

## Coronavirus Pandemic

# Prevalence of SARS-CoV-2 infections and socio-occupational profile of delivery riders during the COVID-19 pandemic

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### Abstract

**Introduction:** We assessed the prevalence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and associated socio-occupational factors among delivery riders from a Brazilian city at two time points during the pandemic.

**Methodology:** Surveys for antibody and viral RNA testing were conducted from November 2020 to January 2021, and from March to May 2021 in a group of 117 delivery riders. A questionnaire on socio-occupational characteristics and coronavirus disease 2019 (COVID-19) preventive measures was completed. Factors associated with prevalence were analyzed using bivariate analyses and multiple logistic regression models.

**Results:** The overall prevalence of COVID-19 was 15.4% (CI 9.0–23.0). Although not statistically significant, the prevalence was higher in the second phase of the survey (12% (CI 6.0–19.0)) than in the first (5.1% (CI 1.0–10.0)). The seroprevalence was significantly higher ( $p < 0.05$ ) in the second phase of collection (10.3%) than in the first phase (3.4%). There were no statistically significant associations between the social characteristics assessed in the study and prevalence. Five behavioral variables were selected for the final multiple logistic regression model; and only the variable “cleans hands” had a significant association with the outcome, indicating that those who cleaned their hands had lower occurrence.

**Conclusions:** The prevalence among delivery riders was high and they were potentially exposed to risk of infection. Occupational activity and individual prevention behavior were better determinants of infection than social differences. It is necessary to take specific public measures for this group, especially during outbreaks of communicable diseases such as COVID-19.

**Key words:** COVID-19, SARS-CoV-2, health survey, occupational exposure.

*J Infect Dev Ctries* 2024; 18(12.1):S239-S248. doi:10.3855/jdc.19218

(Received 11 September 2023 – Accepted 06 August 2024)

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### Introduction

At the beginning of 2020, scientists in China used bronchoalveolar lavage samples to identify the causative agent of an outbreak of pneumonia of unknown etiology that occurred among the inhabitants of the city of Wuhan. A novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was responsible for the coronavirus disease 2019 (COVID-19) pandemic [1].

The most common form of SARS-CoV-2 transmission is through virus particles exhaled by an infected person [2]. In the absence of an effective therapy to treat the new disease, evidence from other respiratory virus infections has shed light on which non-pharmacological interventions could mitigate the clinical evolution and reduce the peak of SARS-CoV-2 transmission [3]. Among the interventions, social distancing could have a direct impact on the effective reproduction number ( $R_e$ ), because the lower the

number of people exposed, the lower the number of new COVID-19 cases [4,5]. In Brazil, all the people were instructed to stay in their homes until the authorities had determined a safe return to normal life. Only those activities that were considered essential continued with their routine [6].

During the period of social distancing, one group stood out: delivery riders (self-employed or employed by companies). Delivery services involve the transportation of goods purchased at a distance to customers [7]. As the pandemic progressed, delivery riders expanded their delivery activities, as many sectors that had not previously used this service alternative now took advantage of it [8,9].

Regardless of the extent to which social distancing measures were relaxed, the recommendation in Brazil was that the delivery service should be maintained [10]. The delivery riders helped small and medium-sized entrepreneurs to continue their businesses during the

health crisis, and at the same time they were the bridge between the outside world and those who were in social isolation [11].

Most delivery riders can be characterized as fast and cheap laborers who are self-employed. Without the social benefits associated with an employment relationship, delivery riders were exposed to the risk of SARS-CoV-2 infection related with their mobility during the COVID-19 pandemic [8]. In the delivery activity, the worker is in constant contact with colleagues and unknown persons [8]. SARS-CoV-2 is a virus that spreads very easily among people. The exposure of delivery riders is a decisive factor for the infection, which can turn them into spreaders of the disease [9]. Case reports in the literature indicate that a 47-year-old delivery rider who worked in the city of Beijing made 50 deliveries per day for 17 consecutive days before testing positive for COVID-19 in June 2020 [7], and that a pizza delivery rider in India had contact with 72 families and 17 delivery riders who were quarantined before testing positive for SARS-CoV-2 [9].

Considering the importance of delivery workers in maintaining the production chain during the pandemic and given the lack of studies with this group, the present research analyzes the prevalence of SARS-CoV-2 infection and the associated socio-occupational factors.

## Methodology

### *Area, type of study, and population studied*

This is a cross-sectional study conducted in the municipality of Divinópolis, state of Minas Gerais, Brazil. According to the Brazilian Institute of Geography and Statistics, Divinópolis has an estimated population of 242,505 people. Its economy is diversified. In 2020, 27.4% of the municipality's population had a job. In 2010, 98.6% of children and adolescents were enrolled in school, and the infant mortality rate was 9.13 per one thousand live births in 2020.

Two distinct categories of workers were classified as delivery riders: motorcycle taxi/motorcycle freight drivers, and delivery workers. The motorcycle taxi/motorcycle freight drivers are responsible for transporting both passengers and small loads using motorcycles as a mode of transportation. On the other hand, delivery workers are tasked with transporting and delivering various products in a prompt and secure manner. This study specifically focused on workers who utilized motorcycles as a means to transport passengers or deliver a wide range of products, not limited to food, purchased remotely.

The Municipal Department of Traffic, Transportation and Public Safety of Divinópolis provided the contact information of the city's motorcycle taxi/motorcycle freight cooperatives. There were 8 cooperatives with a total of 96 registered vehicles. We used this data as the minimum number of study participants. However, as the activity of delivery riders is informal and not everyone is registered with an association, we included in the sample all the delivery riders who participated in both phases of the survey, also including non-associated delivery riders. Delivery riders were sought out by actively searching in associations for motorcycle taxi and motorcycle freight operators, as well as by reaching out to drivers who were part of delivery driver groups on messaging apps. Those delivery riders who were recruited from the associations and messaging app groups were then invited to join the research.

A questionnaire about social data, disease knowledge, personal care, perception of job dangers, and work routine during the COVID-19 pandemic was filled out during the first phase of the survey. Following the administration of the questionnaire, clinical samples (whole blood and saliva) were obtained from each participant. The first survey phase was held in November/December 2020 and January 2021. The same people who took part in the first survey also participated in the second phase. The same clinical samples from the first phase were collected for the second phase, which took place in March, April, and May of 2021.

Whole blood and saliva samples were collected from delivery riders. The blood samples were obtained by finger pricking to test for anti-SARS-CoV-2 antibodies using the rapid test (RT), and the saliva samples were collected to survey SARS-CoV-2 viral RNA using the quantitative reverse transcription polymerase chain reaction (RT-qPCR) test [12].

### *Inclusion and exclusion criteria*

The inclusion criteria stipulated that participants must possess a motorcycle as a fundamental instrument for their occupation and be actively involved in delivery services. Delivery personnel who declined to provide informed consent, failed to complete the questionnaire, or did not partake in both phases of sample collection were excluded from the study.

### *Serology*

During the initial phase of sample collection, the Rapid Test Wondfo SARS-CoV-2 antibody test® (Wondfo, Guangzhou, China) was employed,

demonstrating a sensitivity of 86.43% and a specificity of 99.57% [13]. Subsequently, in the second phase of collection, the WAMA Immuno-Rapid COVID-19 IgG/IgM Test® (WAMA, San Carlos, Brazil) was utilized, exhibiting a sensitivity of 83.3% and a specificity of 93.1% [14]. Both tests were conducted and the materials were disposed of in accordance with the manufacturer's instructions. The results were disclosed and elucidated to participants upon the conclusion of the designated timeframe for reading the test outcomes. Each sample was identified using a unique code employed in both collection phases, with corresponding personal data recorded in a database.

*Detection of viral RNA by RT-qPCR*

The RT-qPCR test was used for molecular detection of viral RNA from saliva samples. Saliva was collected according to the standardized protocol for saliva collection and analyzed by the Hemominas Foundation [12]. The same protocol for RT-qPCR was used in both phases of the study. RNA was extracted by the viral RNA extraction technique using commercial kits (ReliaPrep™ Viral TNA Miniprep System, Custom - PROMEGA - Madison, WI, USA.) with columns for purification of genetic material according to the manufacturer's instructions. A time-line diagram provides a summary of all the stages of the research project (Figure 1).

We adopted the protocol established by the Centers for Disease Control and Prevention (CDC) in the USA; and the Charité Hospital, Berlin, Germany; for RT-qPCR, and used the primers and probes described in

Supplementary Table 1. The products were amplified and compared to positive SARS-CoV-2 controls to confirm the diagnosis. The human gene (*RNAse P*) was used to confirm the success of the extraction process. All experiments had positive and negative controls.

RT-qPCR results were provided to participants via a messaging app up to 48 hours after their completion, and participants were called by phone to confirm receipt. Positive participants also received a call explaining the result. Positive results were reported to the health authorities.

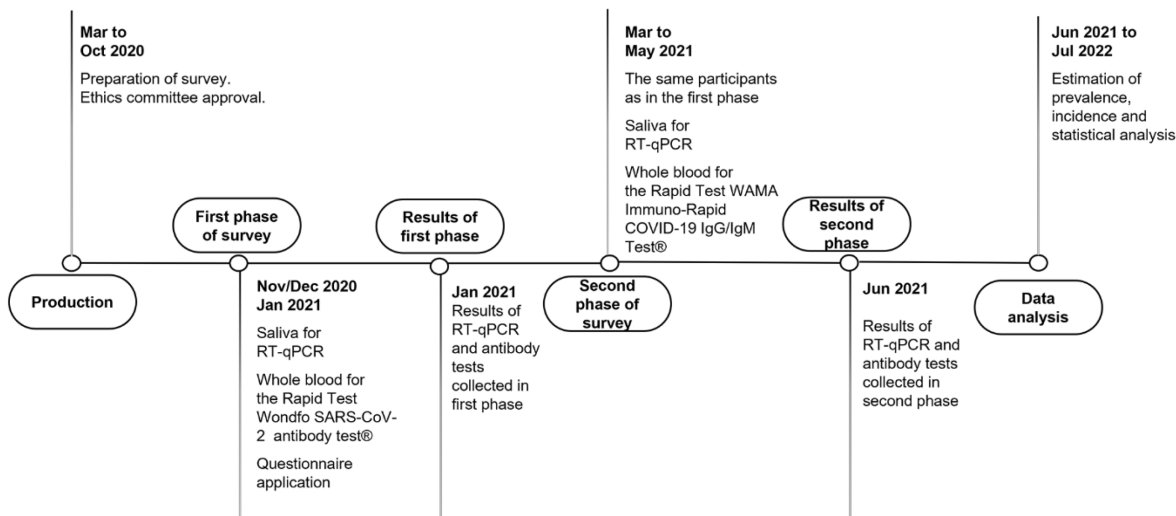
*Questionnaire*

The questionnaire was self-completed, and more than one answer was possible for questions about chronic diseases, prevention methods, work routine, and knowledge about the pandemic. The response variable was infection prevalence. The explanatory variables were extracted from the questionnaire. A summary of the response options from the questionnaire, after grouping, is presented in Supplementary Table 2. The options “low/non-existent” and “sometimes/never” were grouped due to their low frequency (Supplementary Table 2).

*Estimation of prevalence and incidence, and statistical analysis*

We estimated the prevalence (first and second stages separately), the incidence (between stages), and the final prevalence (sum of the results of the two phases). The results of people who tested positive in the two survey phases were not added together to estimate

**Figure 1.** Timeline of survey.



COVID-19: coronavirus disease 2019; RT-qPCR: quantitative reverse transcription polymerase chain reaction; SARS-COV-2: severe acute respiratory syndrome coronavirus 2.

the final prevalence. All data on prevalence and incidence were provided with the 95% confidence interval.

Descriptive statistics were performed to present the results of all variables of the questionnaire. The positivity ratios relating to the categories of the questionnaire variables were compared using the Chi square statistical test and the Mann-Whitney test with a significance level of 5%.

To create multiple logistic regression models, we included the variables that had a *p* value < 0.20 in the bivariate analyses. We used the variance inflation factor (VIF) to analyze the presence of multicollinearity between the variables to be modelled. The variables “cleans hands after delivering orders” and “cleans hands after using the toilet” showed significant collinearity. The variable “cleans hands after using the toilet” was retained in the final model as it showed a stronger relationship with the outcome. The models

were created using non-automatic backward selection procedures. First, all variables were analyzed together. Subsequently, variables with *p* values of more than 0.05 were removed. The results of the models were presented by means of odds ratios with 95% confidence intervals. Model fit was assessed by the Hosmer-Lemeshow method and by analyses of the raw and fitted residuals.

The statistical analyses were carried out using the software R, version 4.4.1 (The R Foundation for Statistical Computing, Vienna University of Economics and Business, Vienna, Austria), and SSPS, version 22 (IBM Corporation, Armonk, New York, United States).

The project was approved by the Ethics Committee on Research with Human Subjects of the Federal University of São João Del Rey (UFSJ, Protocol. 4.353.408). All participants read and signed an informed consent form.

**Table 1.** Characterization and comparative data analysis of delivery riders from Divinópolis, Brazil.

Variables and categories		Frequency (%)	Prevalence (confidence interval)	<i>p</i> value	
<b>Social</b>	Gender	Male	111 (95%)	15.3% (9.1–23.4)	0.92
		Female	6 (5%)	16.7% (0.4–6.4)	
	Age (years)	19–39	73 (63%)	15% (7.7–25.3)	0.95
		40–59	39 (33%)	15.4% (5.9–30.5)	
		≥ 60	5 (4%)	20% (0.5–71.6)	
	Schooling	Incomplete high school	42 (36%)	14.3% (5.4–28.5)	0.11
		Complete high school	60 (51%)	12% (4.8–22.5)	
		College education complete/incomplete	15 (13%)	33% (11.8–61.6)	
	Self-declaration color/race	Black	18 (15%)	22.2% (6.4–47.6)	0.33
		Brown	58 (50%)	10.3% (3.9–21.2)	
White		37 (32%)	21.6% (9.8–38.2)		
Others (indigenous, yellow)		4 (3%)	0%		
<b>Health and Lifestyles</b>	Smoker	Yes	29 (25%)	17.2% (5.8–35.8)	0.78
		No	86 (75%)	15.1% (8.3–24.5)	
Chronic disease	1 or more	27 (26%)	14.8% (4.2–33.7)	0.84	
	No	75 (74%)	13.3% (6.6–23.2)		
<b>Work conditions</b>	Type of delivery	With contact	78 (67%)	16% (9.1–26.5)	0.42
		Contactless	38 (33%)	11% (3.0–25.4)	
Type of payment	With contact	85 (80%)	16% (9.3–26.1)	0.16	
	Contactless	21 (20%)	5% (0.1–23.8)		
<b>Responsible and Preventive Behavior</b>	What would you do if you had symptoms of COVID-19?	Excellent behavior	51 (44%)	14% (5.7–26.3)	0.15
		Good behavior	61 (53%)	15% (6.9–26.2)	
		Bad behavior	4 (3%)	50% (6.8–93.2)	
	Frequency of use of masks	High	72 (63%)	12% (5.9–22.4)	0.28
		Average	35 (30%)	20% (8.4–36.9)	
		Low/none	8 (7%)	0	
	Applies social distancing?	High	34 (30%)	18% (6.8–34.5)	0.48
		Average	63 (55%)	14% (6.7–25.4)	
		Low/none	18 (15%)	6% (0.1–27.3)	
	Sanitize hands after coughing?	Ever	63 (55%)	13% (5.6–23.5)	0.67
Sometimes/never		52 (45%)	15% (6.9–28.1)		
Sanitize hands after going to the toilet? *	Ever	51 (51%)	6% (1.2–16.2)	0.03	
	Sometimes/never	49 (49%)	20% (10.2–34.3)		
Sanitizes hands after delivering the order?	Ever	41 (39%)	5% (0.6–16.5)	0.06	
	Sometimes/never	64 (61%)	17% (8.9–28.7)		
Sanitizes surfaces?	1 or more	81 (70%)	13% (6.9–23.0)	0.87	
	No	34 (30%)	15% (4.9–31.0)		

\*Variable with the highest number of losses of information (n = 100). Source: author's archive; 2022. COVID-19, coronavirus disease 2019.

**Table 2.** Results of diagnostic tests of COVID-19 in delivery riders from Divinópolis, Brazil, by phases of collection.

Variable	1st phase		2nd phase		Final prevalence		p value
	Positives	Prevalence (CI)	Positives	Prevalence (CI)	Positives	Prevalence (CI)	
Proportion of + by phases	6	5.1% (1.0–10.0)	14	12% (6.0–19.0)	18	15.4% (9.0–23.0)	0.06
Rapid test	Total Ig: 4	3.4% (0.9–8.0)	Total Ig: 12 (IgM: 2 IgG: 10)	10.3% (5.0–17.0)	15	12.8% (7.4–20.2)	0.03
RT-qPCR	3	2.6% (0.5–7.0)	5	4.3% (1.0–9.0)	8	6.9% (3.0–13.0)	0.47

+, positives; Source: author's archive; 2022. CI: confidence interval; COVID-19: coronavirus disease 2019; RT-qPCR: quantitative reverse transcription polymerase chain reaction.

**Results**

Initially, 140 delivery riders were included in the study as they met all the first stage inclusion criteria. However, 23 delivery riders were excluded due to the factors described below:

- 18 participants did not participate in the second phase of the survey;
- 1 participant gave up;
- 3 participants stopped working with deliveries;
- 1 participant refused to provide the saliva sample.

One hundred and seventeen (117) delivery riders participated in both survey phases. Among them, 43 participants were affiliated with associations of motorcycle taxi/motorcycle freight and delivery riders, while 74 were recruited through active search and messaging applications (Table 1).

There was a disparity in prevalence among the categories of school education and payment type, albeit without statistical significance. Similar trends were observed in the behavior of delivery riders when experiencing symptoms, with the majority demonstrating satisfactory and responsible behavior, predominantly categorized as "good behavior". However, the highest prevalence was noted in the group characterized by poor behavior. Notably, the frequency of hand hygiene practices after toilet use significantly correlated with outcomes, with higher prevalence

observed among individuals reporting inadequate hand hygiene.

The positivity criterion was defined as a positive result in either one or both phases of testing. The overall prevalence of COVID-19, calculated as the sum of positivity across both phases, was 15.4% (CI 9.0–23.0). Notably, the proportion of positive results in the second survey phase (12% (CI 6.0–19.0)) considerably increased compared to the first phase (5.1% (CI 1.0–10.0)), although not significantly. Seroprevalence exhibited a significant increase ( $p = 0.03$ ) in the second collection phase (10.3% (CI 5.0–17.0)) compared to the initial phase (3.4% (CI 0.9–8.0)) (Table 2). The incidence among delivery riders in the second phase was 11% (CI 5.7–18.1). No diagnostic test yielded an indeterminate result.

One participant who tested positive with RT-qPCR in the first phase did not test positive in the immunoglobulin test in the second phase, and three participants who tested positive with RT-qPCR in the first phase were not positive in the second phase. Two IgM-positive participants were not positive in the RT-qPCR. Three IgG-positive/IgM-negative participants tested positive with RT-qPCR.

We identified five variables that were included in the regression models (Table 3). The probability that the delivery rider was infected with SARS-CoV-2 was significantly higher among those who reported that they

**Table 3.** Multiple logistic regression models comprising the main variables associated with SARS-COV-2 infection in delivery riders from Divinópolis, Brazil.

Variables in the equation		95% CI for OR			p value
		OR	Bottom	Higher	
<b>Model with all variables</b>	Cleans hands after using the toilet (Sometimes or never)	4,421	1,049	18,636	0.04
	Level of schooling: complete high school	1			
	Level of schooling: incomplete high school	1,142	0.242	5,403	0.87
	Level of schooling: college education complete/incomplete	5.516	0.885	34,394	0.07
	What would you do if you had symptoms of COVID19: excellent behavior <sup>†</sup>	1			
	What would you do if you had the symptoms of COVID19: good behavior	0.646	0.17	2,450	0.52
	What would you do if you had symptoms of COVID19: bad behavior	4.205	0.206	85,740	0.35
<b>Final model</b>	Type of payment: with contact	2.61	0.288	23,675	0.39
	Cleans hands after using the toilet: sometimes or never	4,830	1,181	19,753	0.03
	Level of schooling: incomplete high school	1			0.15
	Level of schooling: complete high school	1.235	0.277	5,507	0.78
	Level of schooling: college education complete/incomplete	4,772	0.824	27,626	0.08

Source: author's archive; 2022. COVID-19, coronavirus disease 2019; OR, odds ratio; SARS-COV-2, severe acute respiratory syndrome coronavirus 2.

did not have the habit of “clean hands after using the toilet”. This independent association was significant in all constructed models. Table 3 summarizes the associations with all variables included in the models as well as the association of the model with the variables “cleaning” and “school education”.

## Discussion

This study has added to the body of knowledge on exposure to SARS-CoV-2 by examining the seroprevalence of COVID-19 in delivery riders and linking their social characteristics and occupational routines to SARS-CoV-2 infection. We found an increase in the proportion of positive results in the second phase of the survey, and an important finding was the significant increase shown by serology. Among the social and occupational characteristics measured by the questionnaire, preventive behaviors during occupational routine were more strongly associated with the risk of SARS-CoV-2 infection.

Similar to the results of our study, Ortiz-Prado *et al.* found a prevalence of 15.2% in 145 delivery riders who worked in the city of Quito, Ecuador, from July to August 2020 [9]. In this study, only RT-qPCR was used as the diagnostic test. Despite the similarity between the prevalence found in our study and that of Ortiz-Prado *et al.* [9], the use of a protocol for current infection (RT-qPCR) and previous infection (serology) favors a more accurate observation of the individuals exposed to the pathogen in the population studied [15,16]. We also attribute the increase to the spread of new variants, which are a cause for concern – Alpha and Gamma, especially Gamma, which was prevalent throughout the Brazilian territory when the survey was conducted [17–19]. In addition to the fact that the strains circulating in the second phase were more infectious, the maintenance of the pandemic and the lack of control measures such as vaccines contributed to the increase in the total number of infected people in the second phase of the survey.

In terms of laboratory tests, the proportion of positive results with the RT-qPCR test was similar in both phases. The RT-qPCR test detects a current infection, and the best moment to detect the virus is between the third and seventh day after the onset of symptoms. After the seventh day, the viral load gradually decreases and consequently also the sensitivity of the test [20]. Antibody detection, on the other hand, is generally used for the late diagnosis of a disease. It is often used in epidemiological surveys [21] and can be used to complement the diagnosis of a disease such as COVID-19 [15,16]. Based on the

characteristics of our study, the rapid test may have been able to detect individuals who were infected in the time window between surveys. It is important to emphasize that vaccines were not available during the survey periods of our study; therefore, seroconversion could only occur in the case of natural infection.

A population-based survey including 133 sentinel cities in all Brazilian states conducted before the withdrawal period showed that the seroprevalence for sentinel cities in the state of Minas Gerais, including Divinópolis, was lower than 2% in June 2020 [22]. Assuming that blood donors represent a part of the population, the overall seroprevalence collected in 7 blood centers in Minas Gerais from March to December 2020 was 5.20% [23]. Given the circumstances of the pandemic, even when social distancing was observed, the population infected itself. The need to work face-to-face required contact and proximity with the public and employees, which put delivery riders at risk.

It is important to comprehend how social factors can raise the chance of coming into contact with SARS-CoV-2. Disseminating the social profile of delivery drivers accentuates the findings from the literature about the characteristics of employed workers throughout the pandemic.

When we compared infection rates among self-declared black, brown, and white individuals, we did not find any statistically significant differences; however, we did find that self-declared black individuals had the highest infection rate. The high prevalence among self-reported blacks supports previous research findings that black workers during the pandemic frequently engaged in occupations that required a high degree of interpersonal interaction and that put them at the highest risk of contamination [24,25]. Black people are disproportionately represented among essential workers due to the effects of racial capitalism. The COVID-19 pandemic has further exacerbated this situation, as essential workers face greater challenges in adhering to social distancing and stay-at-home guidelines due to the nature of their occupations. Additionally, they are more likely to reside in crowded households and have pre-existing health conditions, compounding the risks they face [25]. The observations made by the author regarding the black population also apply to the delivery riders' demographics, given their necessity to continue working during the pandemic and the social circumstances they confront.

Through the analysis of educational attainment, we discovered social differences among delivery riders that contribute to the higher prevalence between classes. In

this study, schooling and income were inversely proportional to seropositivity to SARS-CoV-2.

Despite the low frequency of delivery riders with a college degree in this study (13%), a higher prevalence was found in this group. In contrast, more than half the population in our study had a low level of education (36% attended high school but did not complete it). There exists an association between lower levels of education and delayed diagnosis of airborne diseases such as tuberculosis and COVID-19 [26,27], a circumstance which may lead to exacerbation of clinical conditions.

These traits are also seen in other occupational classes, suggesting that workers are at a higher risk of contamination. After stratifying socioeconomic risks, a study conducted in a Rio de Janeiro hospital in June/July 2020 with 1,141 participants found a prevalence of 30% and concluded that the highest infection rate was found among support workers, who were non-white individuals with lower wages, lower educational attainment (up to high school), and use of public transportation [28].

However, the positivity in our study with delivery riders was not influenced by education level, as the adjusted analysis in the logistic regression models showed that education level was not significant. Although access to higher education facilitates interpretation of risk and the commitment to implementing prevention behaviors [7,29], the results show that inefficient hand cleaning was the factor that favored contamination.

In this study, the highest prevalence occurred among delivery riders who were required to have contact with consumers. The end customer is part of a long chain of contacts that add up over the course of their work routine. It is possible that the additional contact increases the associated risk during the work activity. This need for contact can trigger a range of reactions culminating in increased non-compliance with protective measures such as hand cleaning. This is due to competition for deliveries, which was exacerbated by the high demand for delivery riders' labor fueled by unemployment during the health crisis [30].

The delivery riders' perception of risk may have been skewed because to their ignorance of infection prevention guidelines, which is linked to the adoption of preventive measures [31], the identification of vulnerability, and the gravity of the threat [32]. Certain sociodemographic traits of the delivery riders might have shaped the perspectives surrounding the responses. Previous research indicates that being a man

[29,31] and having little education have an impact on one's degree of COVID-19 understanding [29,32].

Since the outbreak of the pandemic, many ministers have headed the Brazilian Ministry of Health, which had a direct impact on the management of the health crisis. With the change of ministers, the recommendation to respond to symptoms also changed – from seeking health services depending on the severity and intensity of symptoms to seeking health services immediately when symptoms appear. At the time, the Department of Health argued that the change in recommendation was based on the observation that people were taking too long to seek clinical care. Thus, early medical treatment could prevent the severity of the disease. However, the same government agency was responsible for poor dissemination of the recommendations, resulting in disinformation among the population, and that may have caused confusion among the delivery riders also.

The variable “cleans hands after using the toilet” was given greater statistical power and was therefore included in the final multiple logistic regression model. However, from a public health perspective, the variable “cleans hands after delivering the orders” has the same value in assessing the good health practices adopted by delivery riders during the pandemic.

In both situations, delivery riders showed that they had a limited understanding of disease transmission. Although fomite contamination does not have the greatest epidemiological importance for COVID-19 [2], poor hygiene can facilitate exposure. Consequently, infection rates can increase in a population exposed to face-to-face work and contact with biological fluid aerosols formed by toilet flushing or contaminated surfaces of public toilets that may not meet hygiene standards [33].

The recognition of fecal-oral contamination by SARS-CoV-2 is controversial [33–35]. The virus can be detected in the feces of both asymptomatic and symptomatic individuals. However, the presence of viral particles in feces does not necessarily indicate the presence of an infectious virus [33,34]. Our findings revealed that delivery riders who did not habitually clean their hands after using the toilet, had a much higher chance of infection. It is recommended to practice proper hand hygiene after toilet use to reduce the risk of infection from agents that cause intestinal diseases [33]. Adequate hand hygiene has been shown to be an effective measure in preventing SARS-CoV-2 infection during the COVID-19 pandemic [2].

The platform “Fairwork Brazil” evaluates the working conditions of digital delivery platforms and

classifies them according to their performance. According to “Fairwork Brazil” one of the workers’ demands for fair working conditions is access to toilets, rest areas, and drinking water. Unfortunately, the problem persisted during the pandemic and continues to this day. New models of restaurants that are completely dependent on delivery riders have not organized to provide them with better working conditions. They lack restrooms, drinking water, adequate places for workers to wait for orders, and areas where they can rest and eat.

Rahman *et al.* found that of 1,382 adults surveyed between December 2020 and January 2021, 17.6% reported that inadequate toilets prevented them from adopting efficient preventive behaviors like handwashing [29].

Some limitations of the research warrant acknowledgment. The fear of being tested positive for COVID-19 was a factor that hindered the delivery riders’ commitment in this study. Although we explained to potential participants that our study was not a random sample designed to find infected individuals and would not go on to be used as a method to control transmission, we were unable to persuade many delivery riders to participate. The loss to follow-up that occurred when some participants who had tested positive in the first survey did not return for the second survey phase may have confounded the analysis of the explanatory variables from the questionnaire. Although some variables showed relevant differences, they were not significant due to the low statistical power of the sample. We conducted a survey within our questionnaire to ascertain which delivery riders presented one or more chronic diseases. The presence of one or more chronic diseases may have been underreported due to the interviewees’ lack of awareness. The questionnaire results indicate that delivery riders exhibited a low level of health consciousness, as some were unable to identify appropriate actions in the presence of symptoms and displayed a lack of attention to the importance of hand hygiene. Consequently, it is conceivable that a deficiency in comprehension or a lack of prior diagnosis of potential chronic diseases may have influenced the assessment of this variable among delivery riders. In spite of the clearness of the questions, the fact that the questionnaire was self-administered was also a limiting factor that reflects the low level of schooling of the evaluated group. Thus, we emphasize the importance of administering health literacy questionnaires, which would have allowed us to know the ability of the delivery riders to receive, process, and understand the information contained in the questionnaire.

## Conclusions

Delivery riders are a group with high potential for exposure to SARS-CoV-2. We did not find a significant difference in prevalence when we analyzed the social characteristics of the individuals, which leads us to believe that the occupational activity (delivery service) favors the risk of exposure to SARS-CoV-2 independent of the social profile of the delivery riders. The behavioral variables were more associated with the risk of infection. We highlight the higher risk of infection among those who did not have good hygiene habits. Due to the exposure to new SARS-CoV-2 variants of concern with a more infectious profile, the relaxation of social distancing measures, and the lack of vaccines during the study, an important, although not significant, increase in the proportion of positive results was found in the second phase of collection.

The COVID-19 pandemic raised a red flag about the exposure of the so-called informal workers. They have always been exposed to airborne and direct contact infectious diseases. The results show the need to apply specific public policies to this group, prioritizing the improvement of the working environment, facilitating personal hygiene practices in the post-pandemic period and especially during outbreaks of communicable pathologies such as COVID-19.

## Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001, by Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) APQ-02358-18, the Universidade Federal de São João Del-Rei and the postgraduate program in Health Sciences. We would like to acknowledge all the delivery riders who participated in this study. We are also thankful to the State Department of Health of the State of Minas Gerais, through the Divinópolis Regional Health Department and the Ministry of Health of Brazil who provided the serodiagnosis and RT-qPCR kits.

## Author contributions

EPA and RGTN: conceived the study and its design, had full access to the data, and take responsibility for the integrity of the data and accuracy of the analysis; EPA and MSF: collected clinical samples for diagnosis and survey data; EPA, MSF, MHMG, MPCO and MMLMT: responsible for the molecular diagnosis; EPA, VSB, RCF: organized and entered data; EPA, VSB, RCF and RGTN: contributed to data analyses; EPA, VSB, RCF, ESS and RGTN: contributed to data interpretation; EPA, VSB, and RGTN drafted the article. All authors critically revised the drafted article and approved the submitted manuscript.



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**Conflict of interests:** No conflict of interests is declared.

## Annex – Supplementary Items

**Supplementary Table 1.** Oligonucleotides (primers and probes) used for RT-qPCR reactions.

Oligonucleotide	Sequence	Reference
Primer Sars-Cov-2.CDC.N1.72. F	GACCCCAAAATCAGCGGAAT	CDC*
Primer Sars-Cov-2.CDC.N1.72. R	TCTGGTACTGCCAGTTGAATCTG	
Sars-Cov-2.CDC.N1.72. P probe	FAM-ACC CCG CAT TAC GTT TGG TGG ACC-BHQ1	
Primer Sars-Cov-2.CDC.N2.67. F	TTACAAACATTGGCCCGCAAA	CDC*
Primer Sars-Cov-2.CDC.N2.67. R	GCCGGACATTCCGAAGAA	
Sars-Cov-2.CDC.N2.67. P probe	FAM-ACA ATT TGC CCC CAG CGC TTC AG-BHQ1	
P-F RNase Primer	AGA TTT GGA CCT GCG AGC G	CDC*
P-R RNase Primer	GAG CGG CTG TCT CCA CAA GT	
RNase P Probe	FAM – TTC TGA CCT GAA GGC TCT GCG CG – BHQ1	

\*Protocol available at <https://www.fda.gov/media/134922/download>. Source: author's archive; 2022. CDC: Centers for Disease Control and Prevention; RT-qPCR: quantitative reverse transcription polymerase chain reaction; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

**Supplementary Table 2.** Variables, including social data, health conditions, working conditions, responsible and preventive behavior; and categories in the questionnaire for delivery riders of Divinópolis, Brazil.

Variables	Answer Options
Gender	Male Female
Age (years)	19–39 years 40–59 years ≥ 60 years
Schooling	Did not complete high school Completed high school College education (complete/incomplete)
Self-declaration color/race	Black Brown White Others (indigenous, yellow)
Smoker	Yes No
Chronic disease	Yes - 1 or more chronic disease (asthma/bronchitis, cancer, cardiovascular disease including hypertension, chronic lung disease, liver disease, kidney disease, chronic neurological or neuromuscular disease, HIV infection or immunodeficiency, obesity) No chronic disease
Frequency of using masks	High Average Low/None
Frequency of applying social distancing measures?	High Average Low/None
During the COVID-19 pandemic did you wash your hands or sanitize them with 70% alcohol after coughing or sneezing?	Ever Sometimes/never
During the COVID-19 pandemic did you wash your hands or sanitize them with 70% alcohol after going to the toilet?	Ever Sometimes/never
During the COVID-19 pandemic did you wash your hands or sanitize them with 70% alcohol after delivering the orders?	Ever Sometimes/never
What surfaces are you in the habit of sanitizing: motorcycle handlebars, card machine, cell phone.	1 Surface or More I'm not in the habit of disinfecting
During the COVID-19 pandemic, what was the most common way to deliver?	Delivery with consumer contact Contactless delivery
During the COVID-19 pandemic, what was the most common way to receive payment for goods?	Payment with contact (card machine or cash) Contactless payment (delivery app or payment apps)
What would you do if you had COVID-19 symptoms?	<b>Excellent Behavior:</b> "I would seek medical support as soon as possible" and "Isolation at first and if symptoms became more intense (shortness breath and chest pain) I would seek medical support". <b>Good behavior:</b> Only "Isolation at first and if the symptoms became more intense (shortness of breath and chest pain) I would seek medical support". <b>Bad behavior:</b> "I would stay at home but go out to buy items that I consider essential" or "I would continue working normally and only communicate to my family and friends if the symptoms became more intense"

Source: author's archive; 2022. COVID-19: coronavirus disease 2019; HIV: human immunodeficiency virus.