Received: 15 June 2023 | Revised: 14 September 2023 | Accepted: 22 September 2023

DOI: 10.1002/ajim.23542

RESEARCH ARTICLE

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE WILEY

# The role of occupation in SARS-CoV-2 infection within a Brazilian municipality: A test-negative case-control study

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**Funding information**

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## Abstract

**Objective:** To investigate the association between occupation and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections within a Brazilian municipality.

**Methods:** In this test-negative study, cases and controls were randomly selected among individuals aged 18–65 years that were registered in a primary health care program in São Caetano do Sul, Brazil. Those who had collected samples for RT-PCR testing between April 2020 and May 2021 were randomly selected to compose the case (positive for SARS-CoV-2) and control (negative for SARS-CoV-2) groups, frequency-matched by sex, age group, and month of sample collection. Complementary data were collected through phone interviews. We estimated the residual effect of occupation on SARS-CoV-2 infection using multiple conditional logistic regression models incrementally adjusted for confounding variables.

**Results:** 1724 cases and 1741 controls who reported being at work at the time of RT-PCR collection were included. Cases were mainly females (52.9%), Whites/Asians (73.3%), and unvaccinated against COVID-19 (46.6%). Compared to other university-level professionals, the highest odds of having COVID-19 were found for workers in police and protective services (odds ratio [OR] 2.21; 95% confidence interval [CI] 1.27–3.84), healthcare and caregiving (OR 1.90; 95% CI 1.34–2.68), and food retail and production (OR 1.88; 95% CI = 1.14–3.11), after adjustment for age, sex, education, means of transport, household crowding, and COVID-19 vaccination.

**Conclusion:** Occupation played an important role in SARS-CoV-2 infection. Food retail and production, health care and caregiving, and police and protective services showed the highest odds of SARS-CoV-2 infection.

KEYWORDS

Brazil, case-control studies, COVID-19, occupational exposure, occupational groups, SARS-CoV-2

## 1 | INTRODUCTION

In March 2023, Brazil, which has approximately 2.7% of the world's population,[1] reached 700,000 COVID-19 deaths, representing 10.3% of global deaths from this disease.[2] Cases are underreported due to the evolving characteristics of the infection, absence of a mass testing policy and, since 2022, easy access to self-tests without a notification flow. Although the World Health Organization declared the pandemic end as a global health emergency,[3] the scenario remains uncertain as there is a continuous emergence of new strains of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) with high transmissibility and vaccine evading.[4]

The pandemic imposed an initial phase of economic slowdown due to the need for physical distancing and mandatory lockdowns, followed by a gradual resumption of work activities. These movements were characterized by profound changes in individual and social habits. Social and economic inequalities were disclosed by differences in access to protective measures, since not all individuals could adequately avoid exposure to the virus, either because they were essential workers, they needed to work for survival, or could not work remotely. According to the Institute of Applied Economic Research, approximately 11% of the employed Brazilian population, were working remotely in 2020.[5]

On March 20, 2020, the Brazilian government published Decree No. 10,282, defining essential services for the population, such as food supply, health services, banks, public cleaning services, and security, industrial and agricultural activities. Four subsequent Decrees altered that list to include religious organizations, lottery retailers, beauty salons, and gyms.[6] It should be noted that, although they can represent more than 50% of the workforce, there is no single definition of essential workers.[7]

Soon after the beginning of the pandemic it was clear that work was a variable to be considered when assessing the risk of infection with SARS-CoV-2, and healthcare workers were not the only ones at an increased risk.[8] Subsequent studies quickly identified that other professions, like drivers in public transportation, retail and sales workers, domestic workers, and public safety workers were at an increased risk of infection.[9] Physical proximity[10,11] and working in poor ventilated areas[12] were reported as being associated with increased risk of infection. In the United Kingdom, data from the BIOBANK in the early period of the pandemic showed that the risk of severe COVID and death from COVID was significantly higher in workers considered essential, notably in health services, social care, and transport.[13] A study on COVID-19 mortality in an expanded population in England revealed that occupational factors were relevant for health workers, social workers, salespersons, and drivers, even when confounding factors and mediators were included in the modelling.[14]

The contribution of work to the burden of SARS-CoV-2 infection and illness, as well as the sectors and occupations involved, are not directly comparable between countries, as they involve singularities of social and economic structures that, in turn, reflect different exposures and risks. In Brazil, occupations related to healthcare, education, and retail/sales presented a higher risk of SARS-CoV-2 infection.[15] An exploratory analyses of data from 1,627,374 interviews collected in the National Household Sample Survey (PNAD-COVID) in July 2020, encompassing workers in both formal and informal jobs, showed that the sectors with the highest prevalence of positive results for the COVID-19 antigen were human health and social work (27.6%), public administration (12.7%), commerce (10.4%), and education (9.1%). Among informal workers, the most affected occupations were salespersons (16.6%), food services workers (8.2%), domestic workers (7.9%), and construction workers (7.7%).[16]

There is little information on the occupational risks of SARS-CoV-2 infection in Latin American countries, including Brazil, which is critical to reduce COVID-19 cases and develop public policies in the long term. This study aims to investigate the association between occupation and SARS-CoV-2 infections within a Brazilian municipality.

## 2 | METHODS

### 2.1 | Study design

This is a test-negative case-control study in which participants were selected from the "Corona São Caetano"[17] platform and classified as cases or controls based on RT-PCR test results. Test-negative studies enroll as cases individuals who visit a healthcare facility and receive a positive test result for a specific disease. Controls are selected among individuals undergoing identical tests, for the same reasons, at the same health care facility, but yielding negative test results.[18] Primary data were collected through phone interviews.

### 2.2 | Setting

Corona São Caetano is a primary care program from the municipality of São Caetano do Sul that assists residents with suspected COVID-19 symptoms. It was established in March 2020 in response to the COVID-19 health emergency.[19]

São Caetano do Sul is part of the São Paulo metropolitan area, in the southeast region of Brazil. Its population was estimated at 162,763 inhabitants in 2021. Its Human Development Index is the highest in the country, and the proportion of the population with higher education degrees is higher than the national average.[20] For 2020, the proportion of employed population was estimated at 74.7% and the average monthly wage of formal workers at 3.1 minimum wages.[20]

Individuals with symptomatic COVID-like illness were encouraged, by the local media, to access the program via telephone or website, and were invited to answer a screening questionnaire that includes sociodemographic data, and type, onset, and duration of symptoms. All individuals who met the suspected COVID-19 case definition received a phone call for clinical assessment, and were referred for sample collection, as necessary. All pregnant women and individuals with serious illness were referred to a hospital.[19]

The study population was composed of individuals registered at the Corona São Caetano platform who submitted to sample collection for RT-PCR between April 6, 2020, and May 31, 2021. Phone interviews were conducted from June 17, 2021 to August 19, 2021.

## 2.3 | Participants

Individuals aged 18–65 years who reported working at the time of testing were eligible. The cases were randomly selected from individuals who had at least one positive result in the RT-PCR test. Individuals with negative results in all tests were eligible for the control group. The time frame between the RT-PCR test and the interviews ranged from 1 to 16 months with a median of 7 months (±3.7).

Samples were self-collected using a nasopharyngeal swab under the supervision of trained healthcare personnel, transferred to a bottle containing transport medium, and conveyed to the Clinical Analysis Laboratory at the University of São Caetano do Sul (USCS), where RT-PCR tests were performed. Additional information can be found in corollary publications.[17]

Controls were matched to cases (1:1) by sex, age group (18–25, 26–35, 36–45, 46–55, and 56–65 years), and month of sample collection.

Trained interviewers contacted the participants by text message to schedule the interviews, which were conducted both inside and outside of business hours. When there was no response after three attempts, the individual was considered a loss. If the nonrespondent was eligible for the control group, they were replaced, respecting the eligibility and matching criteria.

## 2.4 | Variables

The study outcome was SARS-CoV-2 infection and the dependent variable was the occupational category. Occupation was collected as an open question and was subsequently coded according to the Brazilian Classification of Occupations (CBO) by an experienced interviewer. CBO is the classification adopted by the Brazilian Institute of Geography and Statistics (IBGE) to normalize, name and code occupations in the Brazilian labor market for statistical purposes.[21] Afterwards, two occupational health experts (E. A. and M. M.) reclassified the occupations manually. Each occupation was assigned to a group of the Classification of Occupations for Household Research (COD), developed by the IBGE[22] with reference to the International Standard Classification of Occupations (ISCO), proposed by the International Labor Organization.[23] COD is identical to ISCO at the most aggregated level, and re-groups some major subgroups and grassroots groups. This reclassification resulted in occupations being obtained in 28 of the 36 groups. The groups were reclassified with lesser disaggregation for analysis purposes, as many occupations had a small number of respondents, resulting in 10 groups (Supporting Information: Table 1).

The covariates were: sex (female/male), age group (18–25, 26–35, 36–45, 46–55, and 56–65 years), education (elementary school, high school, higher education), commonly used means of transport (car, motorcycle, bicycle, and on foot), household crowding (people per room: ≤1, >1), and COVID-19 vaccination (none, incomplete schedule, complete schedule).

## 2.5 | Data sources and measurement

Name, telephone, registration number, date of sample collection, RT-PCR results, date of birth, and sex were extracted from the Corona São Caetano platform database. Occupation and the other variables were self-reported by the participants through phone interviews conducted by trained interviewers, who used a questionnaire previously tested in a pilot study with 20 eligible individuals who did not participate in the study. Data were recorded on SurveyMonkey and transferred to spreadsheets.

## 2.6 | Bias control

Given the availability of the RT-PCR test results for COVID-19, the test-negative study design was adopted. This design has many advantages, such as similarities between groups in proportions of participation, in information quality and integrity, in the participants' original geographical area, in the probability of including individuals with behavioral similarities, and in the protocols adopted by the health services to indicate the diagnostic test.[24] Thus, cases and controls became eligible for the study with similar manifestations of the disease. The matching procedure reduced potential confounding. The construction of sequential multiple conditional logistic models allowed the analysis of potentially confounding variables and consistency of the effect measures. The use of clinical data from the platform, as well as the relatively short period elapsed between the performance of diagnostic tests for COVID-19 and the interview, contributed to minimizing information bias. Data collection by trained interviewers favored internal validity.

## 2.7 | Study size

Sample size was defined as 5000 individuals (2500 cases and 2500 controls), based on the availability of resources for interviews. Initially, 3000 eligible individuals were randomly drawn to compose the case group, considering potential refusals or losses of participants when contacted by phone. For each eligible case, two eligible controls were randomly selected, considering the possibility of loss of eligible controls paired to the selected cases. Given that the proportion of losses during data collection exceeded 20%, a further 1000 eligible individuals were randomly selected for the case group and 2000 for the control group. The interviews continued until the defined sample size was reached.

## 2.8 | Statistical analyses

Initially, descriptive analyses were performed to estimate the frequencies of the variables of interest and to compare them between cases and controls, using $\chi^2$ tests. To estimate the odds ratio (OR) and 95% confidence intervals (95% CI) of the association

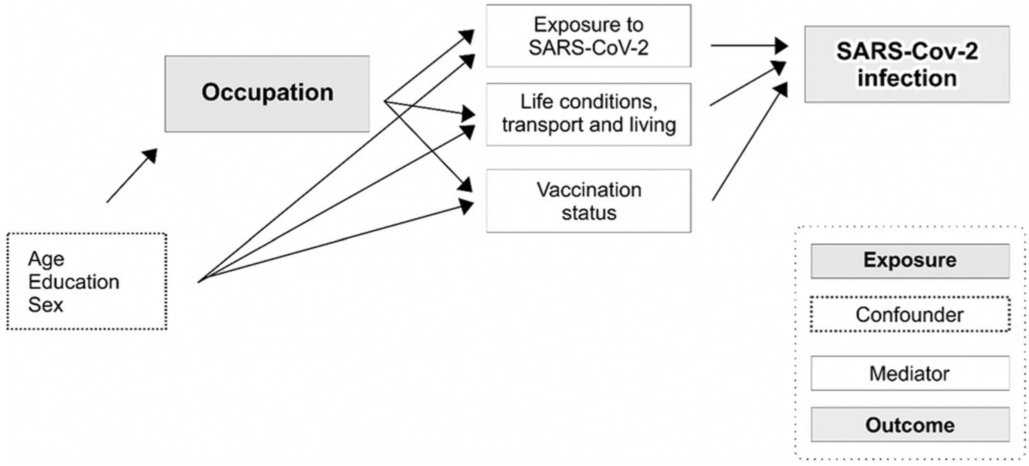


**FIGURE 1** Directed acyclic graph (DAG) to assess occupational exposure in SARS-Cov-2 infection. Adapted from: Nafilyan et al.[13,14]

between occupational category and SARS-CoV-2 infection, we used conditional logistic regression models, having "other university-level professions" as reference category (Supporting Information: Table 1). We chose it as the reference category due to their greater possibility of teleworking. Although many health and education professionals have higher education degrees, we kept them separate because of the intrinsic nature of their jobs.

Sample collection date was the conditional matching variable. This variable was included to account for the differential risk of SARS-CoV-2 infection over time, given the course of the epidemic in the source population. Covariates were selected based on the model developed by Nafilyan et al.[14] which included factors such as age group, sex, ethnicity, education, living and health conditions (Figure 1). These factors can affect occupational choice and can be associated with SARS-CoV-2 infection and COVID-19 outcomes. Their inclusion in incremental models was adopted to verify the residual effects of occupation.

Following crude analyses, we estimated three models, sequentially adjusting for additional covariables to assess how they might be confounding or mediating the association of interest. Our first model was adjusted for sex and age, as these variables were used for matching.[25] The second also included means of transport and household crowding, related to living conditions. The third was further adjusted for COVID-19 vaccination status. Statistical analyses were performed in Stata version 15 (Stata Corp.). We considered $p < 0.05$ to be statistically significant.

## 3 | RESULTS

From April 06, 2020, to April 22, 2021, there were 20,613 individuals aged 18–65 years with RT-PCR tests for COVID-19 registered in the platform. Of these, 6275 (30.4%) individuals were laboratory-confirmed for SARS-CoV-2 infection, hence eligible for the case group, and 14,338 (69.6%) tested negative and were eligible for the control group. After the targeted sample size was reached, 776 individuals in the case group and 759 in the control group were excluded because they were not working on the date of sample collection. Thus, the study included 1724 cases and 1741 controls (Figure 2).

Overall, there were more females ($n$ = 1835; 53.0%), Whites/Asians ($n$ = 2607; 75.5%), individuals aged 36-45 years ($n$ = 1098; 31.7%), with higher education degrees ($n$ = 1,768; 51.0%), and without financial difficulties ($n$ = 1412; 40.8%). The prevalence of complete vaccination schedules was 14.0% ($n$ = 484), being 11.5% ($n$ = 199) and 16.4% ($n$ = 285) among cases and controls, respectively. The most frequent occupational categories were clerical, office and other support staff (n = 582; 33.8%), and other university-level professionals ($n$ = 291; 16.9%) (Table 1). Among the occupational categories, workers in Education ($n$ = 70; 30.8%), Health Care and Caregiving ($n$ = 161; 55.9%) and Police and Protective Services ($n$ = 28; 36.4%) presented higher prevalence of vaccination (Supporting Information: Table 2).

Inequalities in the diagnosis of COVID-19 were found in the bivariate analysis. Brown and black workers (OR = 1.36; 95% CI = 1.15–1.60) and those whose level of education was elementary school (OR = 1.33; 95% CI = 1.02–1.73) presented the highest odds of infection. Furthermore, occupational categories considered "essential" had a higher chance of SARS-CoV-2 infection than other university-level professionals, such as food retail and production (OR = 1.92; 95% CI = 1.21–3.03), housekeeping and maintenance (OR = 1.57; 95% CI = 1.12–2.22), and industry, construction and agriculture (OR = 1.51; 95% CI = 1.12–2.02) (Table 1).

The association between occupation and SARS-CoV-2 infection was observed in the three incremental models. In model 1, the highest chance of SARS-CoV-2 infection occurred in the occupational categories of housekeeping and maintenance, food retail and production, industry, construction and agriculture, and retail and sales. Of these, only retail and sales had no difference compared to other university-level professionals after adjustment in model 2. In model 3, the inclusion of vaccination modified the results. Housekeeping and maintenance, food retail and production, and industry,

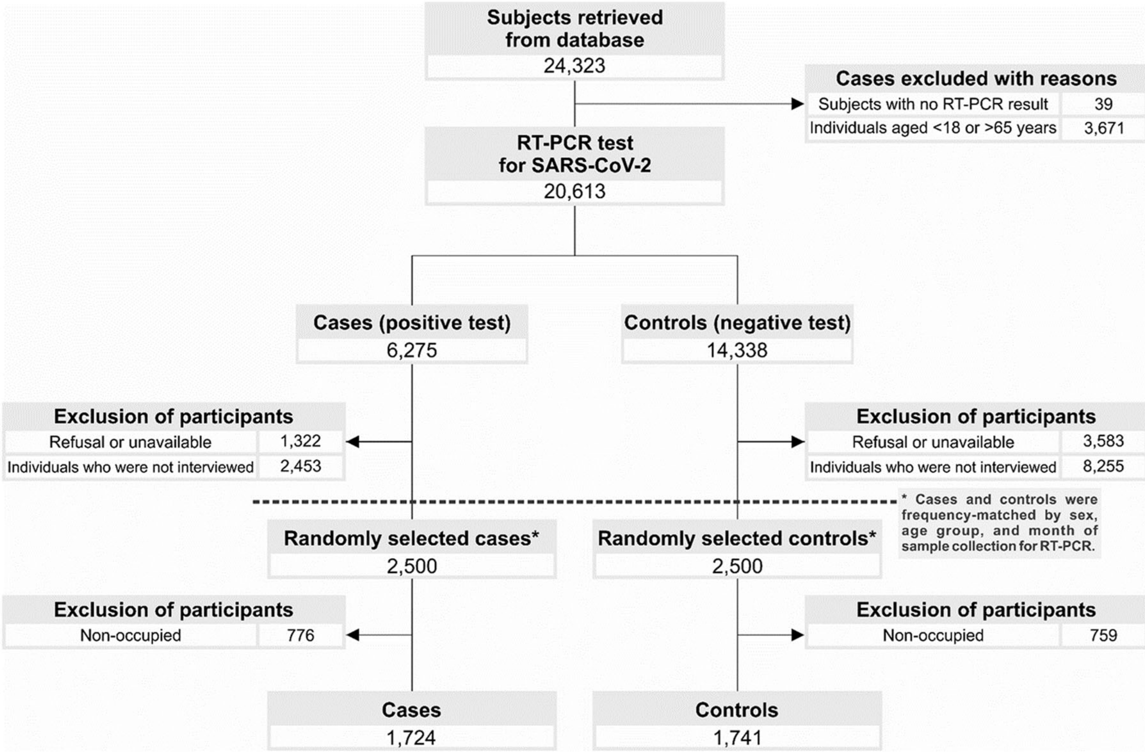


**FIGURE 2** Flow diagram showing the selection of eligible cases and controls, São Caetano do Sul, 2020–2021.

construction and agriculture presented higher odds of infection. However, healthcare and caregiving (adjusted OR = 1.90; 95% CI = 1.34–2.68) and police and protective services (adjusted OR = 2.21; 95% CI = 1.27–3.84) workers presented higher odds only after adjustment for COVID-19 vaccination (Figure 3 and Table 2).

## 4 | DISCUSSION

To our knowledge, this is the first study in Brazil that investigated the role of occupation in SARS-CoV-2 infection using a test-negative design. We found a positive association between SARS-CoV-2 infection and occupations such as housekeeping and maintenance, food retail and production, industry, construction and agriculture, healthcare and caregiving, and police and protective services, compared to other university-level professionals. It is worth noting that the socioeconomic characteristics of this study's sample differ from those of Brazil overall, a country where 52.1% of the working age population was emplyed in 2021,[26] 42.7% of the population declared being white, and only 21% of the adult population had higher education degrees.[27] Even so, inequalities related to skin color and low educational level were clearly reflected by a greater chance of infection among black/brown individuals and those with elementary or secondary educational level. Racial and ethnic inequalities are known and persistent in Brazil, and during the first year of the pandemic were reflected by the higher chances of Brazilian Afro-descendant men dying from COVID-19, irrespective of their placement in the labour market.[28] During the first 4 months of the pandemic, in the state of Rio de Janeiro, non-whites and individuals with lower socioeconomic conditions presented a higher risk of dying from COVID-19.[29] In 2020, in the US, an overall analysis of racial and ethnic differences that split ethnicity into 12 groups showed that blacks and Latinos with a lower educational level were over-represented in lower standing occupations that entailed a higher risk of SARS-CoV-2 infection.[30]

At the time of testing, 29% of the individuals reported working remotely, without having contact with anybody except for family members. This percentage was much higher than the national estimates (17.8%), and higher than those referring to blacks and browns, among workers with a lower educational level and with a precarious employment status.[31] Even among workers with college education in the US, the odds for teleworking among African Americans were 35% lower than those for white workers.[32]

An analysis of death certificates containing occupational information calculated the proportion of deaths in 2020 due to COVID-19 among occupations listed in the Brazilian Classification of Occupations. Higher proportions were found in religious leaders, health care workers, security services, and arts and culture workers.[28] A study conducted in the state of Rio de Janeiro from March to July 2020 showed similar results: healthcare workers, public order and safety professionals, and police and protective service workers had a greater chance of dying from COVID-19.[29] In England, a population-based cohort study showed that, in addition to occupation, other risk factors such as ethnicity,

**TABLE 1** Cases and controls according to sociodemographic variables, occupational category, and vaccine status for SARS-CoV-2 infection. São Caetano do Sul, 2020-2021.

| Variable | Total *n* (%) | RT-PCR test *n* (%) Positive | Negative | OR (95% CI) | *p* Value |
|---|---|---|---|---|---|
| | 3465 (100.0%) | 1724 (50.0%) | 1741 (50.0%) | | |
| Sex | | | | | |
| Male | 1630 (47.0) | 812 (47.1) | 818 (47.0) | Ref. | |
| Female | 1835 (53.0) | 912 (52.9) | 923 (53.0) | 0.99 (0.86–1.14) | 0.872 |
| Age group | | | | | |
| 18–25 | 392 (11.3) | 182 (10.5) | 210 (12.1) | Ref. | |
| 26–35 | 834 (24.1) | 413 (24.0) | 421 (24.2) | 1.21 (0.93–1.56) | 0.151 |
| 36–45 | 1098 (31.7) | 553 (32.1) | 545 (31.3) | 1.23 (0.96–1.58) | 0.093 |
| 46–55 | 716 (20.6) | 365 (21.2) | 351 (20.1) | 1.26 (0.97–1.64) | 0.081 |
| 56–65 | 425 (12.3) | 211 (12.2) | 214 (12.3) | 1.18 (0.88–1.57) | 0.271 |
| Ethnic group[a] | | | | | |
| White and Asian | 2607 (75.5) | 1260 (73.3) | 1347 (77.7) | Ref. | |
| Black and Brown | 847 (24.5) | 460 (26.7) | 387 (22.3) | 1.36 (1.15–1.60) | <0.001 |
| Education | | | | | |
| University education | 1768 (51.0) | 827 (48.0) | 941 (54.1) | Ref. | |
| Elementary school | 300 (8.7) | 162 (9.4) | 138 (7.9) | 1.33 (1.02–1.73) | 0.034 |
| High school | 1397 (40.3) | 735 (42.6) | 662 (38.0) | 1.32 (1.13–1.54) | <0.001 |
| Difficulty to survive with family income until the end of the month | | | | | |
| Without difficulty | 1412 (40.8) | 689 (40.0) | 723 (41.5) | Ref. | |
| With difficulty | 987 (28.5) | 511 (29.6) | 476 (27.4) | 1.12 (0.94–1.34) | 0.183 |
| With some difficulty | 1065 (30.7) | 524 (30.4) | 541 (31.1) | 1.03 (0.87–1.22) | 0.727 |
| Household crowding (people per room) | | | | | |
| <=1 | 2946 (90.3) | 1464 (89.4) | 1482 (91.3) | Ref. | |
| >1 | 315 (9.7) | 173 (10.6) | 142 (8.7) | 1.23 (0.96–1.58) | 0.106 |
| Occupational categories | | | | | |
| Other university-level professions | 642 (18.5) | 291 (16.9) | 351 (20.2) | Ref. | |
| Housekeeping and maintenance | 212 (6.1) | 121 (7.0) | 91 (5.2) | 1.57 (1.12–2.22) | 0.009 |
| Clerical, office and other support staff | 1232 (35.6) | 582 (33.8) | 650 (37.3) | 1.07 (0.87–1.32) | 0.499 |
| Retail and sales | 236 (6.8) | 130 (7.5) | 106 (6.1) | 1.50 (1.09–2.07) | 0.013 |
| Transport and delivery workers | 148 (4.3) | 83 (4.8) | 65 (3.7) | 1.42 (0.96–2.08) | 0.077 |
| Food retail and production | 99 (2.9) | 60 (3.5) | 39 (2.2) | 1.92 (1.21–3.03) | 0.005 |
| Industry, construction and agriculture | 304 (8.8) | 165 (9.6) | 139 (8.0) | 1.51 (1.12–2.02) | 0.006 |
| Education | 227 (6.5) | 107 (6.2) | 120 (6.9) | 1.05 (0.76–1.45) | 0.775 |
| Healthcare and caregiving | 288 (8.3) | 144 (8.3) | 144 (8.3) | 1.27 (0.93–1.71) | 0.126 |
| Police and protective services | 77 (2.2) | 41 (2.4) | 36 (2.1) | 1.52 (0.92–2.52) | 0.104 |
| Commonly used means of transport | | | | | |
| Car, motorcycle, bicycle, on foot | 2883 (83.2) | 1442 (82.5) | 1461 (83.9) | Ref. | |
| Public transport | 582 (16.8) | 302 (17.5) | 280 (16.1) | 1.12 (0.93–1.36) | 0.238 |

(Continues)

**TABLE 1** (Continued)

| Variable | Total *n* (%) | RT-PCR test *n* (%) | | OR (95% CI) | *p* Value |
|---|---|---|---|---|---|
| | | Positive | Negative | | |
| Vaccination against COVID-19 | | | | | |
| No | 1326 (38.3) | 802 (46.6) | 524 (30.1) | Ref. | |
| Incomplete vaccination schedule | 1655 (47.7) | 723 (41.9) | 932 (53.5) | 0.36 (0.30–0.44) | <0.001 |
| Complete vaccination schedule | 484 (14.0) | 199 (11.5) | 285 (16.4) | 0.32 (0.25–0.41) | <0.001 |

Abbreviations: OR, odds ratio; 95% CI, confidence interval of 95%; Ref., Reference.

[a]The sample presented 10 indigenous people and 1 missing.

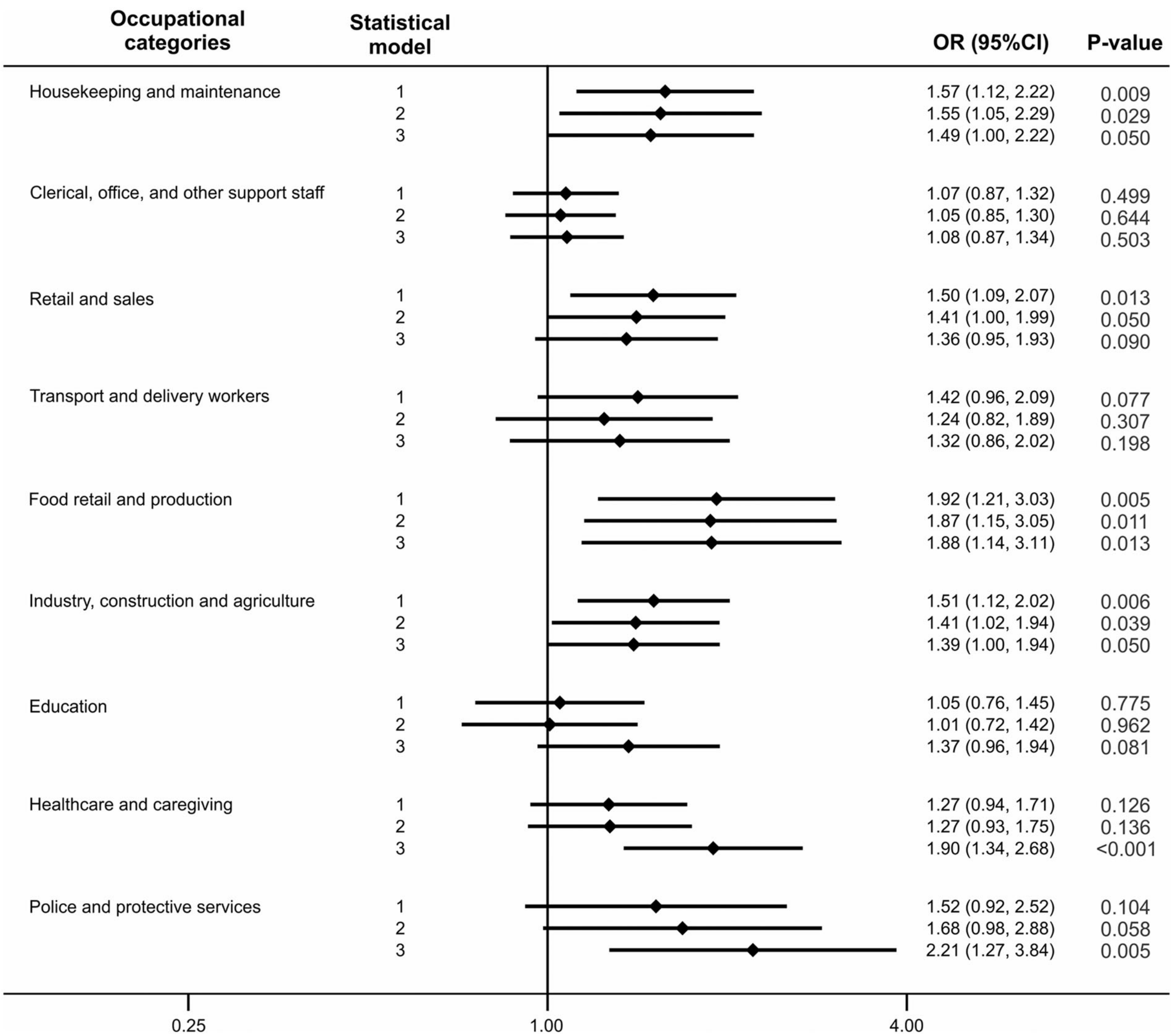


**FIGURE 3** Forest plot depicting pooled odds ratio for cases and controls according to occupational category.[a,b,c]. [a]Data based on conditional logistic regression models for nine occupational categories compared to "Other university-level professions". [b]Adjustment set by model: (1) age group and sex; (2) age group, sex, education, means of transport, and household crowding; and (3) age group, sex, education, means of transport, household crowding, and COVID-19 vaccination. [c]In all three models, cases and controls were grouped by sample collection date for the RT-PCR test. OR, odds ratio; 95% CI, confidence interval of 95%.

**TABLE 2** Incremental multiple conditional regression models of the association between occupational category and SARS-CoV-2 infection, São Caetano do Sul, 2020–2021.

| | Model 1[a] (*n* = 3403) | | Model 2[b] (*n* = 3192) | | Model 3[c] (*n* = 3192) | |
|---|---|---|---|---|---|---|
| Variable | Adjusted OR (95% CI) | *p* Value | Adjusted OR (95% CI) | *p* Value | Adjusted OR (95% CI) | *p* Value |
| Occupational categories | | | | | | |
| Other university-level professions | Ref. | | Ref. | | Ref. | |
| Housekeeping and maintenance | 1.57 (1.12–2.22) | 0.009 | 1.55 (1.05–2.29) | 0.029 | 1.49 (1.00–2.22) | 0.050 |
| Clerical, office and other support staff | 1.07 (0.87–1.32) | 0.499 | 1.05 (0.85–1.30) | 0.644 | 1.08 (0.87–1.34) | 0.503 |
| Retail and sales | 1.50 (1.09–2.07) | 0.013 | 1.41 (1.00–1.99) | 0.050 | 1.36 (0.95–1.93) | 0.090 |
| Transport and delivery workers | 1.42 (0.96–2.09) | 0.077 | 1.24 (0.82–1.89) | 0.307 | 1.32 (0.86–2.02) | 0.198 |
| Food retail and production | 1.92 (1.21–3.03) | 0.005 | 1.87 (1.15–3.05) | 0.011 | 1.88 (1.14–3.11) | 0.013 |
| Industry, construction and agriculture | 1.51 (1.12–2.02) | 0.006 | 1.41 (1.02–1.94) | 0.039 | 1.39 (1.00–1.94) | 0.050 |
| Education | 1.05 (0.76–1.45) | 0.775 | 1.01 (0.72–1.42) | 0.962 | 1.37 (0.96–1.94) | 0.081 |
| Healthcare and caregiving | 1.27 (0.94–1.71) | 0.126 | 1.27 (0.93–1.75) | 0.136 | 1.90 (1.34–2.68) | <0.001 |
| Police and protective services | 1.52 (0.92–2.52) | 0.104 | 1.68 (0.98–2.88) | 0.058 | 2.21 (1.27; 3.84) | 0.005 |
| Age group | | | | | | |
| 18–25 | Ref. | | Ref. | | Ref. | |
| 26–35 | 1.24 (0.96–1.61) | 0.101 | 1.27 (0.97–1.67) | 0.080 | 1.51 (1.14–1.99) | 0.004 |
| 36–45 | 1.25 (0.98–1.60) | 0.078 | 1.29 (0.99–1.68) | 0.057 | 2.01 (1.52–2.67) | <0.001 |
| 46–55 | 1.25 (0.96–1.62) | 0.105 | 1.30 (0.98–1.71) | 0.069 | 2.71 (1.98–3.72) | <0.001 |
| 56–65 | 1.15 (0.86–1.54) | 0.352 | 1.23 (0.90–1.68) | 0.200 | 2.90 (2.04–4.13) | <0.001 |
| Sex | | | | | | |
| Female | Ref. | | Ref. | | Ref. | |
| Male | 1.00 (0.85; 1.16) | 0.979 | 1.03 (0.88; 1.21) | 0.738 | 1.01 (0.85–1.19) | 0.926 |
| Education | | | | | | |
| University education | | | Ref. | | Ref. | |
| Elementary school | | | 1.03 (0.75–1.42) | 0.836 | 0.95 (0.68–1.31) | 0.747 |
| High school | | | 1.16 (0.97–1.38) | 0.094 | 1.07 (0.90–1.28) | 0.454 |
| Household crowding (people per room) | | | | | | |
| <=1 | | | Ref. | | Ref. | |
| >1 | | | 1.07 (0.83–1.39) | 0.602 | 1.05 (0.81–1.37) | 0.715 |
| Commonly used means of transport | | | | | | |
| Car, motorcycle, bicycle, on foot | | | Ref. | | Ref. | |
| Public transport | | | 1.05 (0.86–1.29) | 0.630 | 1.05 (0.85–1.29) | 0.651 |
| Vaccination against COVID-19 | | | | | | |
| No | | | | | Ref. | |
| Incomplete vaccination schedule | | | | | 0.35 (0.29–0.43) | <0.001 |
| Complete vaccination schedule | | | | | 0.26 (0.19–0.35) | <0.001 |

Abbreviations: Adjusted OR, adjusted odds ratio; 95% CI, confidence interval of 95%; Ref., Reference.

[a]Adjusted for: age group and sex;

[b]Adjusted for: age group, sex, education, means of transport, and household crowding;

[c]Adjusted for: age group, sex, education, means of transport, household crowding, and COVID-19 vaccination.

education, living conditions, and comorbidities are determinants of severe COVID-19. However, for health and social work professionals, public transport drivers, and commercial workers, occupation was a significant determinant for severe COVID-19.[13]

COVID-19 vaccination in the state of São Paulo started in mid-January 2021. All the respondents were registered in the Corona platform, but most of them had been interviewed before the start of the vaccination campaign. The prevalence of vaccination among the occupational categories (Supporting Information: Table 2) reflected the country's vaccination defined priorities which did not encompass all essential workers such as food retail and production and commerce and sales.[33] We could not check the time frame between vaccination and RT-PCR collection, nor the vaccination scheme for each individual. Notwithstanding the fragility of the information, considering its relevance, we include it in the final model as an adjustment variable, reinforcing the residual effects of occupation.[34]

The study findings should not be considered a mirror of the Brazilian circumstances because São Caetano do Sul holds a favorable social and economic conditions compared to other Brazilian municipalities. The number of respondents who were working at the time of data collection covered 28 of the 36 occupational groups[21]; the low numbers found in some of them precluded more specific statistical analyses and led to the need for aggregation into 10 broader groups for analysis purposes (Supporting Information: Table 1) limiting the extent of more in-depth analysis for many occupations and possibly introducing a selection bias. The selection of cases and controls was also subject to a potential bias, given that individuals who are covered by health insurance were more likely to seek care in private services and were possibly underrepresented. There may have been an additional selection bias because eligible individuals were not captured when referred to the hospital in case of serious illness. The retrospective nature of this study led to a greater propensity for individuals eligible for the case group to participate in interviews. Another limiting factor was the inclusion of individuals who were tested during a relatively long period of the pandemic, which encompassed two infection waves, the first from February 2020 until November 2020 and the second from late November 2020 until October 2021. In the first wave the parental SARS-CoV-2 B1 strains prevailed, being gradually surpassed by Gamma and Delta strains after November 2020.[35] In this interval, there were changes in flexibility policies, which led to the resumption of social interactions and physically-present activities. As an example, the investigation period covered only 3 months of face-to-face work in education,[36] which was reflected in a odds ratio close to that of the reference category (Figure 3). Fluctuations in the incidence of SARS-CoV-2 infection are known to have occurred in some occupations over this period: data from the province of Ontario, Canada, in an extended period of the pandemic, showed more cases attributable to the workplace in the period from April to August 2020.[37] In the UK, infection rates varied over the course of the pandemic: for example, there was a decrease in risk among health workers and an increase among education workers.[38] In addition, the effect of escalated vaccination according to age and occupational group was not analyzed, as the campaign began in January 2021.

The use of the test-negative design, a particular type of case-control study, has advantages, such as increasing similarities between groups in the proportion of participation of individuals, the quality and completeness of information, the places where participants sought healthcare, and the probability of inclusion of individuals, due to the comparability of diagnostic suspicion and standardization of screening. It allows estimates of the effect measures that are closer to the population parameters.[34] The matching procedure reduced the occurrence of confounding and increased the accuracy of the study. Other strengths of this investigation were the use of data on occupation at the time of sample collection, as well as data on housing conditions and means of transport used by individuals. The use of administrative data and the short period elapsed between diagnostic tests and interviews also contributed to the validity of the study.

## 5 | CONCLUSIONS

This study showed an association between occupation and SARS-CoV-2 infection in a Brazilian municipality. The highest odds of SARS-CoV-2 infection were observed among individuals working in housekeeping and maintenance, food retail and production, healthcare and caregiving, and police and protective services.

Working conditions in similar occupations can vary greatly across countries, entailing distinct risks for infection and, sometimes, making comparisons between studies not only difficult, but also of limited relevance. Even so, conditions such as in-person work, close interpersonal contact and, mostly, inequalities related to educational level and race/ethnicity, all of them connected with job opportunities, are common denominators in the increased odds of SARS-CoV-2 infection. The national vaccination policy did not include all groups of essential workers. Therefore, it is necessary to consider these factors in the implementation of policies for prevention of COVID-19 and other future epidemics in work environments.

### AUTHOR CONTRIBUTIONS

Eduardo Algranti, Maria Maeno, Fabrício dos Santos Menezes, Leila Posenato Garcia, and Tatiana Natasha Toporcov designed the study and sampling, Leandro Campi Prearo directed the data collection and supervised the critique, and Fabrício dos Santos Menezes and Leila Posenato Garcia performed the data analysis. Eduardo Algranti, Leila Posenato Garcia, Fabrício dos Santos Menezes, and Maria Maeno drafted the paper. All authors read and approved the final version and agree to be accountable for all aspects of the work.

### ACKNOWLEDGMENTS

We are indebted to Dr. Dario Consonni, Clinica del Lavoro, Fondazione Ca' Granda, University of Milan, for fruitful discussions and modelling orientation. This work was funded by a grant from

Universidade Municipal de São Caetano do Sul (protocol number: N/A).

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

## DATA AVAILABILITY STATEMENT

Data from administrative records in the "Corona São Caetano Platform" can be obtained by sending a request to the Municipal Health Department. Primary data obtained from interviews cannot be publicly shared due to confidentiality terms and national regulations (i.e., Resolution no. 466/2012 of the National Health Council and Law no. 13.709/2018).

## ETHICS APPROVAL AND INFORMED CONSENT

The study was approved by the Research Ethics Committees of USCS (opinion no. 4,602,907 issued on 03/22/2021) and of the School of Public Health, University of São Paulo (opinion no. 4,632,799 issued on 04/06/2021). All participants provided oral consent.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

**How to cite this article:** Menezes FdS, Garcia LP, Maeno M, Prearo LC, Toporcov TN, Algranti E. The role of occupation in SARS-CoV-2 infection within a Brazilian municipality: a test-negative case-control study. *Am J Ind Med*. 2023;66:1090-1100. doi:10.1002/ajim.23542