Title: SARS-CoV-2 Infection Among Healthcare Workers in Tijuana, Mexico: A cross-sectional study

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Discussion Points:

1. Healthcare workers have higher odds of contracting COVID-19 than the general population.
2. Nurses are the healthcare workers with the highest likelihood of acquiring COVID-19.
3. Resident physicians are the group with higher odds of SARS-CoV-2 infection among the medical hierarchy.
4. Interns in Tijuana, Mexico have a protective factor against COVID-19 because they were withdrawn from the health workforce during the pandemic's first stages.

ABSTRACT.

Background: Healthcare workers (HCW) are a high-risk group for contraction of the SARS-CoV-2 infection. The aim of this study was to estimate the effect size of being a HCW and acquiring COVID-19 at the Mexican Institute of Social Security (IMSS) in Tijuana, Mexico.

Methods: A cross-sectional study from Epidemiologic Surveillance Online Notification System database was conducted, including entries from Tijuana City, in the time period of March 11, 2020 to May 1, 2020. Multiple imputation was performed 99 times for the SARS-CoV-2 RT-PCR result variable where data was missing. Chi-squared statistic with Yates correction and prevalence odds ratios (POR) were calculated to estimate the effect size of HCWs contracting COVID-19 compared to the general population (GP).

Results: From a total of 10,216 entries, only 6,256 patients were included for analysis. HCW status was significantly associated with higher odds of acquiring COVID-19, (POR = 1.730; CI 95% 1.459, 2.050). Nurses had double the odds (POR = 2.339; CI 95% 1.804, 3.032) than the GP. Physicians had a POR = 1.828 (CI 95% 0.766, 1.380). Resident physician status was double the likelihood of the GP (POR = 2.166; CI 95% 0.933, 5.025). Meanwhile, interns had an apparent protective factor (POR = 0.253; CI 95% 0.085, 0.758). Among medical specialties, emergency medicine had the highest exposure-effect association (POR = 4.071; CI 95% 1.090, 15.208), followed by anesthesiologists (POR = 2.806; CI 95% 0.544, 14.466).

Conclusion: HCW in this study had up to 73% increased odds of acquiring COVID-19 than the GP in Tijuana, Mexico. Nurses were the group with the highest likelihood out of all HCW, as a result of prolonged and close contact with patients. Emergency medicine and anesthesiology were the medical specialties with highest odds of infection because they frequently perform aerosol-generating procedures.

Key Words: COVID-19; coronavirus; SARS-CoV-2; health personnel; healthcare workers

INTRODUCTION.

Healthcare workers (HCW) are a high-risk population for acquiring COVID-19. [1-2] Viral transmission has multiple pathways, the most studied being through respiratory droplets, with increased estimates of transmission of SARS-CoV-2 compared to influenza.[3,4] For HCW, the workplaces at greater risk of infection are the respiratory and infectious disease departments, the ICU, and the operating room, given the prolonged times exposed to patients and the performance of aerosol-generating procedures.[5–7] Since January 2020, Category A specifications for control and prevention of infection measures were recommended by Chinese Centers for Disease Control and Prevention.[8] These measures focus on preventing transmission primarily through respiratory droplets during the execution of high-risk procedures such as endotracheal intubation, extubation, non-invasive ventilation, CPR, bronchoscopy, surgery, and autopsies.[9]

However, many cases with mild symptoms, or even asymptomatic, which are still infectious, continue to seek medical attention for other health problems at primary care clinics and emergency departments, contributing to the increase in the number of cases.[4,10] Taking this into consideration, primary care and emergency physicians are considered to be most at risk for acquiring SARS-CoV-2 infection, from subclinical to some symptomatic cases.[11,12] Furthermore, different modes of the virus transmission are still being researched, with new recommendations on the management and handling of fecal matter[13] and corpses of confirmed COVID-19 cases. Although vertical transmission has not been demonstrated, there has been reports of pregnant women admitted with suspected COVID-19 at the end of gestation giving birth to newborns with positive SARS-CoV-2 test results.[14]

As a result of the uncertainty regarding disease transmission, severity, and mortality, access to some resources, such as face masks, sanitizers, and thermometers were soon scarce. At present, actions are being enforced to minimize the risks in the workplace with measures such as filtering at entry points, sanitizing hospitals, and continually providing personal protecting equipment (PPE) to the medical staff. Despite this, many HCWs in Mexico still feel vulnerable and question whether the PPE with which they are provided is sufficient.[9] In other countries, HCW screening has been proposed, as they are considered amplifiers of nosocomial and community transmission.[7]

Regardless, the measures implemented have not been sufficient to contain the escalating number of cases. COVID-19 disease outbreaks have been reported all across Mexico, and several hospitals have notified of outbreaks internal to the hospital involving HCWs.[9] The increase in the number of cases among the general population (GP) has also been reflected in HCWs,[2,15,16] with sustained rises of confirmed cases. On April 24, 2020, 1,934 HCWs had a positive RT-PCR result for SARS-CoV-2, which represented 15% of the total (12,872) confirmed cases up to that day. The affected HCWs were distributed as follows: 47% physicians, 35% nurses, 15% other HCWs, 1% dentists and 1% laboratory staff, with as many as 4,148 HCWs temporarily removed from the workforce due to infection.[17]

Thus, the aim of this study was to estimate the effect size of being a HCW and acquiring COVID-19 at the Mexican Institute of Social Security (IMSS) in Tijuana, a US-border city in Mexico. As secondary analyses, risk estimates were stratified by HCW categories, by physician hierarchies, and by medical specialties.

MATERIALS AND METHODS.

Study design

A cross-sectional database study was conducted using data from the IMSS's Epidemiologic Surveillance Online Notification System (SINOLAVE). An internal network database that included the records of COVID-19 suspected cases reported from different IMSS centers in Mexico. As this was secondary research from an institutional database, it was exempt from IRB review at IMSS.

Data source

The data for the study was extracted on May 11, 2020 and it corresponded to the entries recorded from March 11, 2020[t] to May 1, 2020. The data extraction criteria from SINOLAVE database were subset records from the Baja California delegation, including healthcare units from "all regimes". Additional information about specific occupations of patients identified as HCWs was manually obtained through social security number (SSN) from electronic medical records before concealing subject identities for further analysis.

Data type

The SINOLAVE database consists of the following items: patient SSN, registry date, symptoms onset date, occupation and employer, clinical history including presence or absence of signs and symptoms, personal medical history (including chronic disease, tobacco smoking, alcohol consumption and pregnancy status, as well as history of travel and contact with COVID-19 cases and/or animals), results from RT-PCR for SARS-CoV-2 from nasopharyngeal or oropharyngeal swabs or specimens from lower respiratory tract secretions, treatment, and outcomes from primary and secondary healthcare systems.

Participants

The database was filtered to only include patients of all ages registered in Tijuana, Mexico, which corresponded to those notified from primary care centers number 7, 18, 19, 27, 33, 34, 35 and 36, and secondary care centers number 1 and 20. Individuals without complete personal and clinical history were excluded and duplicated or triplicated entries were eliminated, keeping the first chronological record or the one that fulfilled severe acute respiratory infection (SARI) criteria if it was registered at the same healthcare level. If duplicates were reported by different healthcare levels, the entry kept was either from the highest healthcare level included a reported laboratory test result. Data was recorded in a way that the identity of the human subjects could not be ascertained.

Variables

Patients whose registered occupation was "physician", "nurse", "laboratory staff", "dentist" or "other HCW", along with being enrolled as "IMSS employee" were defined as HCWs. Other IMSS employees with entries of different occupations from the ones previously mentioned, were reclassified as "other HCW". The remainder of patients who did not satisfied the above-mentioned criteria were defined as GP.

Additional categories were assigned within the physician subgroup by hierarchy position and medical specialty. The former divides the patient into three groups: “attending physician”, “resident physician” and “intern”. In the latter, groups by medical specialty were classified by combining attending physicians and residents from the same area, including “anesthesiology”; “surgery”; “OB-GYN”; “internal medicine”; “primary care medicine”, which includes family medicine and general practitioners; “emergency medicine”; and “other specialties”, which includes physicians in executive positions, intensive care medicine, orthopedics, pediatrics, occupational medicine, and physical medicine and rehabilitation.

Regarding outcomes, patients with at least one positive RT-PCR test for SARS-CoV-2 were considered confirmed COVID-19 cases and patients with a negative result were considered non-COVID-19 cases.

Statistical analysis

Multiple imputation with logistic linear regression was performed. A total of 99 imputations were created using multiple imputation under the missing at random (MAR) assumption for entries where a RT-PCR for SARS-CoV-2 result was missing. Age, gender, occupation, IMSS employee, signs and symptoms, personal medical history and contact with suspect cases were considered predictors of missingness and defined as auxiliary variables for imputation before the analysis was conducted.

The mode value from the multiple imputation was assigned to registries with missing information, obtaining the following two sets of data: the complete-case analysis, excluding participants without a RT-PCR result (Analysis 1) and an alternative data set incorporating multiple imputation data including all of the patients (Analysis 2).

For the analysis of the relationship between HCW and COVID-19 case status, crude prevalence odds ratios (POR) were calculated and the χ^2 test was used in the bivariate analysis, in addition to Yates correction. The Mantel-Haenszel test was used to control for confounding, stratifying by age, gender, and history of chronic disease, as no other demographic data was included in the database. Statistical analysis for each set of data was conducted using IBM SPSS Statistics (Version 25) and STATA 15. Statistical significance was considered as a P-value < 0.05.

An alternative statistical analysis using Rubin’s rules for pooling multiple imputation results and binomial logistic regression to estimate the effect size of being a HCW and acquiring COVID-19 is included in **Supplementary files 1–5**.

RESULTS.

From a total of 10,216 entries in the SINOLAVE registry, data from 6,256 patients was analyzed after eliminating 3,960 cases that failed to meet the inclusion criteria (3,858 were records from outside of Tijuana City, 72 were repeated, and 30 had missing data, see **Figure 1**). Only 897 (14.33%) patients from the 6,256 included had at least one RT-PCR test for SARS-CoV-2, thus it was possible to classify them as a COVID-19 case or a non-case for Analysis 1. On the other hand, multiple imputation was performed on data from 5,359 (85.66%) subjects to complete Analysis 2, which included all the patients involved in this study.

Mean age for Analysis 1 was 45 years (SD 13), with a minimum of 0 to a maximum of 88 years of age (**Table 1)**. Analysis 2 showcased a mean age of 39 years (SD 19), with an age range of 0 to 97 years. The most represented age group was 40 to 59 years (47.05%) in Analysis 1, and for Analysis 2 it was 16 to 39 years (52.40%). There were slightly more males than females included in both analyses, with 493 (54.96%) vs. 404 (45.04%) in Analysis 1, and 3,190 (50.99%) vs. 3,066 (49.01%) in Analysis 2, respectively. While the Analysis 2 group included 5,634 patients (90.06%) from the GP and only 622 HCWs (9.94%), the Analysis 1 group was composed of 653 members (72.80%) of the GP and 244 HCWs (27.20%). A confirmatory test was performed on 36.01% of HCW suspect cases and only 11.59% of the GP. A history of chronic disease was more common in the Analysis 1 group with 39.69%, compared to 28.84% in Analysis 2. The most prevalent chronic diseases among HCW were hypertension (17.4%), obesity (11.9%), and asthma (8.2%), whereas in the GP they were hypertension (18.1%), obesity (13.4%), and diabetes (11.6%). A similar proportion of smokers were involved in both groups with 4.1% vs. 4.7% in HCW and GP, respectively.

Of all HCWs included (**Table 2**), physicians represented the largest subgroup within Analysis 1 with 96 subjects (39.34%), followed by nurses and other HCWs with 80 (32.79%) and 66 (27.05%), respectively. However, nurses represented the largest subgroup among HCWs within Analysis 2 with 236 subjects (37.94%), followed by other HCWs with 208 (33.44%), and physicians with 173 (27.81%). Likewise, within the doctors' subgroup, 41 (58.57%) and 80 (63.49%) were attending physicians; 18 (25.71%) and 26 (20.63%) were residents; and 11 (15.71%) and 20 (15.87%) were interns in both Analyses 1 and 2, respectively.

From a total of 173 physicians (**Table 3**) it was possible to identify the area of specialty or job position of only 126 subjects (72.8%) through a hospital records search. In both sets of analyses, the specialty with the largest representation was internal medicine. However, subtracting resident physicians, that respectively account for 30.51% and 24.52% in Analyses 1 and 2, from their respective specialties showcased that interns were the largest subset among the doctors' subgroup.

The association between being a HCW and a COVID-19 confirmed case was statistically significant, both in Analysis 1 (χ^2 = 5.947, df = 1, P = 0.015), and Analysis 2 (χ^2 = 40.692, df = 1, P < 0.001), but the direction of risk is contrary according to each analysis. In Analysis 1, the POR = 0.689 (CI 95% 0.511, 0.930), whilst in Analysis 2, POR = 1.730 (CI 95% 1.459, 2.050). The GP was used as referent for analysis. Stratifying by age group, the statistical significance of the Analysis 1 was lost (POR = 0.757; CI 95% 0.551, 1.040; χ^2_{MH} = 3.566, df = 1, P = 0.168) It was identified that only the age group of 40 to 59 years maintained a statistically significant association (POR = 0.550; CI 95% 0.349, 0.869; χ^2_{MH} = 6.668, df = 1, P = 0.010). In this same analysis, there was no change after adjusting by gender (POR = 0.728; CI 95% 0.537, 0.986; χ^2_{MH} = 3.880, df = 1, P = 0.049), but higher odds were observed after adjusting by history of chronic disease (POR = 1.451; CI 95% 1.075, 1.956; χ^2_{MH} = 5.967, df = 1, P = 0.015). A slight increase in size effect was observed in Analysis 2 after adjusting by age group (POR = 1.857; CI 95% 1.563, 2.206; χ^2_{MH} = 51.05, df = 1, P < 0.001) and gender (POR = 1.897; CI 95% 1.596, 2.254; χ^2_{MH} = 53.552, df = 1, P < 0.001), whereas adjusting by history of chronic disease rendered lower odds (POR = 0.578; CI 95% 0.488, 0.685; χ^2_{MH} = 40.692, df = 1, P < 0.001).

Nurses were the HCW subgroup with the highest odds of acquiring COVID-19 (**Figure 2**), with a POR = 2.339 (CI 95% 1.804, 3.032) compared to the GP in Analysis 2, and POR = 1.210 (CI 95% 0.640, 1.628) in Analysis 1. In addition, other HCWs had a POR = 1.765 (CI 95% 1.336, 2.330) in Analysis 2, whereas in Analysis 1 this was not statistically significant (OR = 0.689; CI 95% 0.511, 0.930). On the other hand, physicians showcased a protective factor in Analysis 1 (POR = 0.557; CI 95% 0.365, 0.851) and a small excess in effect size compared to the GP in Analysis 2 (POR = 1.028; CI 95% 0.766, 1.380). No change was observed after stratifying by gender, age group and history of chronic disease. It was not possible to estimate the association and individual risk of dentists and laboratory staff for COVID-19 given the low number of subjects in these subgroups.

Within the different physician hierarchies (**Figure 3**), it was found that interns had a POR = 0.345 (CI 95% 0.099, 1.179) and POR = 0.253 (CI 95% 0.085, 0.758) in Analyses 1 and 2, respectively. Meanwhile, residents had a higher likelihood of acquiring COVID-19 than the GP in both analyses (Analysis 1: POR = 1.593; CI 95% 0.563, 4.510; Analysis 2: POR = 2.166; CI 95% 0.933, 5.025). On the other hand, attending physicians showcased a POR = 0.561 (CI 95% 0.290, 1.083) in Analysis 1, and POR = 1.320 (CI 95% 0.841, 2.070) in Analysis 2. Adjusting by gender, age group and history of chronic disease showed no difference.

Further analysis was conducted to estimate the risk attached to each medical specialty included in this study compared to that of the cluster of physicians (**Figure 4**). It was observed that emergency medicine had the highest odds for contracting COVID-19 among medical specialties (Analysis 1: POR = 8.828; CI 95% 1.040, 74.934; Analysis 2: POR = 4.071; CI 95% 1.090, 15.208), followed by anesthesiology (Analysis 1: POR = 1.943; CI 95% 1.452, 2.447; Analysis 2: POR = 2.806; CI 95% 0.544, 14.466). Surgeons (Analysis 1: POR = 1.084; CI 95% 0.298, 3.946; Analysis 2: POR = 1.963; CI 95% 0.734, 5.247) and primary care physicians also showed increased odds compared to that of all doctors. The internal medicine specialists had a possible protective factor (Analysis 1: POR = 0.71; CI 95% 0.215, 2.407; Analysis 2: POR = 0.722; CI 95% 0.313, 1.906). Likewise, all other medical specialties, which for this analysis included intensive care physicians, pediatricians, and physicians in executive positions had a lower likelihood of acquiring COVID-19 (Analysis 1: POR = 0.629; CI 95% 0.205, 1.929; Analysis 2: POR = 0.156; CI 95% 0.017, 1.048). On the other hand, OB-GYN was shown to have conflicting effect size estimates (Analysis 1: POR = 0.82; CI 95% 0.165, 4.706; Analysis 2: POR = 1.111; CI 95% 0.284, 4.343).

DISCUSSION.

In this study, HCWs had 73% higher odds of acquiring COVID-19 than the GP. A disparity in the number of COVID-19 confirmatory tests was observed, since the HCW cluster was tested at least three times more (36.01%) than the GP (11.59%). Therefore, multiple imputation was performed to reduce the bias generated by the lack of confirmatory test results. Comparing between HCW categories, nurses were identified as the group with highest likelihood of acquiring COVID-19, with nearly double the odds of the GP. Conversely, the physician subgroup showcased a statistically significant protective factor in one of the analyses. However, using Analysis 2, it demonstrated only an additional 2.8% increase in odds from the GP, without statistical significance. Analyzing the physicians cluster by hierarchy, the group with the largest effect size estimate was resident physicians, with approximately 50% to 60% higher odds than GP in both analyses, but neither were statistically significant. On the contrary, interns showcased a potential protective factor compared to the GP. Finally, emergency medicine held the largest effect size among the medical specialties included in this study, with four- to eight-fold increase in odds compared to the all the other medical specialties, and although statistically significant, wide confidence intervals were estimated. Anesthesiology followed as the second medical specialty with the highest likelihood of infection, by nearly double the estimate, but also with wide confidence intervals. In contrast, internal medicine posed a possible protective factor, with a close to 30% decreased likelihood of contracting COVID-19 than the rest of physicians; however, this finding was not statistically significant in either analysis.

Among all confirmed cases of COVID-19, HCWs represent nearly a quarter of the patients in Analysis 1 and only 7.55% in Analysis 2. In this study, HCWs were demonstrated to have roughly 73% higher odds of acquiring COVID-19 than the GP. This can be explained by HCW having direct or indirect contact with multiple patients and their surroundings, sometimes in confined areas.[16,18] Thus, HCW may experience a greater exposure to the virus, both chronologically and quantitively, than the GP. Even though infection prevention protocols were established according to HCW categories and tasks from the start of the pandemic, these measures were mostly focused on droplet and contact transmissions.[19] However, as recently reported, SARS-CoV-2 transmissibility can be heterogeneous[20,21] and the ability to appropriately don and doff PPE varies widely between each individual worker and by level of training.[1,22] Age was found to be a possible confounding factor in one of the analyses, this can be attributed to the fact that most HCW included in this study were in the age group of 40 to 59 years. Although this phenomenon was not seen in Analysis 2. Therefore, being a HCW—independently of category, despite the use of PPE, and other protective measures—represents a major risk of acquiring COVID-19.

Although it was not possible to calculate the effect size estimate for every individual category included under the term HCW, nurses were identified as the group with the highest likelihood for acquiring COVID-19. This phenomenon has been previously described by Chen et al.[23] during the 2009 influenza pandemic in Singapore, while other authors[24] have found that nurses have a greater COVID-19 mortality rate compared to physicians in Italy, Brazil, Spain and France. This could be attributed to multiple factors, such as the type and length of interventions carried out by nurses and having more frequent and closer contact with patients for extended periods of time compared to, for example, physicians.[25,26] Therefore, they are subjected to a greater exposure than the rest of the healthcare workforce. Additionally, it should be considered that nurses are the largest group of all the HCWs in this study population. Because of this, they may also have higher probabilities of coming into contact with infected colleagues in the workplace. On the other hand, physicians were subjected to a smaller effect size, and even appeared to have a degree of protection in Analysis 1. This could be explained considering the diversity within medical specialties, including the heterogeneity of procedures they perform and the PPE recommended for each group. A similar situation emerged when analyzing the odds of other HCWs, which included a vast range of job positions such as physicians in executive roles, social workers, receptionists, stretcher-bearers, ambulance drivers, cleaning staff, among others; each one of them with a different level of occupational exposure and PPE usage requirements.[7,27]

Comparing hierarchy roles among physicians, residents were the group of doctors with the highest odds of acquiring COVID-19 compared to the GP. Although resident physicians essentially partake in the same activities as their attendings, the workload is not comparable. The long working hours and greater frequency of contact with patients[28,29] appears to increase the risk of exposure to infected patients in this group. Moreover, residency training for physicians is a well-established stressful experience, which may contribute to a compromised immune system.[30,31] Conversely, interns usually execute tasks of a slightly lesser complexity but under the same working conditions as residents. However, in Mexico they are still considered medical students and therefore most of them were withdrawn from COVID-19 high-risk areas[32] and, in addition to being younger than the rest of physicians, this could have contributed to lower odds of contracting COVID-19 for this group.

Analyzing the differences in effect size estimates between medical specialties, emergency medicine physicians had the highest odds for COVID-19. This coincides with the results published by Whiteside et al.,[33] in which emergency department and primary care personnel infection risk was greater than that of other areas. This could be explained considering that emergency rooms are primary points of entry to any other department in most hospitals. Despite the implementation of entry-point filters for patients with respiratory symptoms and COVID-19 suspect cases, emergency physicians are still exposed to many patients seeking urgent medical attention for other reasons while possibly being asymptomatic carriers of SARS-CoV-2,[34] and even perform resuscitation maneuvers in severely ill patients, some of whom could be potential COVID-19 cases. Moreover, patients gathering in emergency rooms is commonplace in Mexico, compromising the implementation of infection control and prevention measures required to limit disease transmission. Not surprisingly, the second medical specialty with highest odds was anesthesiology, as they perform aerosol-generating procedures on a regular basis,[35] and consequently have a greater exposure to viral particles. In contrast, other medical specialties showcased a protective factor, such as internal medicine and OB-GYN, although neither had statistically significant results. However, it is necessary to further investigate if different, or even more stringent measures—such as indiscriminate use of PPE and implementation of multiple filter systems for patients—are being taken that could explain this phenomenon.

The limitations of this study are inherent to the design itself, considering that the data used was not specifically generated with the intention of answering our research question. Errors in categorization could have been made due to not having complete information on the occupation from all participants. Likewise, lack of information about HCW type of contact with patients, working hours, and frequency of exposure did not allow for further analysis to meaningfully compare different patterns between HCW categories. These results are based on data from a public healthcare system in one city in northern Mexico and thus is not necessarily internationally generalizable. It should be noted that POR is not an estimation of risk and therefore these results are to be cautiously interpreted, as they could overestimate the effect size if an approximation to risk is to be inferred. Multiple imputation helped avoid further reduction of our study population and mitigated the bias from missing data. Nevertheless, using this method for analysis showcased some opposing results that could be explained by a number of factors. Primarily, multiple imputation using the MAR assumption implies a random distribution of attributes under the premise that missing data depends on the observed data and not on the values of the missing data, whereas RT-PCR results in Analysis 1 were obtained by testing individuals according to clinical judgement and hospital policies and resources. As a result, characteristics such as the auxiliary variables used for imputation contribute to predict missing data, but with limitations such as complete medical records and individual hospital policies and procedures for testing were not included in the database. Therefore, the distribution of cases could differ from actuality in both analyses. Likewise, results regarding medical specialties should be interpreted cautiously, as the number of participants included was low, resulting in wide confidence intervals. Finally, our study also takes into consideration the non-occupational risk to which HCWs are also exposed to outside the workplace, for instance the analyses used the GP as referent.

CONCLUSION.

In this cross-sectional database study, it was demonstrated that HCWs have higher odds of acquiring COVID-19 than the GP among IMSS users in Tijuana, Mexico. Nurses were the HCW group with the highest likelihood of acquiring SARS-CoV-2 infection. Regarding physician hierarchy, residents had the biggest effect estimate. On the other hand, interns, who were removed from COVID-19 high-risk areas, showcased a protective factor. Moreover, among medical specialties included in this study, emergency medicine and anesthesiology have the highest odds for contracting COVID-19, likely owing to the frequent execution of aerosol-generating procedures. In addition, medical specialties assumed to be more exposed to confirmed COVID-19 cases, such as internal medicine, or departments where more thorough infection control practices are systematically applied, such as OB-GYN, had a possible protective factor. Complementary studies are required to confirm our findings including a bigger and more open population, and even a follow-up of this study population, considering risk factors associated with each HCW category. It is essential to perform local and nation-wide research in order for health authorities to endorse evidence-based preventive protocols aimed at protecting and supporting the workforce that is currently sustaining healthcare systems during the crisis.

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FIGURES AND TABLES.

Figure 1. Flowchart of the study

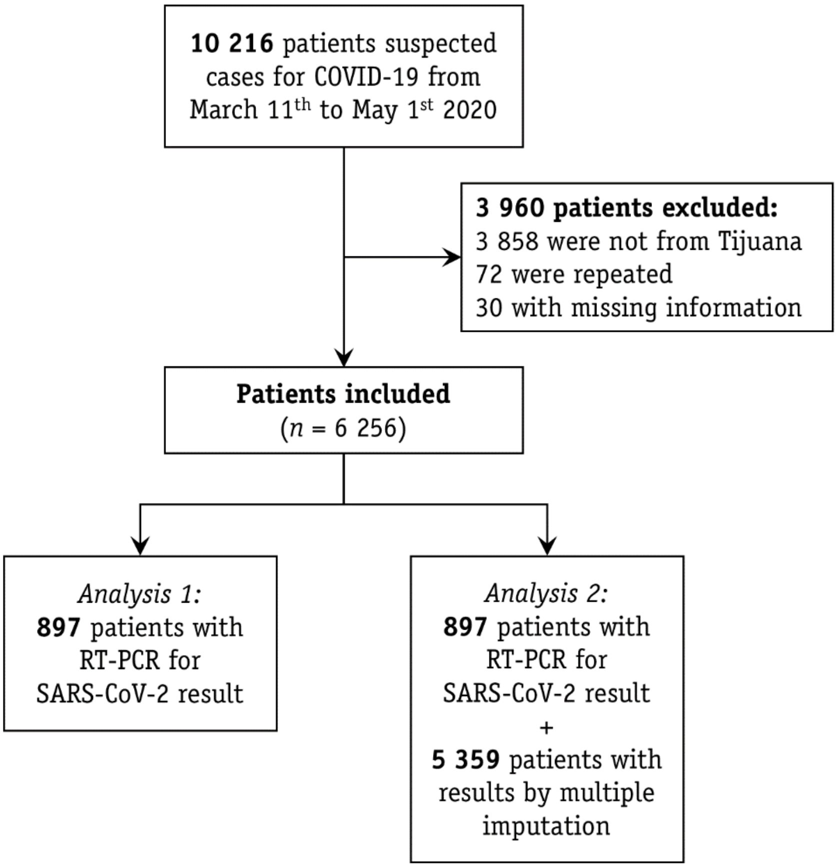


Table 1. Demographic characteristics of study subjects

Variables	Analysis 1 COVID-19 case *n* = 558	Analysis 1 COVID-19 non-case *n* = 339	Analysis 1 Total *n* = 897	Analysis 2 (multiple imputation) COVID-19 case *n* = 3,103	Analysis 2 (multiple imputation) COVID-19 non-case *n* = 3,153	Analysis 2 (multiple imputation) Total *n* = 6,256
Gender, n (%)						
Male	326 (58.42)	167 (49.26)	493 (54.96)	1,770 (57.04)	1,420 (45.04)	3,190 (50.99)
Female	232 (41.58)	172 (50.74)	404 (45.04)	1,333 (42.96)	1,733 (54.96)	3,066 (49.01)
Age, years (standard deviation)						
Mean	47 (14)	41 (16)	45 (16)	42 (13)	36 (12)	39 (19)
Range	7-87	0-88	0-88	0-97	0-91	0-97
Age groups, n (%)						
0 to 5 years	0 (0.00)	13 (3.83)	13 (1.45)	2 (0.06)	36 (1.14)	38 (0.61)
6 to 15 years	4 (0.72)	6 (1.77)	10 (1.11)	9 (0.29)	36 (1.14)	45 (0.72)
16 to 39 years	170 (30.47)	142 (41.89)	312 (34.78)	1,329 (42.83)	1,949 (61.81)	3,278 (52.40)
40 to 59 years	283 (50.72)	139 (41.00)	422 (47.05)	1,476 (47.57)	1,034 (32.79)	2,510 (40.12)
>60 years	101 (18.10)	39 (11.50)	140 (15.61)	287 (9.25)	98 (3.11)	385 (6.15)
Healthcare workers, n (%)						
Yes	136 (24.37)	108 (31.86)	244 (27.20)	384 (12.38)	238 (7.55)	622 (9.94)
No	422 (75.63)	231 (68.14)	653 (72.80)	2,719 (87.62)	2,915 (92.45)	5,634 (90.06)
History of chronic disease, n (%)						
Yes	228 (40.86)	128 (37.76)	356 (39.69)	946 (30.49)	858 (27.21)	1,804 (28.84)
No	330 (59.14)	211 (62.24)	541 (60.31)	2,157 (69.51)	2,295 (72.79)	4,452 (71.16)

Table 2. Frequency of healthcare workers by category

Category	Analysis 1, n (%) (*n* = 244)	Analysis 2, n (%) (*n* = 622)
Nurses	80 (32.79)	236 (37.94)
Other healthcare workers[a]	66 (27.05)	208 (33.44)
Physicians	96 (39.34)	173 (27.81)
Interns[b]	11 (15.71)[c]	20 (15.87)[c]
Residents[b]	18 (25.71)[c]	26 (20.63)[c]
Attendings[b]	41 (58.57)[c]	80 (63.49)[c]
Laboratory staff	1 (0.41)	3 (0.48)
Dentists	1 (0.41)	2 (0.32)

[a] Includes stretcher-bearers, cleaning staff, ambulance drivers, receptionists and others
[b] Includes only those with identified hierarchy (Analysis 1: *n* = 70, Analysis 2: *n* = 126)
[c] From the total of physicians with identified hierarchy

Table 3. Frequency of physicians by declared medical specialty

Medical specialty[a]	**Analysis 1, n (%) (*n* = 70)**	**Analysis 2, n (%) (*n* = 126)**
Internal medicine	13 (18.57)	23 (18.25)
Surgery	11 (15.71)	20 (15.87)
Interns[b]	11 (15.71)	20 (15.87)
Primary care	8 (11.43)	14 (11.11)
Emergency medicine	9 (12.86)	14 (11.11)
Gynegology & Obstetrics	6 (8.57)	9 (7.14)
Anesthesiology	2 (2.86)	8 (6.35)
Pediatrics[c]	1 (1.43)	5 (3.97)
Physicians in executive positions[c]	4 (5.71)	4 (3.17)
Orthopedics[c]	1 (1.43)	4 (3.17)
Intensive care[c]	2 (2.86)	3 (2.38)
Occupational medicine[c]	1 (1.43)	1 (0.79)
Physical medicine and rehabilitation[c]	1 (1.43)	1 (0.79)

[a] Represents the sum of attendings and residents of the same specialty
[b] Do not represent a specific medical specialty, they are rotating medical staff
[c] These make up the group “all other medical specialties” combined

Figure 2. Unadjusted prevalence odds ratios for COVID-19 according to healthcare worker category

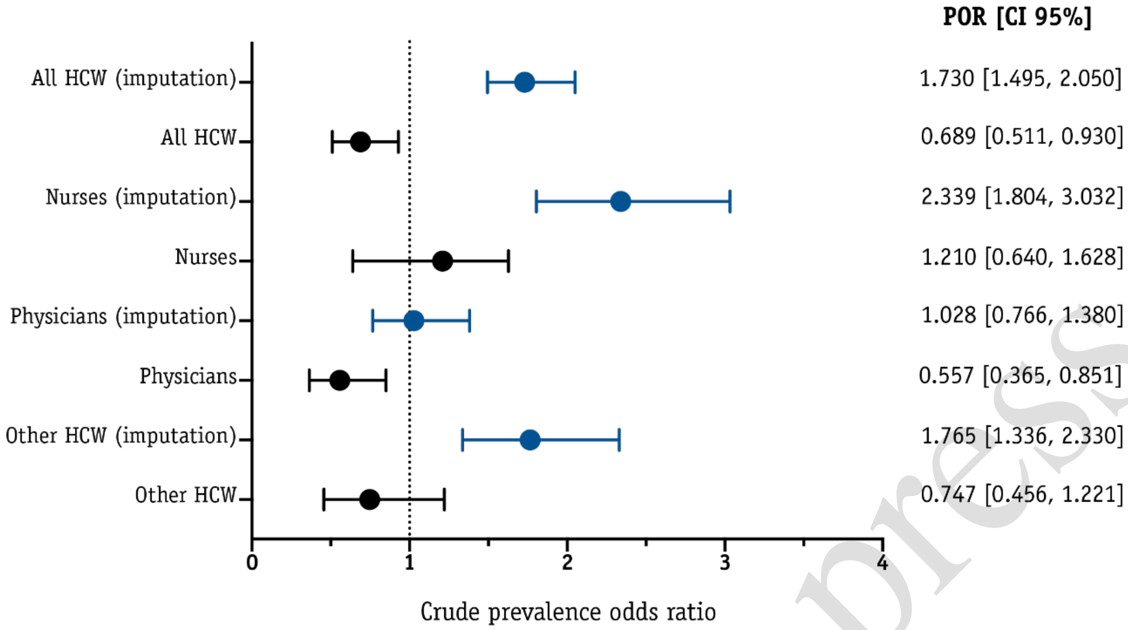


Figure 3. Unadjusted prevalence odds ratios for COVID-19 according to medical hierarchy

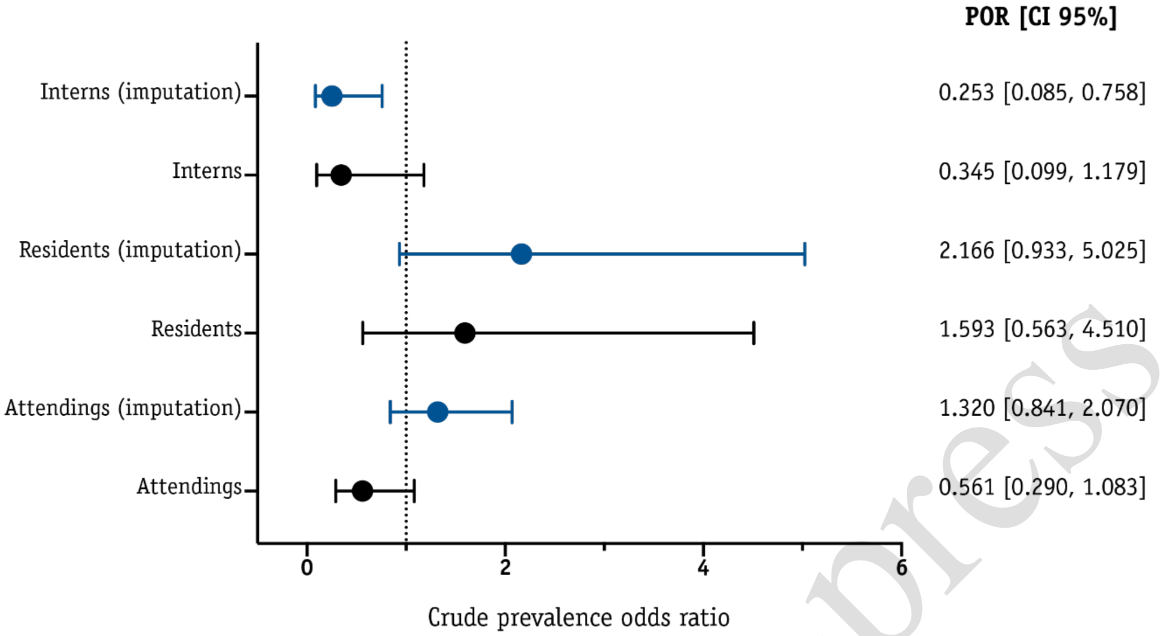
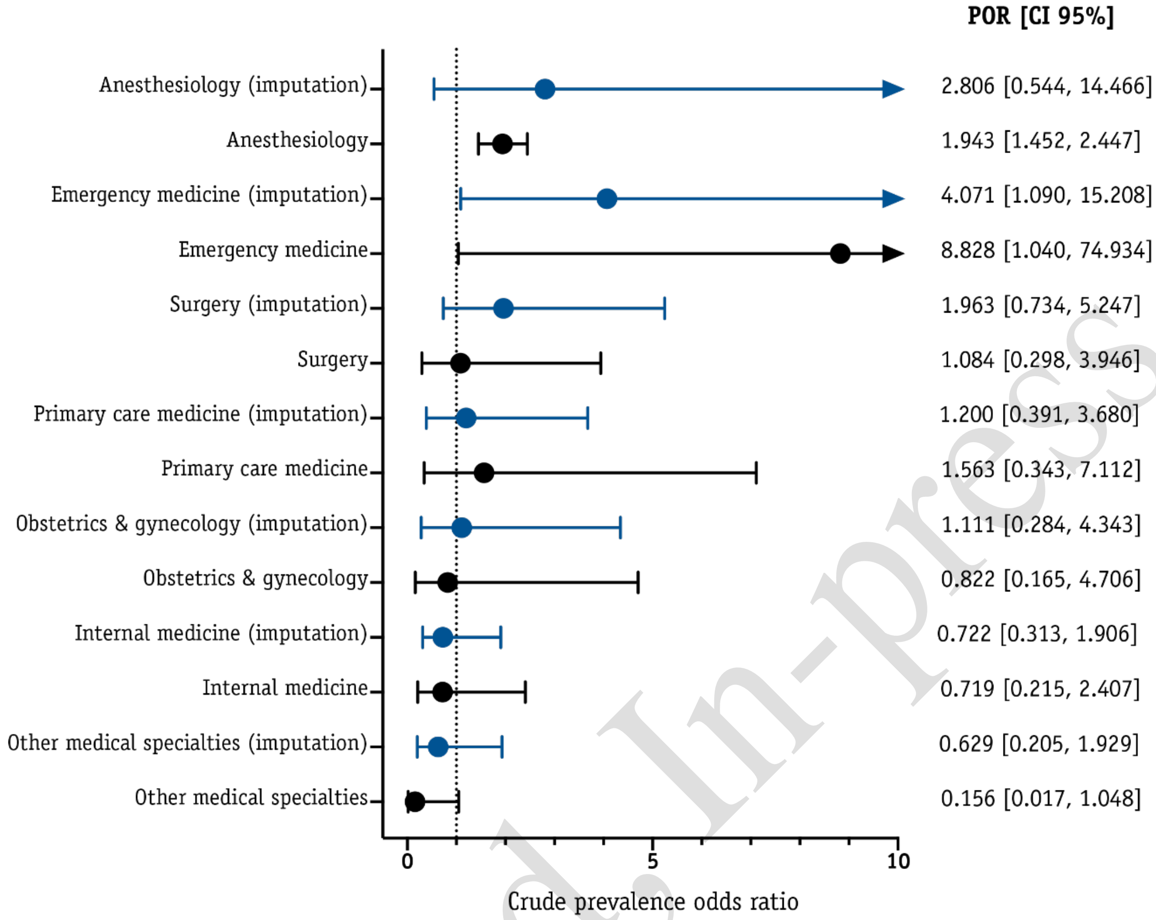


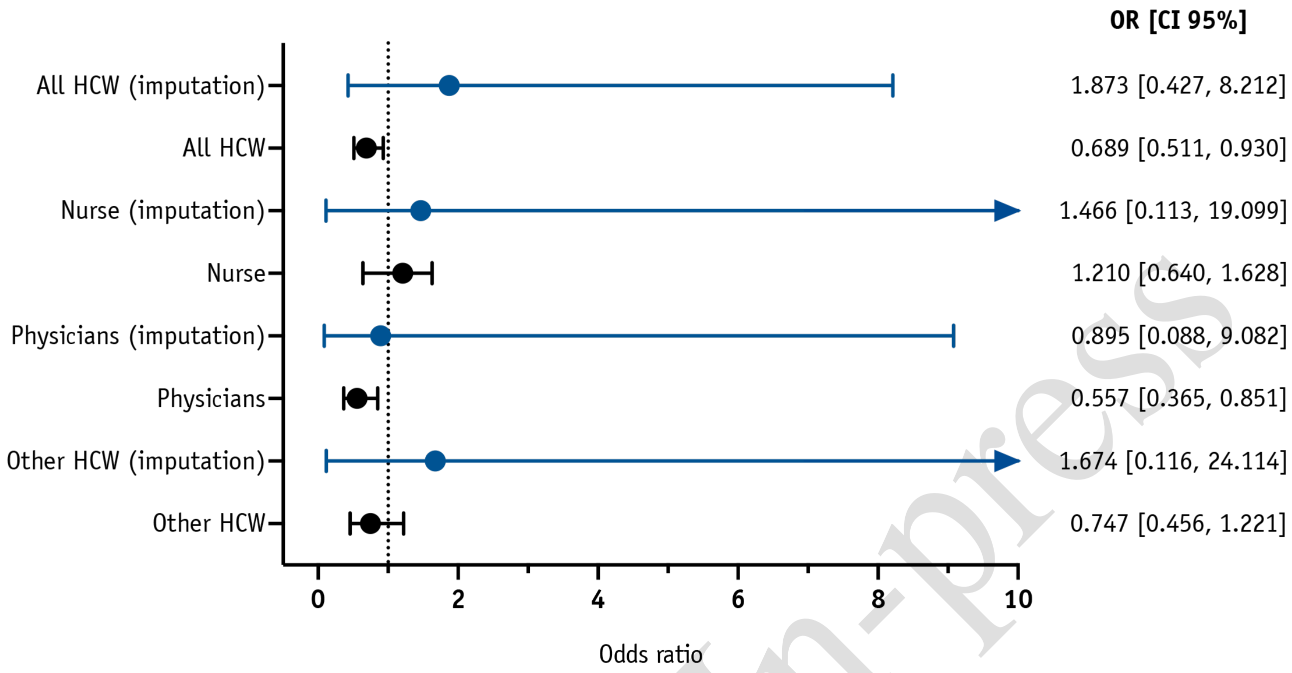
Figure 4. Unadjusted prevalence odds ratios for COVID-19 by medical specialty



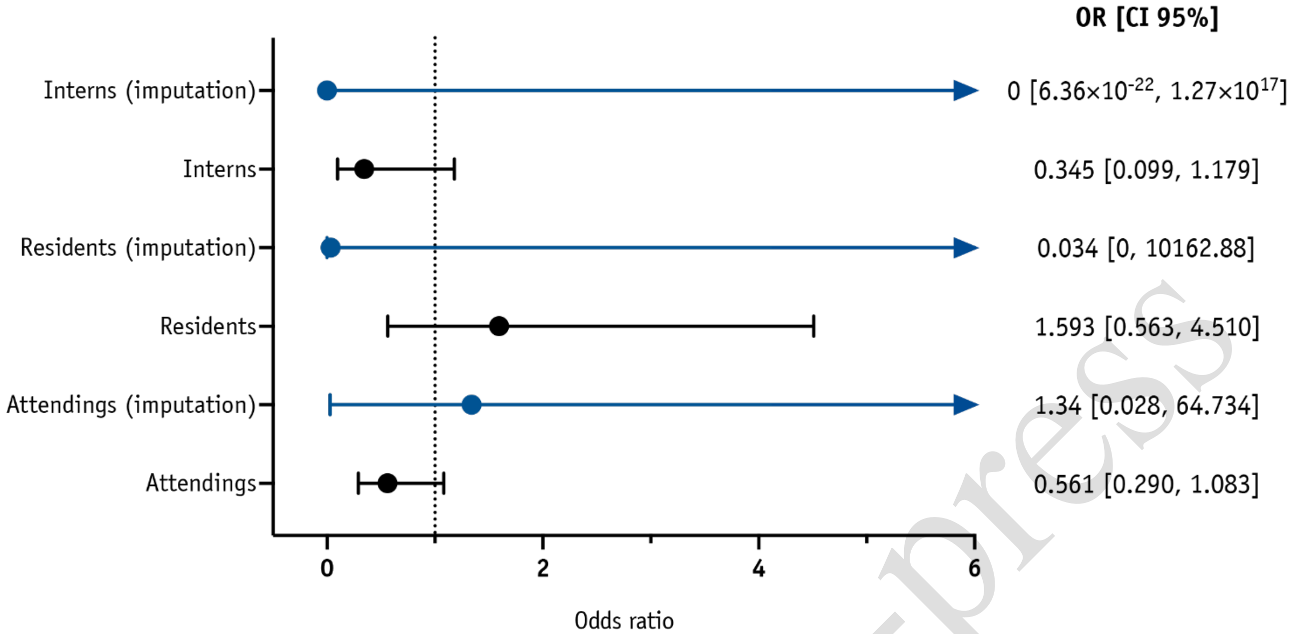
Supplementary file 1. Demographic characteristics of study subjects

Variables	Analysis 1 COVID-19 case *n* = 558	Analysis 1 COVID-19 non-case *n* = 339	Analysis 1 Total *n* = 897	Analysis 2 (pooled multiple imputation) COVID-19 case *n* = 3,263	Analysis 2 (pooled multiple imputation) COVID-19 non-case *n* = 2,993	Analysis 2 (pooled multiple imputation) Total *n* = 6,256
Gender, n (%)						
Male	326 (58.42)	167 (49.26)	493 (54.96)	1,775 (54.40)	1,415 (47.30)	3,190 (50.99)
Female	232 (41.58)	172 (50.74)	404 (45.04)	1,488 (45.60)	1,577 (52.70)	3,066 (49.01)
Age, years (standard deviation)						
Mean	47 (14)	41 (16)	45 (16)	41 (13)	37 (13)	39 (13)
Range	7-87	0-88	0-88	0-97	0-97	0-97
Age groups, n (%)						
0 to 5 years	0 (0.00)	13 (3.83)	13 (1.45)	6 (0.18)	32 (1.07)	38 (0.61)
6 to 15 years	4 (0.72)	6 (1.77)	10 (1.11)	16 (0.49)	29 (0.97)	45 (0.72)
16 to 39 years	170 (30.47)	142 (41.89)	312 (34.78)	1,518 (46.52)	1,760 (58.80)	3,278 (52.40)
40 to 59 years	283 (50.72)	139 (41.00)	422 (47.05)	1,461 (44.77)	1,049 (35.05)	2,510 (40.12)
>60 years	101 (18.10)	39 (11.50)	140 (15.61)	262 (8.03)	123 (4.11)	385 (6.15)
Healthcare workers, n (%)						
Yes	136 (24.37)	108 (31.86)	244 (27.20)	353 (10.82)	269 (8.99)	622 (9.94)
No	422 (75.63)	231 (68.14)	653 (72.80)	2,910 (89.18)	2,724 (91.01)	5,634 (90.06)
History of chronic disease, n (%)						
Yes	228 (40.86)	128 (37.76)	356 (39.69)	998 (30.59)	806 (26.93)	1,804 (28.84)
No	330 (59.14)	211 (62.24)	541 (60.31)	2,265 (69.41)	2,187 (73.07)	4,452 (71.16)

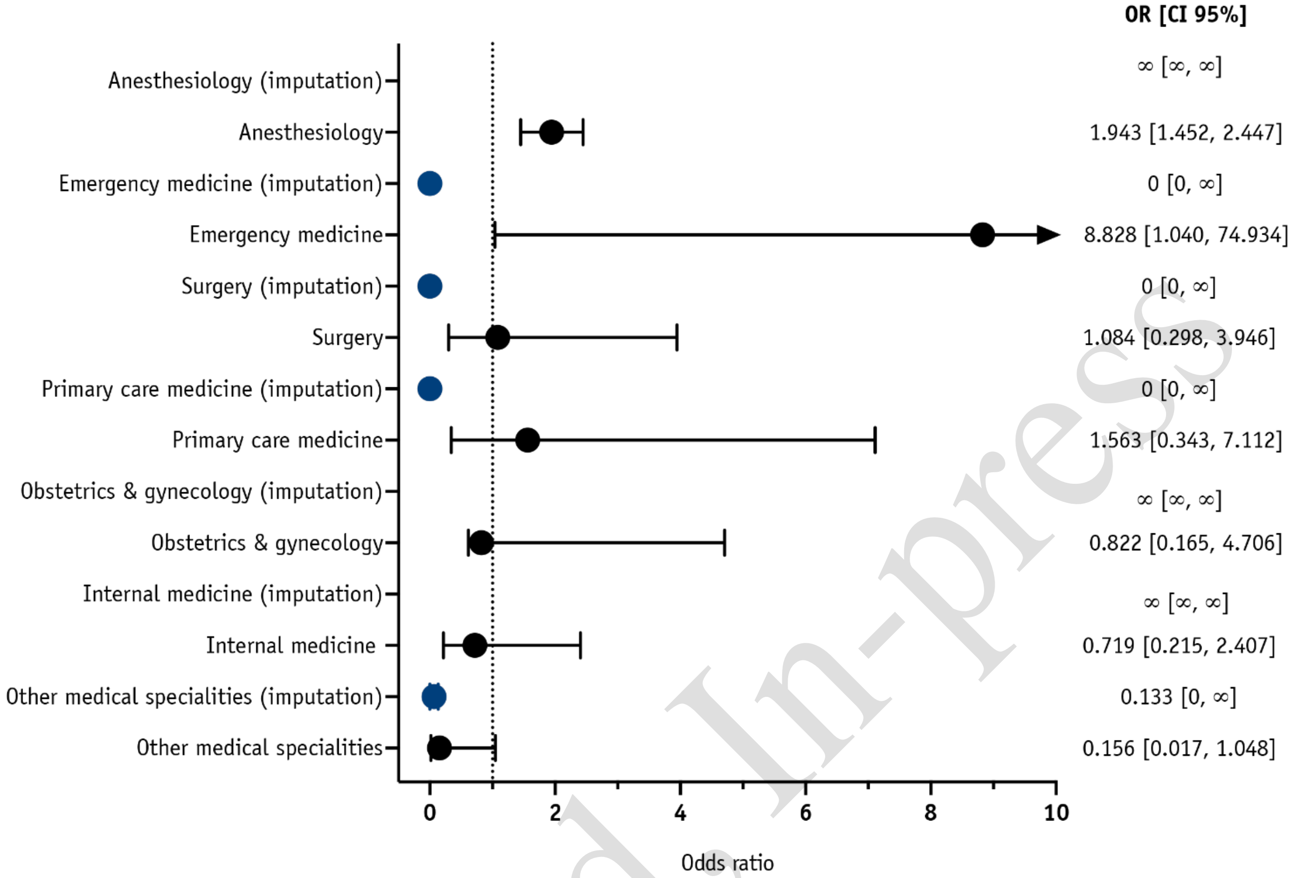
Supplementary file 2. Unadjusted odds ratios for COVID-19 according to healthcare worker category



Supplementary file 3. Unadjusted odds ratios for COVID-19 according to medical hierarchy



Supplementary file 4. Unadjusted odds ratios for COVID-19 by medical specialty



Supplementary file 5. Statistical analysis using binomial logistic regression from pooled multiple imputation data

CATEGORY	*P*	OR	CI 95 LOWER	CI 95 HIGHER
Effect size of being a HCW for acquiring COVID-19 (GP as referent)				
ALL HCW	0.404	1.873	0.427	8.212
ADJUSTED FOR SEX	0.096	1.485	0.932	2.366
ADJUSTED FOR AGE	0.039	0.976	0.054	0.999
ADJUSTED FOR HISTORY	0.137	0.693	0.427	1.124
Effect size for acquiring COVID-19 by HCW category (All HCW as referent)				
NURSES	0.77	1.466	0.113	19.099
ADJUSTED FOR SEX	0.233	1.801	0.684	4.743
ADJUSTED FOR AGE	0.316	0.98	0.942	1.019
ADJUSTED FOR HISTORY	0.094	0.513	0.235	1.119
PHYSICIANS	0.926	0.895	0.088	9.082
ADJUSTED FOR SEX	0.171	1.687	0.798	3.564
ADJUSTED FOR AGE	0.198	0.977	0.942	1.012
ADJUSTED FOR HISTORY	0.801	1.11	0.492	2.507
OTHER HCW	0.705	1.674	0.116	24.114
ADJUSTED FOR SEX	0.172	1.684	0.796	3.562
ADJUSTED FOR AGE	0.286	0.978	0.939	1.019
ADJUSTED FOR HISTORY	0.31	0.645	0.277	1.505
Effect size for acquiring COVID-19 by HCW category (GP as referent)				
NURSES	0.936	1.101	0.104	11.617
ADJUSTED FOR SEX	0.153	1.894	0.788	4.554
ADJUSTED FOR AGE	0.309	0.981	0.944	1.018
ADJUSTED FOR HISTORY	0.144	0.572	0.271	1.21
PHYSICIANS	0.85	0.802	0.081	7.98
ADJUSTED FOR SEX	0.169	1.662	0.806	3.429
ADJUSTED FOR AGE	0.19	0.976	0.941	1.012
ADJUSTED FOR HISTORY	0.661	1.193	0.542	2.628
OTHER HCW	0.644	1.848	0.136	25.059
ADJUSTED FOR SEX	0.162	1.691	0.809	3.538
ADJUSTED FOR AGE	0.215	0.975	0.937	1.015
ADJUSTED FOR HISTORY	0.305	0.647	0.281	1.49
Effect size for acquiring COVID-19 by medical hierarchy (physicians as referent)				
INTERNS	0.54	0.000009	6.37E-22	1.27652E+11
ADJUSTED FOR SEX	0.999	0.003	0	.
ADJUSTED FOR AGE	0.53	1.587	0.375	6.718
ADJUSTED FOR HISTORY	0.999	426.964	0	.
RESIDENTES	0.6	0.034	0	10162.88
ADJUSTED FOR SEX	0.982	1.027	0.107	9.87
ADJUSTED FOR AGE	0.708	1.081	0.719	1.624
ADJUSTED FOR HISTORY	0.899	1.177	0.094	14.802
ATTENDINGS	0.882	1.34	0.028	64.734
ADJUSTED FOR SEX	0.354	1.751	0.535	5.733
ADJUSTED FOR AGE	0.161	0.951	0.887	1.02

ADJUSTED FOR HISTORY	0.477	1.612	0.432	6.024
Effect size for acquiring COVID-19 by medical hierarchy (All HCW as referent)				
INTERNS	0.54	0	0	1.27652E+11
ADJUSTED FOR SEX	0.999	0.003	0	.
ADJUSTED FOR AGE	0.53	1.587	0.375	6.718
ADJUSTED FOR HISTORY	0.999	426.964	0	.
RESIDENTES	0.6	0.034	0	10162.88
ADJUSTED FOR SEX	0.982	1.027	0.107	9.87
ADJUSTED FOR AGE	0.708	1.081	0.719	1.624
ADJUSTED FOR HISTORY	0.899	1.177	0.094	14.802
ATTENDINGS	0.844	1.483	0.029	75.798
ADJUSTED FOR SEX	0.362	1.748	0.525	5.822
ADJUSTED FOR AGE	0.155	0.951	0.887	1.019
ADJUSTED FOR HISTORY	0.519	1.544	0.413	5.777
Effect size for acquiring COVID-19 by medical hierarchy (GP as referent)				
INTERNS	0.54	0	0	1.27652E+11
ADJUSTED FOR SEX	0.999	0.003	0	.
ADJUSTED FOR AGE	0.53	1.587	0.375	6.718
ADJUSTED FOR HISTORY	0.999	426.964	0	.
RESIDENTES	0.6	0.034	0	10162.88
ADJUSTED FOR SEX	0.982	1.027	0.107	9.87
ADJUSTED FOR AGE	0.708	1.081	0.719	1.624
ADJUSTED FOR HISTORY	0.899	1.177	0.094	14.802
ATTENDINGS	0.882	1.34	0.028	64.734
ADJUSTED FOR SEX	0.354	1.751	0.535	5.733
ADJUSTED FOR AGE	0.161	0.951	0.887	1.02
ADJUSTED FOR HISTORY	0.477	1.612	0.432	6.024
Effect size for acquiring COVID-19 by medical specialty (GP as referent)				
ANESTHESIOLOGY	0.993	.	.	.
ADJUSTED FOR SEX	0.998	0.000	0.000	.
ADJUSTED FOR AGE	0.992	0.000	0.000	.
ADJUSTED FOR HISTORY	0.996	1.352E+93	0.000	.
EMERGENCY	0.999	0.000	0.000	.
ADJUSTED FOR SEX	0.999	572.527	0.000	.
ADJUSTED FOR AGE	0.755	1.054	0.758	1.464
ADJUSTED FOR HISTORY	-1375.951	28359749.810	0.000	.
SURGERY	151148.918	0.000	.	0
ADJUSTED FOR SEX	3356828.370	0.000	.	0
ADJUSTED FOR AGE	0.264	0.000	.	0
ADJUSTED FOR HISTORY	5703.153	0.000	.	0
PRIMARY CARE	718318191158.345	0.000	.	0.000
ADJUSTED FOR SEX	3.867	0.000	.	0.000
ADJUSTED FOR AGE	0.568	0.000	3.5796E+196	0.000
ADJUSTED FOR HISTORY	0.001	0.000	.	0.000
OB-GYN	-7004735051268220	151148.918	0.000	.
ADJUSTED FOR SEX	0.999	3356828.370	0.000	.
ADJUSTED FOR AGE	0.999	0.264	0.000	.

ADJUSTED FOR HISTORY	-11477835663185500	5703.153	0.000	.
INTERNAL MED	-7004735051268220	151148.918	0.000	.
ADJUSTED FOR SEX	0.999	3356828.370	0.000	.
ADJUSTED FOR AGE	0.999	0.264	0.000	.
ADJUSTED FOR HISTORY	-11477835663185500	5703.153	0.000	.
OTHERS	1.000	0.133	0.000	.
ADJUSTED FOR SEX	0.657	1.875	0.116	30.192
ADJUSTED FOR AGE	0.494	0.949	0.818	1.102
ADJUSTED FOR HISTORY	1.000	5.740	0.000	.
Effect size for acquiring COVID-19 by medical specialty (All HCW as referent)				
ANESTHESIOLOGY	The parameter covariance matrix cannot be calculated, SPSS ignores the statistics			
ADJUSTED FOR SEX				
ADJUSTED FOR AGE				
ADJUSTED FOR HISTORY				
EMERGENCY	1.000	0.000	0.000	.
ADJUSTED FOR SEX	0.999	572.527	0.000	.
ADJUSTED FOR AGE	0.755	1.054	0.758	1.464
ADJUSTED FOR HISTORY	-1375.951	28359749.810	0.000	.
SURGERY	1.000	5.538	0.000	.
ADJUSTED FOR SEX	1.000	0.000	0.000	.
ADJUSTED FOR AGE	0.615	0.931	0.706	1.229
ADJUSTED FOR HISTORY	1.000	579.528	0.000	.
PRIMARY CARE	0.999	718318191158.345	0.000	.
ADJUSTED FOR SEX	1.000	3.867	0.000	.
ADJUSTED FOR AGE	0.999	0.568	0.000	3.57969836E+196
ADJUSTED FOR HISTORY	0.999	0.001	0.000	.
OB-GYN	-7004735051268220	151148.918	0.000	
ADJUSTED FOR SEX	0.999	3356828.370	0.000	.
ADJUSTED FOR AGE	0.999	0.264	0.000	.
ADJUSTED FOR HISTORY	-11477835663185500	5703.153	0.000	.
INTERNAL MED	1.000	0.000	0.000	.
ADJUSTED FOR SEX	0.735	1.435	0.177	11.610
ADJUSTED FOR AGE	0.925	1.005	0.904	1.117
ADJUSTED FOR HISTORY	1.000	2025.182	0.000	.
OTHERS	1.000	0.133	0.000	.
ADJUSTED FOR SEX	0.657	1.875	0.116	30.192
ADJUSTED FOR AGE	0.494	0.949	0.818	1.102
ADJUSTED FOR HISTORY	1.000	5.740	0.000	.
Effect size for acquiring COVID-19 by medical specialty (physicians as referent)				
ANESTHESIOLOGY	The parameter covariance matrix cannot be calculated, SPSS ignores the statistics			
ADJUSTED FOR SEX				
ADJUSTED FOR AGE				
ADJUSTED FOR HISTORY				
EMERGENCY	0.998	0.000	0.000	.
ADJUSTED FOR SEX	0.999	1115632.547	0.000	.
ADJUSTED FOR AGE	0.849	1.037	0.710	1.516
ADJUSTED FOR HISTORY	1.000	16995783.010	0.000	.

SURGERY	1.000	5.538	0.000	.
ADJUSTED FOR SEX	1.000	0.000	0.000	.
ADJUSTED FOR AGE	0.615	0.931	0.706	1.229
ADJUSTED FOR HISTORY	1.000	579.528	0.000	.
PRIMARY CARE	0.999	718318191158.345	0.000	.
ADJUSTED FOR SEX	1.000	3.867	0.000	.
ADJUSTED FOR AGE	0.999	0.568	0.000	3.57969836E+196
ADJUSTED FOR HISTORY	0.999	0.001	0.000	.
OB-GYN	-7004735051268220	151148.918	0.000	.
ADJUSTED FOR SEX	0.999	3356828.370	0.000	.
ADJUSTED FOR AGE	0.999	0.264	0.000	.
ADJUSTED FOR HISTORY	-11477835663185500	5703.153	0.000	.
INTERNAL MED	1.000	0.000	0.000	.
ADJUSTED FOR SEX	0.735	1.435	0.177	11.610
ADJUSTED FOR AGE	0.925	1.005	0.904	1.117
ADJUSTED FOR HISTORY	1.000	2025.182	0.000	.
OTHERS	1.000	0.133	0.000	.
ADJUSTED FOR SEX	0.657	1.875	0.116	30.192
ADJUSTED FOR AGE	0.494	0.949	0.818	1.102
ADJUSTED FOR HISTORY	1.000	5.740	0.000	.