mannell, MPH[14]; Ozair Naqvi, MS[14]; Aaron M. Wendelboe, PhD[14]; Richard Leman, MD[15]; Joshua L. Clayton, PhD[16]; Bree Barbeau, MPH[17]; Samantha K. Rice, MPH[18]; **Samantha J.H. Rolland, PhD[18]**; Victoria Warren-Mears, PhD[2]; Abigail Echo-Hawk, MA[3]; Andria Apostolou, PhD[19]; Michael Landen, MD[1].

The affiliation for Samantha J.H. Rolland is Washington State Department of Health.

QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Adults Aged ≥20 Years Who Had Taken Any Dietary Supplement† in the Past 30 Days, by Sex and Family Income§ — National Health and Nutrition Examination Survey, United States, 2017–2018



Abbreviation: FPL = federal poverty level.

* Error bars indicate 95% confidence intervals.

† Dietary supplements are products taken by mouth that contain one or more dietary ingredients (vitamins, minerals, herbs or other botanicals, amino acids, and other substances) or their constituents and are labeled as such on the front panel.

§ Family income is defined as a percentage of the FPL. Participants missing information regarding family income were included in the total estimates but excluded in the estimates by family income.

During 2017–2018, 57.6% of adults aged ≥20 years had taken a dietary supplement within the past 30 days. The percentage increased with family income: 44.9% among those with family incomes <130% of the FPL, 56.2% among those with family incomes 130%–349% of the FPL, and 65.7% among those with family incomes ≥350% of the FPL. The increase with family income was seen for both men and women. Women were more likely than were men to use a dietary supplement overall (63.8% versus 50.8%) and at each income level.

Source: National Center for Health Statistics, National Health and Nutrition Examination Survey, 2017–2018. https://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Dietary&CycleBeginYear=2017.

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