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Ethnicity and risk for SARS-CoV-2 infection among the healthcare workforce: Results of a retrospective cohort study in rural United Kingdom

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ABSTRACT

Background: The reason why Black and South Asian healthcare workers are at a higher risk for SARS-CoV-2 infection remain unclear. We aimed to quantify the risk for SARS-CoV-2 infection among healthcare staff who belong to the ethnic minority and elucidate pathways of infection.

Methods: A one-year follow-up retrospective cohort study has been conducted among National Health Service employees who were working at 123 facilities in Lincolnshire, UK.

Results: Overall, 13,366 professionals were included. SARS-CoV-2 incidence per person-year was 5.2% (95% CI: 3.6–7.6%) during the first COVID-19 wave (January–August 2020) and 17.2% (13.5–22.0%) during the second wave (September 2020–February 2021). Compared with White staff, Black and South Asian employees were at higher risk for SARS-CoV-2 infection during both the first wave (hazard ratio, HR 1.58 [0.91–2.75] and 1.69 [1.07–2.66], respectively) and the second wave (HR 2.09 [1.57–2.76] and 1.46 [1.24–1.71]). Higher risk for SARS-CoV-2 infection persisted even after controlling for age, sex, pay grade, residence environment, type of work, and time exposure at work. Higher adjusted risk for SARS-CoV-2 infection were also found among lower-paid health professionals.

Conclusion: Black and South Asian health workers continue to be at higher risk for SARS-CoV-2 infection than their White counterparts. Urgent interventions are required to reduce SARS-CoV-2 infection in these ethnic groups.

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Introduction

To date, nearly 18 million confirmed cases of SARS-CoV-2 infection have been reported in the UK (World Health Organization, 2021). Because they are at the frontline of the outbreak,

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healthcare workers are particularly exposed to SARS-CoV-2 infection (Houlihan et al., 2020; Hunter et al., 2020). Despite supply of personal protective equipment and adoption of social distancing and shielding measures, healthcare staff continue to be more affected by COVID-19 than the general population (Nguyen et al., 2020; Office for National Statistics, 2021).

The risk for infection varies among healthcare staff. In the UK, studies indicate that professionals with face-to-face contact with patients (e.g., porters, healthcare assistants, and nurses) are more likely to be infected by SARS-CoV-2 than those who are not

(Eyre et al., 2020; Martin et al., 2020). Furthermore, healthcare professionals from Black and South Asian backgrounds display a high risk for SARS-CoV-2 infection (Nguyen et al., 2020; Eyre et al., 2020; Martin et al., 2020; Shields et al., 2021; Valdes et al., 2021; Ken-Dror et al., 2021; Hanrath et al., 2021; Shields et al., 2020; Shorten et al., 2021; Patel et al., 2021; Kua et al., 2021). However, many studies investigating risk factors for SARS-CoV-2 infection have limitations, the primary being that they adopt cross-sectional designs; hence, they are unable to demonstrate causality. These studies also collect data from a limited number of health facilities, inhibiting its representativeness and present unadjusted results or omit important confounding variables (e.g., occupational exposure, residential environment).

A key outstanding question in this area is “to what extent are the observed differences in ethnicity risk explained by differences in job profile and other socioeconomic and environmental conditions?” In high-income countries, ethnic minorities are more likely to work in high-risk public-facing jobs including frontline medical positions (Hayward et al., 2021). They are also more likely to have a lower economic status, which has been shown to be associated with higher COVID-19 prevalence in the general population (Chaudhuri et al., 2021; Ho et al., 2020). Yet, the association between socioeconomic deprivation of the home environment and SARS-CoV-2 infection in health care workers differs among studies (Hanrath et al., 2021; Martin et al., 2020; Shields et al., 2020; Valdes et al., 2021). Furthermore, the socioeconomic factors that were considered were mainly area-based, and other individual-based characteristics, such as professional grade or salary, are rarely considered. In addition, SARS-CoV-2 infection risks in rural environments remain poorly described in UK (Asghar et al., 2021).

To quantify changing patterns of infection risk, one needs to go beyond the first wave of the pandemic. However, to date, few studies examined the impact of the second wave of the outbreak on healthcare professionals in the UK (Ken-Dror et al., 2021; Shields et al., 2021). Understanding the evolution of SARS-CoV-2 infection risk factors across the different waves of the pandemic is important to observe if the generalization and adaptation of mitigation measures (e.g., provision of personal protective equipment, vaccination rollout) have reduced sociodemographic and economic risk inequalities among healthcare staff members. The aim of this study was to quantify the risk for COVID-19 infection among healthcare workers who belong to ethnic minorities and elucidate pathway of infection by considering underlying differences in demographics, socioeconomic status, residential environment, and occupational exposure.

Methods

Design and Settings

An occupational and retrospective cohort study has been conducted among all employees (both clinical and nonclinical) who were working at 123 facilities in Lincolnshire, a predominantly rural region in the UK. Staff members are employed at one of three hospital trusts, namely: Lincolnshire Partnership National Health Service (NHS) Foundation Trust, Lincolnshire Community Health Services, and United Lincolnshire Hospitals NHS Trusts. These facilities include 11 hospitals, 44 GP medical practices or health centers, 47 other medical facilities (e.g., hospices), and 21 nonmedical health facilities (e.g., NHS headquarters, county offices). The majority of staff members are hospital-based (72.3%).

Population included

From January 1, 2020–February 10, 2021, all employees working in the three trusts were retrospectively followed up using data

that were routinely collected by human resource departments. Students working in these facilities were excluded from our analysis because their staff group assignment was not reported. Healthcare staff documented as working in different facilities or those not assigned to a specific facility during the same period were also excluded from the study. Individuals belonging to more than one staff group during a given period were assigned to the staff group where the individual spent most of their time.

Data collected

Data collected included demographics (i.e., age, sex, ethnic group), economic status (i.e., NHS pay grade), occupational exposure (i.e., staff group, number of hours worked each weekend, number of NHS staff working in the facility, self or house isolation periods, and leave of absence periods), clinical factors (i.e., number of non-COVID-19-related diseases occurring before SARS-CoV-2 infection during the observation period), and home environment (i.e., UK Index of Multiple Deprivation [IMD], UK urban-rural classification, household size mean). Ethnic group reported by each employee were categorized as White–British, other White minorities (e.g., Europeans), Southern Asian (i.e., Pakistanis, Indians, and Bangladeshis), other Asian minorities, Black (including Black African and Caribbean), and mixed group or other. The NHS pay grade varies according to the NHS body band 1–9, with band 1 indicating lower salaries (starting at around 24,830 US dollars per year), whereas the highest band indicates a higher salary (starting at around 125,483 US dollars per year). The rural-urban classification and the household size mean from 2010 and the IMD from 2019 were linked for each individual by merging the lower layer super output area that was associated to their home postcode with UK census data. Leave of absences (excluding infection precaution or isolation) and self or house isolation periods (including COVID-19 shielding or infection precaution reasons) were measured through the start and end date of these periods. Any change in the situation of the employee (e.g., staff group, isolation period) during the observation period were collected.

SARS-CoV-2-positive tests were routinely collected through the human resource departments of each trust. Following UK NHS recommendations, before November 2020, NHS staff members were tested using PCR-based SARS-CoV-2 tests in the case of COVID-19-related symptoms or contact with COVID-19 cases (Public Health England, 2021). Since November 2020, the NHS provided lateral flow antigen self-test kits and recommended that staff members perform regular SARS-CoV-2 tests (at least twice per week) even in the absence of symptoms and perform a PCR confirmation test in case of positive lateral flow antigen test results. PCR tests were implemented in dedicated testing centers or health services during the study period. In the case of a positive PCR test result, individuals were legally required to report the result to their human resources department and self-isolate.

Statistical analysis

Bivariate analysis of SARS-CoV-2-positive test prevalence by the collected variables was conducted. SARS-CoV-2-positive test incidence rates per person-year were documented and cluster-adjusted on the place of work.

Survival analysis was conducted to measure the hazard risk ratio of positive SARS-CoV-2 test occurrence. For each individual, the observation period was left truncated by the start date of the study observation or the start date of employment contract if that date occurred after the beginning of the study observation. The observation period was also right truncated by the study observation period end date, the end of the contract date, or the date of occurrence of the first positive SARS-CoV-2 test.

Bivariate analysis between a SARS-CoV-2-positive test and other variables of interest was conducted using the log-rank test on Kaplan-Meier estimators (Kaplan and Meier, 1958). Then, we ran bivariate and multivariate Cox regression models depending on the period of observation: all the study period, first, and second COVID-19 wave (Cox, 1972). The first wave (i.e., wave 1) was defined as the period from of January 1, 2020–August 31, 2020 and the second wave, the period between September 1, 2020–February 10, 2021 (Mathur et al., 2021). All initial variables of interest were included in the multivariate model. Because data on leave of absence (other than COVID-19-related) were not available for a trust representing 13.7% of our sample, we assumed this value to be zero in the Cox models to avoid sample attrition.

Robust variances were computed to consider repeat measured were at individual level and the cluster effect on the place of work in the survival analysis. Intragroup comparisons were conducted using pairwise comparison tests with adjusted *P*-values for multiple hypothesis testing using Holm correction (Holm, 1979). Analyses were conducted using the package “survival” from the software R version 4.0.2. (R Core Team, 2021; Therneau, 2021).

Sensitivity Analyses

Complete case analysis for bivariate and multivariate Cox models (i.e., exclusion of the individuals with missing values for the number of leave of absence days) was conducted for sensibility analysis.

Results

Baseline characteristics

Overall, we collected data from 13,880 healthcare professionals. Among them, 56 were documented as working in more than one medical facility and 44 were not based in any facilities and were excluded from the analysis. Additionally, we removed 58 students because their staff group were not mentioned. An additional 356 individuals with missing values have been removed, leading to 13,366 individuals included in our final sample. The selection process led to the exclusion of 4 of the initial 123 health facilities. The mean average follow-up by individual was 356 days; only 24% of the individuals included were followed up less than 407 days (the maximum follow-up).

The cohort comprised mainly women (79.8%, Table 1). White individuals represented 87.9% of the cohort, whereas South Asian and Black employees represented 5.3% and 1.9%, respectively. Employees included at the first COVID-19 wave had similar demographic characteristics to those included in the second wave (Supplementary material, Table S1)

There were 1258 individuals (9.4%) with a documented SARS-CoV-2-positive test, with 397 and 861 cases occurring during the first and the second waves, respectively (Table 1, Fig. 1). Overall, the number of documented positive tests for SARS-CoV-2 increased during the second wave, with some heterogeneity between subgroups (Table S2).

The two largest health facilities accounted for 65.4% of the total cases. The incidence of SARS-CoV-2-positive test during the observation period were highly heterogenous between health facilities (Supplementary materials, Fig. S1).

SARS-CoV-2 infection incidence

The overall SARS-CoV-2 infection incidence per person-year was 10.0% (cluster-adjusted 95% confidence interval [CI]: 8.8%–11.4%). During the first wave, the incidence was 5.2% (3.6%–7.6%), whereas it was 17.2% (13.5%–22.0%) during the second wave. Incidence was

higher for Black (18.6% [13.7%–25.3%]) and South Asian employees (14.7% [11.9%–18.1%]) than White employees (9.5% [8.3%–11.0%]). Higher SARS-CoV-2 incidence was also found among additional clinical service staff members (14.8% [11.7%–18.7%]) and nurses (12.4% [11.0%–14.1%]).

Probability of SARS-CoV-2 infection

Using Kaplan-Meier curves, we found that Black employees had significantly higher probability to test positive for SARS-CoV-2 infection than White employees at 6 months of follow-up (7.1% [2.6%–11.4%] vs 3.4% [2.3%–4.5%], Holm-corrected *P*-value=0.018) and at the end of the observation period (20.9% [14.5%–26.8%] vs 10.5% [9.0%–12.0%], *P*<0.001) (Fig. 2A). Similar results were found for South Asian employees (6.8% [3.9%–9.5%] vs 3.4% [2.3%–4.5%], *P*<0.001 at 6 months and 15.8% [13.5%–18.0%] vs 10.5% [9.0%–12.0%], *P*<0.001 at the end of the observation period). Women and employees with lower NHS pay grades were also found with a significantly higher probability for SARS-CoV-2 infection (Figs 2C and 2D).

Adjusted and unadjusted hazard risks for SARS-CoV-2 infection

Compared with White staff members, Black and South Asian employees were at higher risk for SARS-CoV-2-positive test but above the significance threshold of 0.05 during the first wave (cluster-adjusted hazard ratio, HR 1.58 [0.91–2.75], Holm-corrected *P*-value=0.311 and 1.69 [1.07–2.66], *P*=0.119, respectively) and below the significance threshold during the second wave (HR 2.09 [1.57–2.76], *P*<0.001 and 1.46 [1.24–1.71], *P*<0.001) (Fig. 3, associated tables can be found in supplement material, Tables S3 and S4). Higher significant risks for SARS-CoV-2 infection were still found among Black employees during the second wave (wave 1: aHR 1.80 [1.07–3.02], *P*=0.109; wave 2: aHR 2.12 [1.70–2.64], *P*<0.001) and among South Asian employees during both waves (wave 1: aHR 2.05 [1.33–3.15], *P*=0.005; wave 2: aHR 1.50 [1.10–2.03], *P*=0.038) after adjusting for demographics, economic situation, occupational exposure, clinical factors, and home environment.

Overall, women (aHR 1.27 [1.06–1.52], *P*=0.009) and employees with the lowest paygrade (vs highest, aHR 2.93 [2.00–4.35], *P*<0.001) were at higher risk for SARS-CoV-2 infection. Residential characteristics such as rural-urban classification, IMD, and household size mean were not found to be significantly associated with SARS-CoV-2 infection in both adjusted and unadjusted models.

Experiencing a number of isolation days for two weeks or less was significantly associated with a higher risk for positive SARS-CoV-2 test (vs none, aHR 2.17 CI 95% [1.79–2.63], *P*<0.001) but not when that number exceeded two weeks (vs none, aHR 0.97 CI 95% [0.82–1.15], *P*=0.764).

Sensitivity analysis

In the complete case analysis, results from the Cox multivariate models were similar to those previously presented, except for the IMD of the healthcare workers' residence which was significantly associated with SARS-CoV-2 infection in the complete case analysis; although, the effects remained small (Fig. S2).

Discussion

Our results demonstrated a 110% excess risk for SARS-CoV-2 infection among Black healthcare workers (relative to their White counterparts) in a large occupational cohort in the predominantly rural English county of Lincolnshire. The corresponding figures for South Asian healthcare workers was more than 60%. These excess

Table 1
Population characteristics and SARS-CoV-2 prevalence during the study period (n=13,366).

	Headcount		Tested positive for SARS-CoV-2		P-value ^a
	N	%	n	% (n/N)	
Sex					<0.001
Female	10 667	79.8	1 062	10.0	
Male	2 699	20.2	196	7.3	
Age					0.002
30 and below	2 619	19.6	259	9.9	
31–40	2 976	22.3	290	9.7	
41–50	3 000	22.4	307	10.2	
51–60	3 462	25.9	317	9.2	
61 and over	1 309	9.8	85	6.5	
Ethnic group					0.009
White - British	11 248	84.2	1 035	9.2	
Other White minorities	499	3.7	48	9.6	
Southern Asian ^b	707	5.3	83	11.7	
Other Asian background	249	1.9	23	9.2	
Black ^c	250	1.9	36	14.4	
Mixed and other	413	3.1	33	8.0	
Staff group					<0.001
Additional Clinical Services	2 926	21.9	399	13.6	
Administrative and Clerical	2 925	21.9	113	3.9	
Allied Health Professionals	784	5.9	71	9.1	
Estates and Ancillary	1 111	8.3	87	7.8	
Medical and Dental	1 250	9.4	96	7.7	
Nursing and Midwifery Registered	3 719	27.8	458	12.3	
Scientists, Prof Scientific and Technic	654	4.9	34	5.2	
Pay grade					0.072
NHS Body Band 1, 2 and 3	4 945	37.0	509	10.3	
NHS Body Band 4 and 5	3 310	24.8	355	10.7	
NHS Body Band 6 and 7	3 097	23.2	263	8.5	
NHS Body Band 8, 9 and others ^d	2 014	15.1	131	6.5	
Contract type					0.179
Part-time	5 809	43.5	523	9.0	
Full-time	7 557	56.5	735	9.7	
Number of healthcare staff working in the facility					0.057
[1–50]	927	6.9	65	7.0	
[51–100]	787	5.9	51	6.5	
[101–200]	1 126	8.4	154	13.7	
>200	10 526	78.8	988	9.4	
Index of multiple deprivation					0.119
lower decile (1–4)	4 396	32.9	432	9.8	
middle decile (5–7)	4 433	33.2	448	10.1	
upper decile (8–10)	4 537	33.9	378	8.3	
Urban-rural classification					0.822
Urban	8 062	60.3	763	9.5	
Rural	5 304	39.7	495	9.3	
Household size mean					0.742
[1–2]	739	5.5	73	9.9	
]2–2.5]	11 107	83.1	1 045	9.4	
>2.5	1 520	11.4	140	9.2	
Number of non-COVID diseases					<0.001
0	5 561	41.6	404	7.3	
1	3 451	25.8	309	9.0	
2	2 177	16.3	244	11.2	
3+	2 177	16.3	301	13.8	
Number of isolation days^e					<0.001
0	8 671	64.9	712	8.2	
[1–14]	3 225	24.1	455	14.1	
>14	1 470	11.0	91	6.2	
Other leave of absence days^e	NA = 1821		NA = 262		0.001
0	7789	67.5	736	9.4	
[1–7]	2 784	24.1	203	7.3	
>7	972	8.4	57	5.9	

NHS: Nahtional Health Service.

^a two-sided global *P*-values (i.e., both rows and columns comparison for each characteristic) were computed using cluster-adjusted chi-square test of independence.^b Include Pakistanis, Indians, Bangladeshis.^c Include Black African and Caribbean .^d Other pay grades encompass mainly specialty registrar and consultant.^e Measured during the study period.

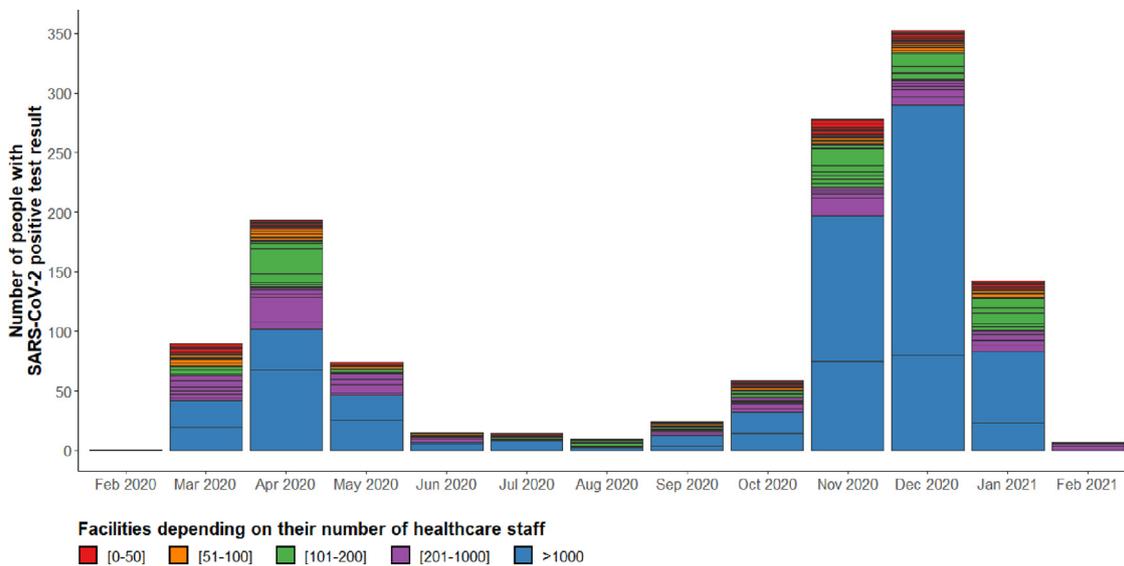


Figure 1. Evolution of the number of positive SARS-CoV-2 test by facility size.
 Note1: each rectangle represents a facility. The height of the rectangle is depending on the number of documented SARS-CoV-2-positive tests.
 Note2: Data were obtained through February 10, 2021.

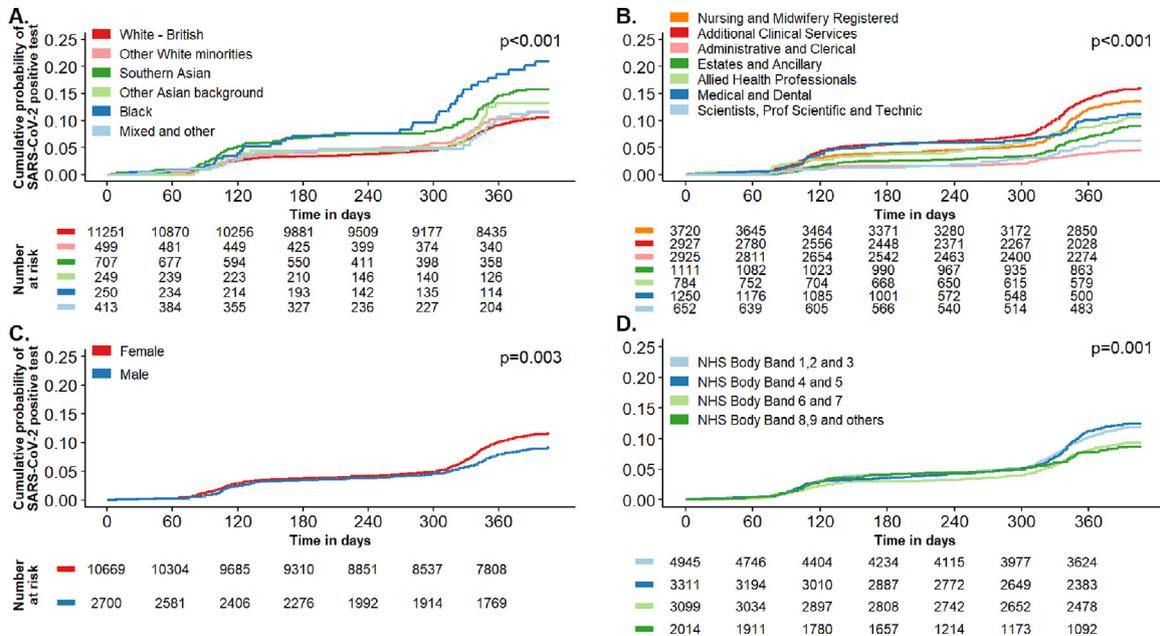


Figure 2. Cumulative event curves, on the basis of Kaplan-Meier estimates of COVID-19-positive tests among healthcare professional by ethnic background (A), by staff group (B), by sex (C), and NHS salary grade (D). NHS: National Health Service.
 Note1: two-sided P -values were computed using the log-rank test.
 Note2: NHS body band 1 is corresponding to the lower salary grade while NHS body band 9 is corresponding to the higher pay grade

risks were not fully explained by demographics, economic situation, occupational exposure, clinical factors, or home environment. Although SARS-CoV-2 infection incidence increased during the second wave of the pandemic, risk groups remained similar between the first and second COVID-19 outbreak waves.

One of the major contributions of our study is to rigorously quantify the higher risk for being infected by the SARS-CoV-2 virus among ethnic minorities in the healthcare workforce during both outbreak waves of the pandemic. Our results support previous findings showing higher risk for SARS-CoV-2 infection among Black and South Asian healthcare workers in the UK (Nguyen et al., 2020; Eyre et al., 2020; Martin et al., 2020; Shields et al., 2021; Valdes et al., 2021; Ken-Dror et al., 2021; Hanrath et al., 2021;

Shields et al., 2020; Shorten et al., 2021; Patel et al., 2021; Kua et al., 2021). Yet, our research is one of the first to have considered more than one year of follow-up and found no differential changes in SARS-CoV-2 exposure by ethnic group between waves. Similar results have been found in general population in another high-income country (Coyer et al., 2022). Although Black and Asian communities were considered to be at higher risk for SARS-CoV-2 infections during the first wave of the pandemic, their persistent higher risk during the second wave suggests that interventions aimed at protecting them were either absent or failed in reducing their occupational risk (Public Health England, 2020; Iacobucci, 2020). Considering the fact that these communities tend to have worse clinical outcomes when tested positive for COVID-

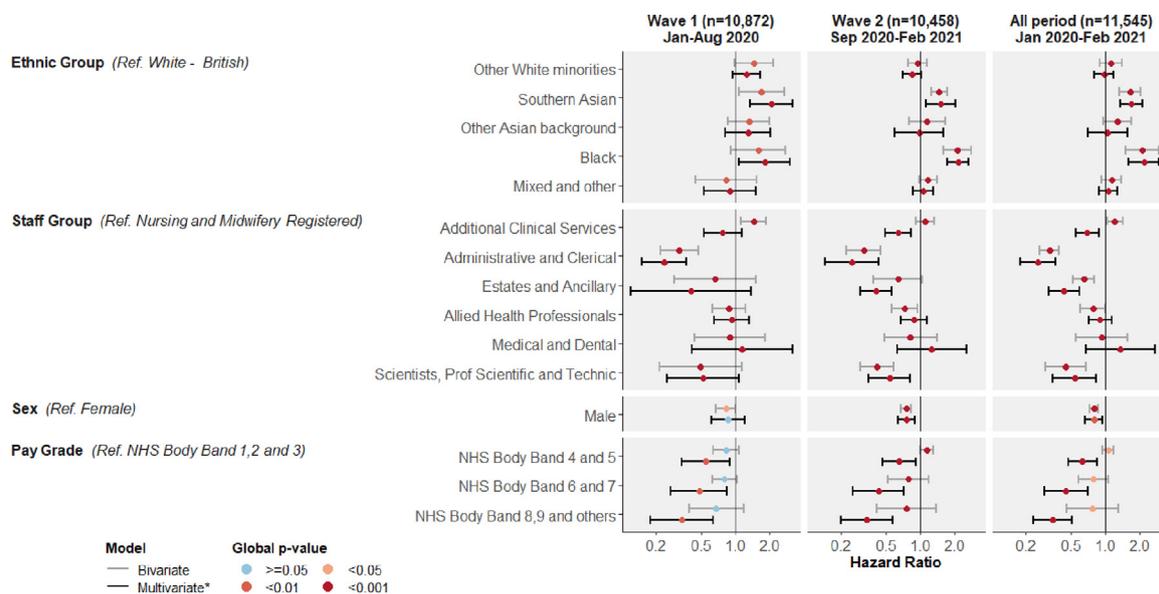


Figure 3. Hazard ratio of COVID-19 positive test among healthcare professional by time period, bivariate and multivariate Cox models. NHS: National Health Service. * adjusted for age, contract type, index of multiple deprivation, urban-rural classification, number of non-COVID diseases, number of isolation days and number of other leave of absence days. The associated result table with all the covariables can be found in Table S2 and Table S3 in supplementary materials
 Note1: two-sided P-values were computed using Wald-test adjusted for clustering.
 Note2: NHS body band 1 is corresponding to the lower salary grade while NHS body band 9 is corresponding to the higher pay grade
 Note3: logarithmic scale has been used for the hazard ratio axis

19 (Chaudhuri et al., 2021; Mathur et al., 2021), tailored interventions as well as improved access to vaccination are urgently needed to protect essential workers who belong to the ethnic minority (Iacobucci, 2020; Race Disparity Unit, Cabinet Office, 2021).

A second contribution of this paper is to show persistent infection risk among Black and South Asian communities even after adjusting for demographics, economic situation, occupational exposure, clinical factors, or home environment. In other words, the occupational, socioeconomic, and environmental conditions do not fully explain the persistent higher risk among Black and South Asian NHS staff members in our study. This persistent higher risk may suggest other potential risk factors that were not collected or partially collected in our analysis. For example, this persistent risk could be explained by the nonaccess to or inadequate use of personal protective equipment found in other studies (Nguyen et al., 2020; Valdes et al., 2021). Additionally, although economic and social home environment through IMD and rural-urban classification of home residence were considered in our analysis, some important factors, such as household composition or use of public transport, have not been included (Katikireddi et al., 2021). It is also possible that other occupational exposures, such as working location (e.g., intensive care), can explain the higher exposure in several ethnic minorities (Eyre et al., 2020).

Our findings reinforce the results from other studies that show the limited effect of the IMD among healthcare professionals (Shields et al., 2020; Valdes et al., 2021). The IMD is an area-level indicator rather than individual-level socioeconomic position, which may not be representative of every individual, especially those currently working and who may be less likely to be affected by the environment in which they live. However, after adjusting for other individual characteristics and staff group, we found that having a lower salary was associated with the risk for being tested positive for SARS-CoV-2. This last result could reflect other social inequalities, such as public transport dependence to go to work or overcrowded housing, that are linked to higher SARS-CoV-2 exposure (Hayward et al., 2021).

Another strength of our analysis is to have considered exposure time at work. As expected, those spending more time at work and those who did not take any leave days were those more likely to be tested positive for SARS-CoV-2, which suggests that these professionals were mainly infected at work and not outside of their workplace. Alternatively, this result could be explained by the fact that exposed health staff (e.g., intensive care or emergency department workers) may have taken less time off work because of the increased demand for care caused by the pandemic. Regarding isolation periods, our results show higher risk for SARS-CoV-2 infection among those self-isolating for less than two weeks than those isolating for a longer time. Staff required to self-isolate for two weeks were often those who have been exposed to COVID-19 cases, whereas those required to self-isolate for a long period were mainly vulnerable staff (e.g., pregnant women, older employees) who were asked to shield from a potential SARS-CoV-2 infection.

Our results show that staff groups, such as nurses, doctors, and additional clinical services (i.e., healthcare assistants, support workers), were found to be at higher risk for SARS-CoV-2-infection. This result is expected as these staff groups are in close contact with patients and are such more likely to be exposed to SARS-CoV-2 infection (Hayward et al., 2021).

Our study has several limitations. First, SARS-CoV-2 tests were mostly targeted to symptomatic or contact cases during the first wave, which may have underestimated the SARS-CoV-2 incidence in our results. Second, we were not able to access data on the number of tests performed by individuals, specifically the negative ones, because only the positive results were collected. Thus, it was not possible to control for the number of tests done by individuals. However, ethnic differences in testing are shown to be small during the first two waves of the pandemic (Mathur et al., 2021). Therefore, the higher risk for a positive SARS-CoV-2 test among ethnic minorities is unlikely to be a result of a higher number of tests performed. Vaccination status was not collected at the time of the study, although vaccination rollout began for frontline healthcare professionals in mid-December 2020, 60 days before the end

of our study follow-up, which may have limited the effect of vaccination on our results (*Medicines and Healthcare products Regulatory Agency (MHRA), 2020*). The reason for sick leave was not available for more of our population; thus, we were not able to consider specific conditions (e.g., diabetes, cardiovascular disease, other infections), although most of these conditions are more associated with a higher risk for COVID-19-related mortality than with a higher risk for infection (*de Lusignan et al., 2020; Piroth et al., 2021; Shields et al., 2021*).

Nevertheless, our survey is one of the first to document SARS-CoV-2 exposure across one year of follow-up among a large population of healthcare professionals at a regional level. The fact that we included the three NHS trusts operating within the region has facilitated a comprehensive sample. Yet, it is possible that private sector structures as well as several GP surgeries may not have been included in our study. Because most of these structures were doing online consultations or referring people to the hospital in case of severe symptoms of COVID-19, professionals working in these structures could have been less exposed to SARS-CoV-2 infections than those working in a hospital setting.

Evidence indicates low vaccine coverage among healthcare workers, especially with Black and South Asian groups (*Martin et al., 2021*). Vaccine hesitancy has been shown to be higher in ethnic minority groups as well as in the most socioeconomic deprived areas (*Razai et al., 2021*). This disparity in vaccination uptake could lead to increased risk for SARS-CoV-2 infection in these communities during future waves of the outbreak. Reducing access inequalities to protective intervention and measures is urgently needed.

Conclusion

Black and South Asian healthcare workers were consistency at risk for SARS-CoV-2 infection, independent of the period considered. Risk exposure inequalities on the basis of pay grades and sex were also found in our results. Research on interventions aiming to reduce socioeconomic and occupation-based SARS-CoV-2 exposure with these vulnerable groups are urgently needed.

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Competing interest statement

All authors declare no support from any organization for the submitted work; no financial relationships with any organization that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Ethical approval

Data sharing agreements were signed with each trust that provided their data. Given that we were working with a routinely collected existing NHS staff dataset, there was no active recruitment of participants. In addition, the dataset that was provided were anonymized; therefore, there was no direct approach from the research team for informed consent. The study received a favorable

ethical opinion from the Human Ethics Committee at the University of Lincoln on the May 28, 2020 (REC Ref: 2020-3511).

STROBE Statement—checklist of items that should be included in reports of observational studies

Author contributions

RK, JP, TH, and FT conceived the study. MI, RK, JP, TH, and FT contributed to the study design and protocol development. MI, RK, TMC, and TK obtained the data. MI analyzed the data. MI, RK, PL, DN, ZA, and FT contributed to the interpretation of the results. MI and RK had full access to all the data and take responsibility for the integrity of the data as well as the accuracy of the data analysis. MI, RK, PL, and DN wrote the first draft of the manuscript. All authors provided substantive feedback on the manuscript and have read and approved the final version. MI is the guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Transparency declaration

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Data availability

The study data are not publicly available. However, access to the anonymized dataset can be obtained upon approval from participating National Health Service Trusts. The corresponding author can liaise with the point of contact in each trust upon reasonable request.

Code availability

Code related to the analysis can be provide upon request to the corresponding author.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.ijid.2022.05.013](https://doi.org/10.1016/j.ijid.2022.05.013).

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