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Major article

Reported exposure trends among healthcare personnel COVID-19 cases, USA, March 2020–March 2021

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A B S T R A C T

Background: Health care personnel (HCP) have experienced significant SARS-CoV-2 risk, but exposure settings among HCP COVID-19 cases are poorly characterized.
Methods: We assessed exposure settings among HCP COVID-19 cases in the United States from March 2020 to March 2021 with reported exposures (n = 83,775) using national COVID-19 surveillance data. Exposure setting and reported community incidence temporal trends were described using breakpoint estimation. Among cases identified before initiation of COVID-19 vaccination programs (n = 65,650), we used separate multivariable regression models to estimate adjusted prevalence ratios (aPR) for associations of community incidence with health care and household and/or community exposures.
Results: Health care exposures were the most reported (52.0%), followed by household (30.8%) and community exposures (25.6%). Health care exposures and community COVID-19 incidence showed similar temporal trends. In adjusted analyses, HCP cases were more likely to report health care exposures (aPR = 1.31; 95% CI:1.26-1.36) and less likely to report household and/or community exposures (aPR = 0.73; 95% CI:0.70-0.76) under the highest vs lowest community incidence levels.
Discussion: These findings highlight HCP exposure setting temporal trends and workplace exposure hazards under high community incidence. Findings also underscore the need for robust collection of work-related data in infectious disease surveillance.
Conclusions: Many reported HCP cases experienced occupational COVID-19 exposures, particularly during periods of higher community COVID-19 incidence.

BACKGROUND

Health care personnel (HCP) have experienced significant SARS-CoV-2 risk during the COVID-19 pandemic.[1–3] Approximately 500,000 COVID-19 cases and 1,635 deaths from COVID-19 among United States (US) HCP were reported to CDC through May 2021.[3] HCP status is documented among only 5%-45% of reported US COVID-19 cases, depending on reporting week,[3] and HCP cases and deaths are undercounted.[3,4]

Like all frontline workers, HCP can be exposed to SARS-CoV-2 in their workplaces, households, and communities. HCP workplace exposures include contacts with known COVID-19 patients and undiagnosed patients, coworkers, and visitors.[1] Many reports have identified significant associations of HCP work-related characteristics with infection or seropositivity.[2–7] Work-related characteristics associated with increased risk of SARS-CoV-2 include contact with COVID-19 patients,[2,5,6] clinical role,[6,7] and insufficient personal protective equipment (PPE).[2,5,7] These workplace exposure hazards are reflected in comparatively high COVID-19 diagnosis rates and SARS-CoV-2 seroprevalence among HCP.[2] Other reports in select HCP populations did not identify many work-related associations but identified significant associations of cumulative community incidence[8] and household and/or community exposures[6,8] with seropositivity. Workplaces are microcosms of the community in which frequency of infectious

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contacts broadly parallels community incidence; high community incidence may increase both occupational and nonoccupational exposures.[9] However, the association between community incidence and HCP COVID-19 case exposure setting remains unstudied.

Further understanding of occupational and non-occupational exposures among HCP COVID-19 cases, including temporal changes in exposure trends during the pandemic, is needed to minimize HCP risks from COVID-19 and other emerging infectious diseases. We aimed to (1) describe temporal trends in community COVID-19 incidence and exposure settings among HCP COVID-19 cases and (2) estimate associations of reported community incidence with HCP case exposure settings.

METHODS

Study population

We identified reported COVID-19 cases in national COVID-19 surveillance data[10] with an earliest associated date (date of first clinical observation, including symptom onset, testing, or diagnosis, or date reported to CDC) from March 1, 2020 to March 31, 2021 (Supplementary Fig 1). CDC receives de-identified reports on individual laboratory-confirmed and probable COVID-19 cases from US jurisdictions.[10]

The study population included individuals meeting COVID-19 case criteria who (1) self-identified as HCP; (2) reported ≥1 close contact/s with a known COVID-19 case (probable or confirmed) in the 14 days before illness onset (or diagnosis, if asymptomatic); and (3) reported a known exposure setting. In the instructions for completing the COVID-19 case report form, HCP are defined as "all paid and unpaid persons working in health care settings who have the potential for exposure to patients and/or to infectious materials".[11] HCP status was documented for only 19% of reported cases during the study period and completeness varied widely by time and geography (Supplementary Fig 2). Documentation of HCP status peaked in March 2020 at 45%, hovered between 20% and 30% from April 2020 to October 2020, then declined throughout the remainder of the study period. Close contact was defined as being within 6 feet for ≥15 minutes over a 24-hour period.[12] Exposure setting was reported as the setting in which contact with a known COVID-19 case occurred: (1) health care-associated, including contacts with HCP, patient, or visitor COVID-19 case/s in health care settings; (2) household; and (3) community.

Temporal analyses

Reported COVID-19 cases and deaths among HCP and counts and percentages of HCP cases reporting each exposure setting were plotted by the earliest associated date for each case to assess temporal trends.

We then combined nonoccupational exposures to create a household and/or community exposure indicator and restricted to HCP cases with earliest associated dates March 14 to December 13, 2020. Health care-associated and household and/or community exposures were each classified as Yes/No. Exposure settings were not mutually exclusive; some HCP cases reported and were classified under both exposure settings. We excluded cases from March 1 to 14, 2020 prior to widespread COVID-19 testing (n = 239) and cases after December 13, 2020 to avoid effect modification following initiation of the national HCP COVID-19 vaccination program (n = 16,221).[13]

Breakpoint estimation was used to identify shifts in relative exposure trends, or changes in slope, using segmented linear models regressing time on the 7-day moving mean of the proportion of HCP cases reporting health care-associated exposures. Breakpoint estimation was performed using the strucchange R package.[14,15] A minimum of 30 days between breakpoints was applied to avoid detection of numerous short-term trends. We included values through early 2021 during estimation only to allow identification of a breakpoint <30 days before December 13, 2020. Breakpoints were estimated by minimizing the residual sum of squares over all model segments and the number of breakpoints was identified by minimizing the Bayesian Information Criterion.[15] Robust 95% confidence intervals (95% CI) were estimated using the sandwich estimator.

Breakpoint estimation was repeated for the reported community COVID-19 incidence time series over the same period, regressing time on the median community incidence across reported HCP cases each day. We defined community COVID-19 incidence as the 14-day cumulative count of COVID-19 cases per 100,000 county population in CDC county-level surveillance data. This was calculated as the summed total of newly reported COVID-19 cases in each HCP case's county of residence over the 14 days ending on the earliest date associated with the case, divided by the 2018 estimated county population, multiplied by 100,000.[16]

Reported community COVID-19 incidence and HCP case exposure setting

We used a directed acyclic graph[17] to identify potential confounders of associations of reported community COVID-19 incidence with reported exposure settings (Supplementary Fig 3). The minimally sufficient adjustment set included community COVID-19 testing, community population mobility, urbanicity, and earliest associated date. Community COVID-19 testing was identified from surveillance data as the 14-day cumulative count of COVID-19 nucleic acid amplification tests per 100,000 county population, calculated equivalently to community COVID-19 incidence as defined above. We defined community population mobility as the 14-day moving mean of a county-level, smartphone GPS-based mobility index.[18] Mobility was estimated for the earliest date associated with each HCP case by county of residence as a percentage compared to weekday movement over a baseline period February 17, 2020-March 7, 2020.[18] Urbanicity of each HCP case's county of residence was classified as large central metro, large fringe metro, medium/small metro, or micropolitan and/or noncore.[19] We successively excluded HCP cases with no reported county of residence (n = 591), residence in a US territory (n = 336), or residence in a county with no available value for community mobility (n = 738) for a complete case analysis.

We described demographic, community, and exposure characteristics among this population using counts and percentages for categorical variables and medians with interquartile ranges for continuous variables.

We applied multivariable log-Poisson regression models with robust 95% CIs because log-binomial models did not stably converge.[20] Regression models estimated associations of reported community COVID-19 incidence with reported (1) health care-associated and (2) household and/or community COVID-19 case exposures as adjusted prevalence ratios (aPR). We evaluated functional form for each variable in the minimally sufficient adjustment set to minimize the Bayesian Information Criterion. Community COVID-19 testing, community population mobility, and weeks between March 14, 2020 and the earliest associated case date were modeled with natural cubic splines with 3 degrees of freedom. Urbanicity was modeled as a 4-level factor as defined above. We classified community COVID-19 incidence categorically as (1) ≤100 cases per 100,000 population; (2) 100 < cases ≤ 250; (3) 250 < cases ≤ 1,000; and (4) >1,000 cases. These categories were applied to distinguish very high incidence communities (>1000 cases) during a period of the pandemic when many communities were experiencing high incidence. Heightened incidence levels (categories 2, 3, and 4) were compared to the lowest incidence level (category 1) as the referent in aPRs.

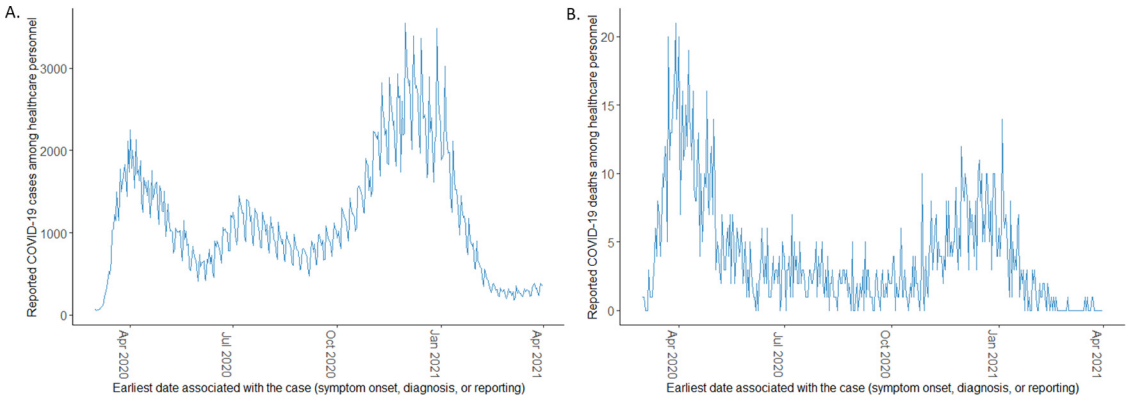

Fig 1. Reported COVID-19 cases (A) and deaths (B) among United States health care personnel from March 1, 2020 to March 31, 2021. Cases and deaths are plotted by the earliest date associated with each case, including symptom onset, diagnosis, or case reporting dates.

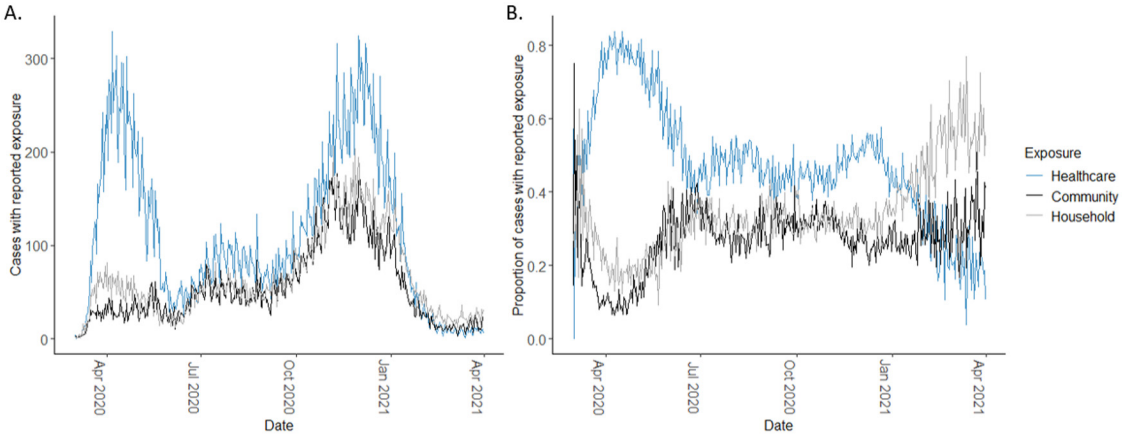

Fig 2. Counts (A) and proportions (B) of reported COVID-19 cases among United States health care personnel who reported known COVID-19 exposure settings from March 1, 2020 to March 31, 2021 by exposure setting during contact with known or suspected COVID-19 cases during the 14 days before COVID-19 symptom onset or diagnosis. Reported exposure settings, including health care-associated, community, and household, are indicated by color.

Regression models were repeated in several sensitivity analyses. We assessed associations between community incidence and (1) household and (2) community exposures separately to evaluate consistency across nonoccupational exposure settings. Additional sensitivity analyses probed the impact of alternative categorization of community incidence using quartiles, removal of single covariates from regression models, and restriction to HCP cases from states with consistent reporting. HCP cases with known exposures were reported by 27 states, the District of Columbia, and 3 territories; 65% of these cases were reported by 3 states (MN, OH, and TN). The sensitivity analysis was restricted to HCP cases reported by the 9 states with consistent reporting from March to December 2020, including 79.3% of eligible HCP cases.

All analyses were conducted in R (version 4.0.2; The R Foundation). This activity was reviewed by CDC and conducted consistent with applicable federal law and CDC policy.[1]

RESULTS

Temporal analyses

Data were reported for 462,453 HCP COVID-19 cases from March 1, 2020 to March 31, 2021 and case and death counts varied over time. Reported COVID-19 cases and deaths among HCP increased rapidly in March 2020. HCP case counts peaked in early April, July, and December 2020 (Fig 1). Deaths were most frequent among HCP cases with earliest associated dates in April 2020 and reached a secondary peak in December 2020-January 2021. Death from COVID-19 (Yes/No) was missing for 20.2% of reported HCP cases.

A subset of HCP cases identified ≥1 exposure/s to a confirmed or suspected COVID-19 case in a known setting (n = 83,775; 18.1%). Health care-associated exposures were most commonly reported (n = 43,586; 52.0%), followed by household (n = 25,786; 30.8%) and community exposures (n = 21,467; 25.6%). Some HCP cases reported multiple exposure settings (n = 6,710; 8.0%). The proportion of HCP cases reporting health care-associated exposures peaked in April 2020 at 84% and declined in May and June 2020 (Fig 2). Health care-associated exposure prevalence then fluctuated around 50% through December 2020 with slight increases during the summer and winter US epidemic peaks. HCP cases dropped sharply from December 2020 to March 2021 and reported health care-associated exposures declined most quickly during this period.

After restricting to March 14-December 13, 2020 (n = 67,315), we identified breakpoints corresponding to shifts in slope for 2 time series: the proportion of HCP cases reporting health care-associated exposures and reported community COVID-19 incidence. Breakpoints in the health care-associated exposure time series were identified on April 12 (*peak 1*), May 25, July 2, August 16 (*peak 2*), September 15, November 11, and December 12 (*peak 3*) (Fig 3). The reported community COVID-19 incidence time series displayed similar trends and breakpoints (April 22 [*peak 1*], June 21, July 29 [*peak 2*], September 9,

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

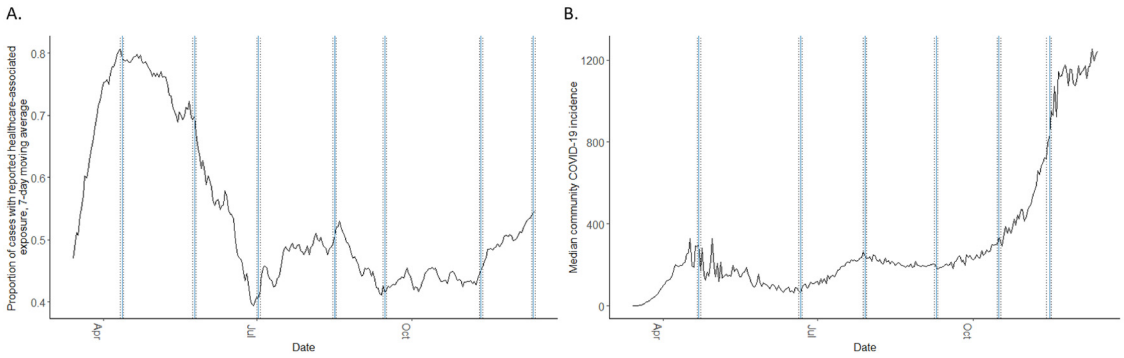

Fig 3. Time series breakpoints within health care personnel (HCP) exposure setting and community COVID-19 incidence time series from March 14, 2020 to December 13, 2020. (A) 7-day moving mean of the proportion of HCP cases who reported known COVID-19 exposure settings reporting health care-associated exposures. Time series breakpoints identified via segmented linear regression are shown as solid vertical lines, with robust 95% confidence limits shown as dotted vertical lines. (B) Median community COVID-19 incidence in HCP cases' communities, defined as the 14-day cumulative count of COVID-19 cases per 100,000 county population.

October 16, and November 15). Peak 3 occurred shortly after HCP vaccination initiation and the analysis cutoff date. Household and community exposure time series trends contrasted health care-associated exposure trends in sensitivity analyses (Supplementary Fig 4).

Reported community COVID-19 incidence and HCP case exposure setting

Among 65,650 HCP cases included in regression analyses, 35,705 (54.4%) reported health care-associated exposures and 34,321 (52.3%) reported household and/or community exposures (Table 1). Specific types of health care-associated exposure/s were reported by 9,404 HCP cases: 66.4% were exposed to another HCP, 65.7% to a patient, and 4.2% to a visitor COVID-19 case. One-third (32.7%) reported multiple types of health care-associated exposures.

Demographic and pandemic-related characteristics varied slightly by exposure setting. HCP cases reporting health care-associated and household and/or community exposures were predominantly female and of similar ages. Compared to HCP reporting household and/or community exposures, a greater proportion of HCP reporting health care-associated exposures identified as Black, non-Hispanic/Latino (18.4% vs 13.1%) and resided in micropolitan/noncore counties (24.2% vs 20.5%). They were also identified earlier in the pandemic (median weeks elapsed since March 14, 2020: 21.4 vs 29.0), under lower community testing (median 14-day cumulative tests/100,000 population: 2,429 vs 3,666), and under lower community population mobility (median mobility index: 60.1 vs 64.5).

Health care workplace setting was reported by 13,968 (21.3%) HCP cases: 17.2% worked in a hospital, 61.3% in a long-term care facility (LTCF) (ie, nursing home, assisted living, and rehabilitation facilities), and 21.6% in another health care setting (eg, home health care, doctor's office, etc.). Compared to HCP reporting household/community exposures, a greater proportion of HCP reporting health care-associated exposures worked in LTCFs (78.8% vs 52.8%) and lower proportions worked in hospitals (11.3% vs 19.8%) or other health care settings (9.9% vs 27.4%).

After adjustment for confounders, health care-associated exposure prevalence rose monotonically with community COVID-19 incidence (Table 2). HCP cases were more likely to report health care-associated exposures (aPR = 1.31; 95% CI: 1.26, 1.36) and less likely to report household and/or community exposures (aPR = 0.73; 95% CI: 0.70, 0.76) under the highest vs lowest reported community incidence levels.

Results were robust to analytical choices when probed in sensitivity analyses. Reported community incidence showed similar associations with household and community exposures when assessed separately (Supplementary Table 1). Findings were also robust to alternative categorization of community incidence using quartiles (Supplementary Table 2), removal of single covariates (Supplementary Table 3), and restriction to HCP cases from states with consistent reporting (Supplementary Table 4).

DISCUSSION

Majorities of US HCP COVID-19 cases with known exposures reported both health care-associated and household and/or community exposures. These findings align with prior reports describing known health care-associated exposures among seropositive HCP.[6,8] They also underscore the critical importance of infection prevention and control (IPC) measures to minimize workplace hazards. Further, the positive association between reported community incidence and health care-associated exposures highlights the workplace as a major driver of COVID-19 among HCP under high community incidence.

HCP case and exposure trends changed as the pandemic progressed. Reported deaths from COVID-19 among HCP were highest from March to May 2020 and most HCP cases reported health care-associated exposures during this period. Limited testing availability[21] and early exposure reporting practices suppressed HCP case counts and impaired knowledge and reporting of all exposures. Low community mobility during stay-at-home orders[18] also likely restricted community exposure opportunities among HCP.[22] Finally, health care workplace IPC measures rapidly evolved due to improving understanding of SARS-CoV-2 transmission.[23] Inconsistent quarantine of exposed HCP due to staffing shortages, incomplete mask use policies regarding nonpatient areas (eg, break rooms), and limited availability of COVID-19 testing may have allowed for greater transmission between coworkers compared to later months. Insufficient PPE availability[5] may have also contributed to health care-associated exposure trends.

Health care-associated exposure prevalence among HCP cases was relatively stable from June to December 2020. Slight increases were observed during the national summer and winter COVID-19 waves. Rising community mobility and testing may have increased the likelihoods of exposure and knowledge of exposure outside of work compared to earlier months, while improved PPE availability and IPC measures likely reduced workplace hazards. CDC IPC recommendations were updated to include enhanced PPE for HCP during all patient encounters, universal source control, and wider screening testing among HCP, especially those in LTCF.[24-26] Although many health care workplaces became safer environments, improvement was not equal across all employers and settings.[27,28] Many HCP that had temporarily reduced in-person services also resumed in-person care during this period.[28] Return to physical workplaces may have increased health care-associated exposure opportunity among this subset.

Table 1
Demographic characteristics of reported United States COVID-19 cases among health care personnel who reported known COVID-19 exposure settings, March 14, 2020-December 13, 2020

Characteristic	All HCP* with reported exposure(s) no. (%)†,‡	HCP* with reported health care exposure(s) no. (%)†,‡	HCP* with reported household or community exposure(s) no. (%)†,‡
Total	65,650	35,705 (54.4)	34,321 (52.3)
Age in years (median, IQR*)	39.0 (28.0-51.0)	40.0 (29.0-52.0)	38.0 (27.0-50.0)
Sex			
Female	53,317 (81.5)	29,448 (82.8)	27,401 (80.1)
Male	12,096 (18.5)	6,096 (17.2)	6,825 (19.9)
Race/ethnicity			
White, non-Hispanic/Latino	38,816 (68.1)	20,290 (66.7)	21,156 (69.5)
Black, non-Hispanic/Latino	8,949 (15.7)	5,611 (18.4)	3,975 (13.1)
Hispanic/Latino	4,299 (7.5)	1,787 (5.9)	2,760 (9.1)
Asian, Non-Hispanic/Latino	1,367 (2.4)	660 (2.2)	808 (2.6)
Multiple/other, non-Hispanic/Latino	3,592 (6.3)	2,088 (6.9)	1,752 (5.8)
County urbanicity			
Large central metro	14,006 (21.3)	6,530 (18.3)	8,460 (24.6)
Large fringe metro	15,299 (23.3)	9,414 (26.4)	6,863 (20.0)
Medium/small metro	21,679 (33.0)	11,124 (31.2)	11,954 (34.8)
Micropolitan/non-core	14,666 (22.3)	8,637 (24.2)	7,044 (20.5)
Health care workplace			
Hospital	2,400 (17.2)	668 (11.3)	1,883 (19.8)
Long-term care facility§	8,556 (61.3)	4,666 (78.8)	5,024 (52.8)
Other§	3,012 (21.6)	589 (9.9)	2,609 (27.4)
14-d cumulative COVID-19 incidence¶			
≤100 cases	12,560 (19.1)	7,565 (21.2)	5,890 (17.2)
100 < cases ≤ 250	15,400 (23.5)	8,009 (22.4)	8,536 (24.9)
250 < cases ≤ 1000	27,344 (41.6)	14,811 (41.5)	14,051 (40.9)
>1000 cases	10,346 (15.8)	5,320 (14.9)	5,844 (17.0)

*HCP, health care personnel; IQR, interquartile range.
†HCP cases reported known exposure to a COVID-19 case in health care-associated, household, or community settings in the 14 days prior to illness onset or diagnosis.
‡Columns may not sum to total due to missing values. Rows may sum to >100% because some HCP reported multiple exposure settings and were included in all columns.
§Long-term care facilities include nursing home, assisted living, and rehabilitation facilities, combining categories from the case report form[13]. Other health care workplaces include home health, doctor's offices, etc.
¶Fourteen-day cumulative COVID-19 incidence is the summed total of reported COVID-19 cases in a county over the 14 days ending on the earliest date associated with the case, divided by the estimated county population in 2018, multiplied by 100,000.

HCP case and exposure trends shifted from December 2020 to March 2021 under vaccine effects. US HCP became eligible to receive COVID-19 vaccines in mid-December 2020.[13] Early HCP vaccination was temporally associated with subsequent sharp declines in reported HCP COVID-19 cases; similar temporal trends have been noted in state-level data.[29] However, documentation of HCP status among reported COVID-19 cases also declined during this period, which may account for part of this effect. Faster reduction in health care-associated versus household and/or community exposures among HCP cases was observed from December 2020 to March 2021. During this period, health care-associated exposures flipped from the most commonly reported exposure type among HCP to the least commonly reported exposure type. These findings suggest that HCP, regardless of personal vaccination status, may have also experienced reduced workplace exposures following coworker and patient vaccination.

Reported community COVID-19 incidence and health care-associated exposures among HCP cases showed similar temporal trends.

Table 2
Adjusted prevalence ratios for reported health care-associated and household and/or community exposures to COVID-19 cases by 14-day cumulative COVID-19 community incidence among United States health care personnel COVID-19 cases who reported known COVID-19 exposure settings, March 14, 2020-December 13, 2020

14-day cumulative COVID-19 incidence†	Health care-associated exposure to COVID-19 case‡			Household or community exposure to COVID-19 case‡		
	no. (%)	Unadjusted PR* (95% CI*)	aPR*,§ (95% CI*)	no. (%)	Unadjusted PR* (95% CI*)	aPR*,§ (95% CI*)
≤100 cases¶	7,565 (60.2)#	—	—	5,890 (46.9)	—	—
100 < cases ≤ 250	8,009 (52.0)	0.86 (0.85, 0.88)	1.07 (1.04, 1.09)	8,536 (55.4)	1.18 (1.15, 1.21)	0.92 (0.89, 0.94)
250 < cases ≤ 1,000	14,811 (54.2)	0.90 (0.88, 0.92)	1.21 (1.18, 1.24)	14,051 (51.4)	1.10 (1.07, 1.12)	0.77 (0.75, 0.80)
>1,000 cases	5,320 (51.4)	0.85 (0.83, 0.87)	1.31 (1.26, 1.36)	5,844 (56.5)	1.20 (1.17, 1.24)	0.73 (0.70, 0.76)
Total	35,705 (54.4)	—	—	34,321 (52.3)	—	—

*aPR, adjusted prevalence ratio; HCP, health care personnel; PR, prevalence ratio; 95% CI, 95% confidence interval.
†Fourteen-day cumulative COVID-19 incidence is the summed total of reported COVID-19 cases in a county over the 14 days ending on the earliest date associated with the case, divided by the estimated county population in 2018, multiplied by 100,000
‡Regression analyses were restricted to HCP cases who reported one or more exposure to a known or suspected COVID-19 case in the health care, household, or community setting during the 14 days before symptom onset or diagnosis.
§Adjusted prevalence ratios were estimated using log-Poisson regression analyses with robust standard errors adjusting for county-level 14-day cumulative COVID-19 tests per 100,000 population, county-level 14-day mobility moving mean, time, and county-level urbanicity
¶aPR reference level.
#Rows sum to >100% because some HCP reported multiple exposure settings and were included under both exposure columns.

Health care-associated exposure prevalence increased compared to household and/or community exposure prevalence during periods of increasing community incidence. They were also associated after adjusting for confounders, including artificially low community incidence values under limited testing during the early stages of the pandemic. Higher reported community COVID-19 incidences were associated with higher health care-associated exposure prevalence and lower household and/or community exposure prevalence among HCP cases. These associations may partially reflect heightened public health measures to limit contacts outside of essential workplaces during periods of higher community transmission. Despite this, we observed the associations after adjustment for community population mobility diminished the effect size.

Recent reports identified significant associations of cumulative community incidence and household and/or community exposures with HCP SARS-CoV-2 seropositivity. These reports concluded that nonoccupational exposures may have predominantly driven COVID-19 among HCP in some settings.[6,8] However, they examined risk factors for HCP seropositivity at select hospital systems and may not reflect COVID-19 workplace exposures in other health care settings. Our findings among all reported US HCP COVID-19 cases with known exposures suggest that an association between reported community incidence and HCP seroprevalence is likely due to increased exposures in both occupational and nonoccupational settings under heightened community incidence.

Most HCP cases with reported work settings worked in LTCFs (61%), compared to just 14% of all US HCP.[30] However, health care work setting was added to case reports on April 30, 2020, and work setting may have differed among HCP cases reported prior. HCP reporting health care-associated exposures were also more likely to work in LTCFs. This finding may result from greater case detection and knowledge of workplace exposures under recommended facility-wide testing practices in LTCFs.[25,26] Nevertheless, higher COVID-19 incidence and seroprevalence have been reported among HCP in nursing homes compared to other health care settings.[2,31] HCP cases in nursing homes were also more likely to report health care-associated exposures[32] and less likely to report using adequate PPE[2,5,32] than those in hospitals in other recent reports.

Workplace IPC measures are necessary to minimize COVID-19-related occupational hazards among HCP. Approximately two-thirds of HCP cases who reported health care-associated exposure settings and specific exposure type/s reported exposures to patient and HCP COVID-19 cases, with substantial overlap. This finding underscores the importance of IPC measures to address transmission through all health care-associated routes. In fact, HCP may have benefited from enhanced workplace IPC measures relative to many other workers. The health care and social assistance sector has shown lower excess mortality, lower COVID-19 case rates overall, and faster declines in COVID-19 case rates from March to May 2020 than many other frontline industry sectors.[33,34]

Generalizability of this analysis is limited by potential selection bias in national COVID-19 surveillance data. HCP status, known exposures, and health care work setting are not required case report fields. Complete data were unavailable for most cases, as described above, and inconsistent documentation of HCP status after disclosure of known exposure types could have biased results. HCP in LTCFs were overrepresented among the subset who reported a work setting and results may not reflect the full population of US HCP. Surveillance of individual cases is important for all notifiable conditions. However, this analysis illustrates the need for a more standardized approach to the collection of variables that describe employment status, industry, occupation, workplace IPC measures, and workplace case contacts for notifiable conditions potentially acquired at work. Standardized collection may support assessments of the contribution of work to notifiable conditions.

The lack of consistent definitions for probable cases, close contacts, and contacts in each exposure setting also limits our ability to understand the relative contributions of exposure settings to HCP SARS-CoV-2 acquisition. Clinical criteria for probable cases and definitions of close contacts varied over time. Reported known exposures were first limited to contacts with laboratory-confirmed cases, then began including contacts with probable cases on May 5, 2020. Definitions of contacts in each exposure setting may have also varied over time and across states. In addition, exposure reporting may be subject to social desirability bias and reported exposures are not explicitly causal.

Adjusted regression models are also subject to several limitations. County-level adjustment variables may not be sufficiently granular but were applied because the residential ZIP code of cases was not typically available. Some HCP also work in counties other than their residence, misclassifying community incidence relative to workplace exposures. Data were unavailable on workplace IPC measures, including PPE, and date was used as an imperfect proxy for changing IPC measures. Data were also unavailable for county-level mask mandates over time, potentially allowing some uncontrolled confounding. Community mobility and testing are both probable confounders and mediators of associations between reported community incidence and HCP case exposure settings. We probed the impact of adjustment for these variables in sensitivity analyses, finding that results were robust to their removal. Despite these limitations, these findings are important because they are the first to describe temporal changes in reported US HCP case exposures. Findings also highlight the potential contribution of occupational exposures to the previously observed association between community COVID-19 incidence and HCP seroprevalence.

CONCLUSIONS

Many reported HCP cases experienced occupational COVID-19 exposures, and higher community COVID-19 incidences were associated with higher health care-associated exposure prevalences. Widespread HCP COVID-19 vaccination is essential to minimize workplace transmissions and safeguard against HCP worker shortages. In addition, adequate training, non-punitive sick leave, screening testing, and other IPC measures[35,36] should be provided to protect at-risk workers. Reliable PPE availability for all HCP is also needed to minimize occupational exposures during the COVID-19 pandemic and future public health crises.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2022.01.007.

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