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Seroprevalence of SARS-CoV-2 antibodies among public transport workers in Sweden

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ABSTRACT

Introduction: Public transportation is an essential societal function in crisis situations like the coronavirus disease 2019 (COVID-19) pandemic. Bus drivers and other public transport workers are essential workers that need to keep working despite the risk of contagion. The SARS-CoV-2 virus may pose an occupational health risk to public transport workers and especially to bus drivers as they interact with passengers in a confined area. By analyzing antibodies towards SARS-CoV-2 proteins in blood samples it is possible to measure if an individual has been infected by COVID-19. Here, we report the prevalence of antibodies among bus drivers and other public transport employees in Stockholm, Sweden and relate it to socio-demographic factors.
Methods: Seroprevalence of IgG antibodies towards SARS-CoV-2 proteins was investigated in a sample of 262 non-vaccinated public transport workers (182 men and 40 women) recruited between April 26 and May 7, 2021. Most of the participants were bus drivers (n = 222). The relationship between socio-demographic factors and seroprevalence was investigated with logistic regression.
Results: The seroprevalence was 50% in the total sample of public transport workers. Among bus drivers, 51% were seropositive compared to 44% seropositive among the other public transport workers. The difference was not significant. The seroprevalence was higher than the national seroprevalence in Sweden during the same period (18.3% in non-vaccinated people aged 20–64 years). The logistic regression model using Wald forward selection showed that men had a higher risk of being seropositive (OR 2.7, 95% CI 1.3 – 5.8) and there was a higher risk with increasing number of people in the household (OR 1.3, 95% CI 1.1 – 1.6).
Conclusions: These findings could imply an occupational risk for COVID-19 infection among public transport workers. Infection control measures are warranted during virus epidemics to assure bus drives' safety and reduce transmission in public transport.

1. Introduction

Public transport is a central function in society and the operation of public transport has high priority in times of crisis. When a pandemic like the coronavirus disease 2019 (COVID-19) occurs, a functional public transport is essential to ensure that important professions such as healthcare workers can get to work. If public transport is canceled, the consequences will be great for many people.

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During the COVID-19 pandemic, public transport continued to be in operation in Sweden, albeit with some limitation in the service. Public transportation vehicles (buses, trams, rails, and metros) are used daily by millions of people; often they carry passengers above their capacity, especially commuters in morning and evening peak hours. This might contribute to the spread of diseases among public transport users and workers (Musselwhite et al., 2020). The SARS-CoV-2 virus may pose an occupational health risk to public transport workers. Workers that interact with many passengers every day, for instance bus drivers, are at risk of becoming infected at work and of infecting others.

To reduce the spread of infection in public transport, the Swedish Public Health Agency issued recommendations to avoid using public transport. These recommendations were effective from 1 April 2020 to 29 September 2021. Travel decreased during the pandemic and the monthly average number of paid journeys decreased 42 percent between March and December 2020 in the Stockholm region (Hultén et al., 2021). This is assumed to be partly an effect of the recommendations from Swedish authorities, partly an effect of the reduced need to travel when many worked from home or were at home due to COVID-19 symptoms (Harrington and Hadjiconstantinou, 2022).

In the spring of 2020, several deaths in COVID-19 among bus drivers received a great deal of media attention and there were news reports from both Sweden and other countries about bus drivers' concerns about being infected at work. Drivers and safety representatives were concerned that drivers were not sufficiently protected. Reports from the Swedish Public Health Agency have shown increased risk of COVID-19 infection in certain occupational groups. A study performed between March 2020 and May 2020 in Sweden indicated that bus and tram drivers had 4.3 (95% CI 3.6 - 5.1) times higher risk of being diagnosed with COVID-19 compared to other occupational groups (Folkhälsomyndigheten, 2020). However, since testing was scarce in Sweden during the first wave of the pandemic, the total number of infected is not reflected in these numbers. Thus, it is not known whether bus drivers have been more affected by COVID-19 than the general population in Sweden. Moreover, bus drivers often have socio-demographic characteristics that have been associated with increased risk of death from COVID-19. It has been reported that being male, having less individual income, lower education, and being an immigrant from a low- or middle-income country all predicted a higher risk of death from COVID-19 in Sweden (Drefahl et al., 2020). A study investigating all recorded COVID-19 deaths in Sweden from 12 March 2020 to 23 February 2021 found that taxi/bus drivers was the occupational group with the highest relative risk of COVID-19 mortality (Billingsley et al., 2022). However, traditional socioeconomic risk factors explained most of the variation in COVID-19 mortality and the authors concluded that studies may overestimate the differences between occupations in COVID-19 mortality due to confounders and mediators such as education, income, and country of birth.

Burdorf et al. (2021) stressed that identification of occupations at higher risk for becoming infected and specific work characteristics that contribute to the risks will be immensely valuable for preparedness to threats of future pandemics. Poor health and wellbeing are quite common among bus drivers (Crizzle et al., 2017; Tse et al., 2006). They often suffer from diabetes, sleep apnea, cardiovascular disease, and risk factors for chronic disease are highly prevalent (i.e., hypertension, obesity, smoking, high cholesterol, no physical activity, less than 6 h of sleep) (Crizzle et al., 2017). Several of these medical conditions have also been identified as risk factors for severe COVID-19 (Jordan et al., 2020). Hence, it is important to prevent the spread of COVID-19 in this group.

Bus drivers' actual and perceived risk of being infected by the coronavirus needs to be studied more closely to investigate how the pandemic has affected safety and security at work. By analyzing antibodies towards SARS-CoV-2 in blood samples it is possible to measure if an individual has been infected by COVID-19. Here, we investigate seroprevalence of IgG antibodies towards SARS-CoV-2 proteins among bus drivers in Stockholm, Sweden and compare it to seroprevalence in public transport employees with other occupations. The relationship between seroprevalence and demographic, socioeconomic and work-related factors is analyzed and worry of contagion and transmission of COVID-19 is studied to investigate how bus drivers and other public transport workers have been affected by the pandemic.

2. Material and methods

2.1. Participants

All employees at three bus depots in central Stockholm (n = 1385) were invited to participate in the study. The study took place during ten consecutive weekdays between 26 April and 7 May 2021. An invitation letter with information about the study was sent home to the employees and written information was also available at the depots. Employees were able to sign up in advance or drop in at the depots to participate. Study personnel were available on site to give information and answer questions before the participants signed the consent form. There were no exclusion criteria at the time of blood sampling. Participants completed a questionnaire comprising demographics, self-reported symptoms compatible with COVID-19, occupation, work conditions, socioeconomics, and questions about perceived risk of COVID-19 contagion and whether they believed they had contracted COVID-19 at any point during the pandemic (the response options were; yes confirmed with a test, probably but not confirmed, and no probably not).

The following factors were investigated in relation to seroprevalence: gender, age, education, occupation, employment, household income, number of people in the household and country of birth. Participants were asked to state their occupation as either bus driver, maintenance technician, garage employee, operations manager, team leader or office worker.

Registered nurses performed all study procedures. Blood samples were taken from an antecubital vein and plasma samples were prepared from whole blood following centrifugation for 20 min at 2000 g at room temperature. Samples were placed in a refrigerator before transportation to SciLifeLab in Solna, Stockholm the same or the next day. The samples were stored at −80 °C until further analyses. The participants received their results of the serological tests by logging in through a personal link sent by sms.

The study was conducted in accordance with the declaration of Helsinki, and informed consent was obtained by all participants.

Study inclusion and informed consent was obtained at the time of blood sampling. The study protocol was approved by the Swedish Ethical Review Authority (dnr 2020–04834).

2.2. Serological analyses of antibodies

The serological test for detection of IgG antibodies towards SARS-CoV-2 proteins was performed using a multiplex bead-based assay as previously described (Hober et al., 2021). In short, three SARS-CoV-2 derived antigens (a soluble trimeric form and the S1-domain of the spike glycoprotein, and the C-terminal domain of the nucleocapsid) were covalently bound to color coded magnetic beads. The beads were mixed and incubated with the samples, and subsequently incubated with a reporter molecule to allow a readout in a FlexMAP3D instrument (Luminex). Twelve negative prepandemic control samples were included in the assay to allow the calculation of a seropositivity cutoff per antigen (mean + 6 × SD). Reactivity towards at least two of the antigens was required for being classified as seropositive. Based on 331 positive and 2090 negative controls, the method has a sensitivity of 99.7% and a specificity of 99.4%.

2.3. Statistical analyses

Descriptive analyses were made on participant characteristics and questionnaire data related to experiences during the COVID-19 pandemic. Results are presented as numbers and percentages. Categorical variables are presented as proportions and continuous variables are presented as means with standard deviations (SD). Differences between bus drivers and other public transport workers were tested using chi-square tests, Student's t-test and Mann-Whitney *U* test. The relationship between demographic, socioeconomic, and work-related factors and seroprevalence was investigated using binary logistic regression and reported as odds ratio (OR) and 95% confidence interval (CI). The logistic regression was performed to investigate the combined effects of gender, age, education, occupation, employment, household income, number of people in the household and country of birth on the likelihood that participants were seropositive. First, all factors were entered in a combined binary logistic regressions analysis (Model 1). As a second step, Wald forward selection was applied to the logistic regression model to select the most influential factors (Model 2). Statistical analyses were

Table 1
Characteristics of the study participants.

	All	Bus drivers	Other	Test statistic	p-value
N	262	222	36		
Age (years), mean (SD)	53 (10)	54 (10)	49 (10)	t = 2.8	0.01
Missing, n	15	13	1		
Sex, n (%)				χ2 = 7.3	0.03
Male	211 (80.5)	182 (82.0)	26 (72.2)		
Female	50 (19.1)	40 (18.0)	9 (25.0)		
Other	1 (0.4)	0 (0)	1 (2.8)		
Seroprevalence, n (%)					
Positive	130 (49.6)	112 (50.5)	16 (44.4)	χ2 = 0.4	0.59
Negative	132 (50.4)	110 (49.5)	20 (55.6)		
Country of birth, n (%)					
Sweden	117 (45.3)	97 (44.3)	19 (52.8)	χ2 = 0.9	0.37
Other	141 (54.7)	122 (55.7)	17 (47.2)		
Missing, n	4	3			
Number of people in the household, mean (SD)	2.6 (1.4)	2.6 (1.5)	2.7 (1.2)	t = −0.2	0.88
Missing, n	13	10	1		
Education				χ2 = 3.5	0.324
Elementary school	20 (7.8)	18 (8.7)	1 (2.9)		
High school	113 (44.1)	97 (44.3)	15 (42.9)		
Trade or technical school	68 (26.5)	54 (24.7)	13 (37.1)		
University	55 (21.5)	49 (22.4)	6 (17.1)		
Missing, n	6	3	1		
Employment				χ2 = 14.7	0.001
Full time	181 (69.9)	144 (65.2)	34 (97.1)		
Part time	37 (14.3)	36 (16.3)	1 (2.9)		
Temporary/hourly	41 (15.8)	41 (18.6)	0 (0)		
Missing, n	3	1	1		
Household income, median	(n = 219)	300-399 kSEK	400-499 kSEK	U = 3 529.0	0.003
Missing, n	43	33	8		

performed in IBM SPSS statistics version 25 (IBM Corp., Armonk, NY, USA).

3. Results

A total of 316 public transport workers were tested at the bus depots. Forty-five participants had received at least one dose of vaccine against SARS-CoV-2 and nine had unclear vaccination status. These participants were excluded from the study, resulting in a total sample of 262. The mean age was 53 (SD 10) years. Most of the participants were bus drivers (n = 222), but the sample also comprised maintenance technicians (n = 14), white-collar workers (n = 12), team leaders (n = 5), operations managers (n = 4), and garage employees (n = 1). Four participants did not state their occupation. Bus drivers were significantly older than the other public transport workers and there were a larger proportion of male workers among bus drivers (Table 1). Full-time employment was less common among bus drivers and the household income was lower (Table 1).

Overall, 130 study participants (49.6%) were seropositive. Seroprevalence was 50.5% in bus drivers compared to 44.4% in other public transport workers. The difference in seroprevalence between bus drivers and other public transport workers was not statistically significant ($\chi2 = 0.4$, $p = 0.591$).

Logistic regression analyses of the effect of socio-demographic factors on seroprevalence are presented in Table 2. The logistic regression model of the combined effects of socio-demographic factors was statistically significant, $\chi2(11) = 31.1$, $p = .001$. The model explained 17.5% (Nagelkerke R2) of the variance in seroprevalence and correctly classified 65.6% of cases. In Model 1 with all variables included, participants born in another country than Sweden were 1.92 times more likely to be seropositive (95% CI 1.03 – 3.59). Being a bus driver was not associated with an increased likelihood of being seropositive, as compared to other public transport workers in this sample. Age, employment, household income and number of people in the household were not associated with seroprevalence (Table 2).

In Model 2 using the Wald forward selection approach, gender, and number of people in the household were the included coefficients. The second model was statistically significant, $\chi2(2) = 16.5$, $p < 0.001$. The model explained 9.6% (Nagelkerke R2) of the variance in seroprevalence and correctly classified 58.4% of cases. The result from model two showed that males were 2.7 times more likely to be seropositive than females, but also that increasing number of people in the household was associated with increased likelihood of being seropositive (Table 2).

When asked if the participants thought they had contracted COVID-19, 42.3% answered that they probably had contracted the disease (confirmed with test or not confirmed combined) (Fig. 1). There was no significant difference between bus drivers and other public transport workers ($\chi2 = 1.783$, $p = 0.410$) but there was a significant difference between seropositive and seronegative participants ($\chi2 = 10.056$, $p<0.001$). Among seropositive participants, 73% stated that they thought they had contracted COVID-19 whereas 27% did not believe they had contracted the disease (Fig. 1). Among seronegative participants, 87% believed they had not contracted COVID-19 and 13% believed they had been infected at some point.

The participants' worry about contagion and transmission to others was not significantly different between bus drivers and other public transport workers (all p-values>0.4 in Mann-Whitney U-tests). Worrying daily or several times per day about contracting COVID-19 was reported by 36% of the bus drivers in the first wave and 33% in the second wave (Fig. 2). The corresponding numbers for other transport workers were 31% during the first wave and 23% during the second wave. Worrying daily or several times per day about transmitting COVID-19 to others was reported by 33% of the bus drivers in both the first and second wave (Fig. 3). The corresponding numbers for other transport workers were 18% during the first wave and 23% during the second wave.

Mann-Whitney U-tests of differences between seropositive and seronegative participants showed that seropositive participants worried more about infecting others during the first wave of the pandemic ($U = 9\ 730$, $p = 0.008$) but there were no differences in

Table 2
Results from the logistic regression analyses.

	B	S.E.	Wald	df	p-value	OR	95% C.I. for OR	
Model 1 – All factors entered							Lower	Upper
Gender (Male)	0.752	0.41	3.37	1	0.066	2.121	0.95	4.734
Occupation (Bus driver)	0.368	0.439	0.702	1	0.402	1.445	0.611	3.419
Country_of_birth (Not Sweden)	0.653	0.318	4.204	1	0.04	1.921	1.029	3.587
Number of people in household	0.192	0.111	2.974	1	0.085	1.212	0.974	1.507
Age	0.015	0.016	0.918	1	0.338	1.015	0.985	1.046
Household income	0.057	0.051	1.252	1	0.263	1.059	0.958	1.17
Employment			2.695	2	0.26			
Employment (Full time)	0.637	0.419	2.313	1	0.128	1.892	0.832	4.301
Employment (Part time)	0.242	0.538	0.203	1	0.652	1.274	0.444	3.655
Education			6.265	3	0.099			
Education (Elementary school)	−0.833	0.632	1.741	1	0.187	0.435	0.126	1.499
Education (High school)	−0.956	0.397	5.784	1	0.016	0.384	0.176	0.838
Education (Trade or technical school)	−0.907	0.437	4.298	1	0.038	0.404	0.171	0.952
Constant	−2.589	1.155	5.023	1	0.025	0.075		
Model 2 – Wald forward stepwise								
Gender (Male)	1.007	0.381	6.97	1	0.008	2.737	1.296	5.78
Number of people in household	0.255	0.104	5.942	1	0.015	1.29	1.051	1.583
Constant	−1.425	0.415	11.806	1	0.001	0.24		

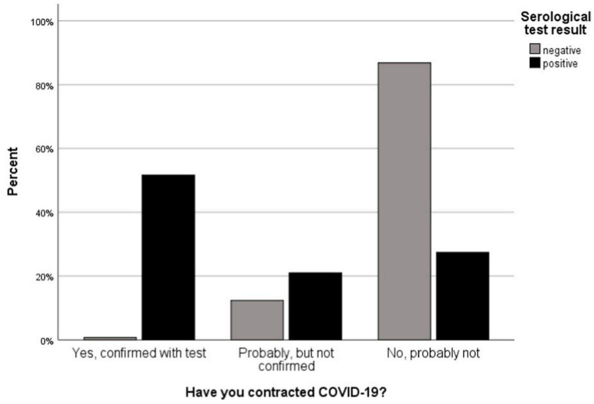

Fig. 1. Self-rated COVID-19 in seropositive and seronegative participants.

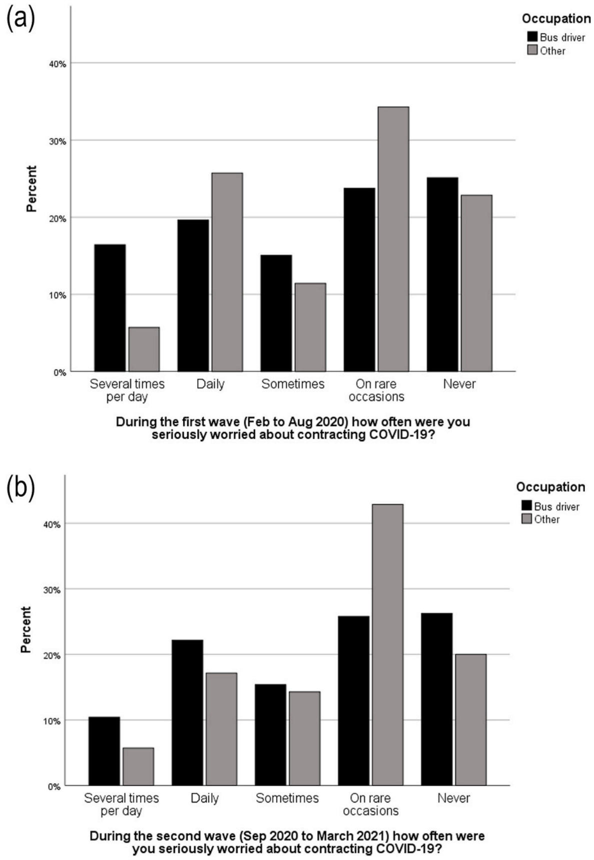

Fig. 2. Worry about contagion of COVID-19 during the first and second wave of the pandemic.

worry about contracting COVID-19 or transmission to others during the second wave (all p-values>0.1).

4. Discussion

The seroprevalence of antibodies against SARS-CoV-2 was 50% among public transport workers. This is higher than the seroprevalence reported in other non-vaccinated populations in Sweden (Castro Dopico et al., 2021; Folkhälsomyndigheten, 2021a) and other developed countries (Jones et al., 2021; Soeorg et al., 2021) during approximately the same period. Direct comparisons between studies are complicated as the demographics of the study subjects differ and the spread of the virus has varied between countries as well as within countries. Time of sampling is also crucial as the seroprevalence cumulates over time as more and more people are

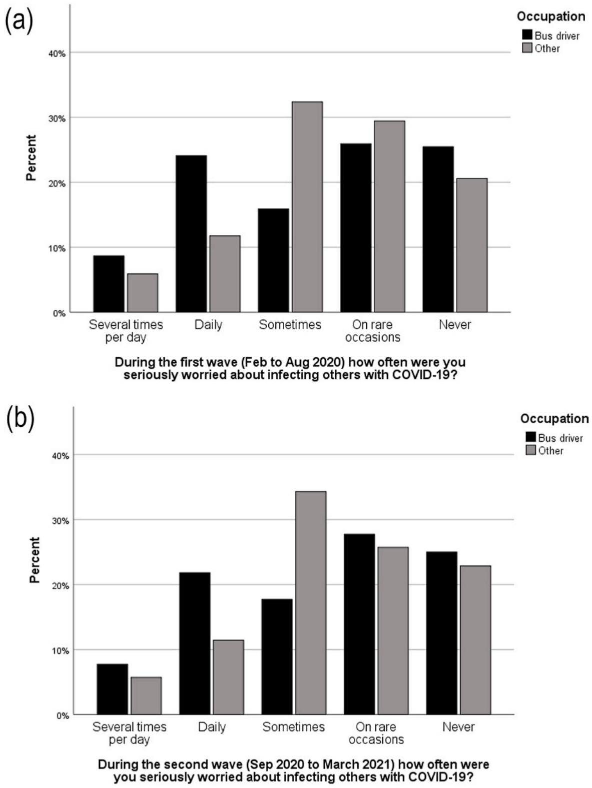

Fig. 3. Worry about transmission of COVID-19 during the first and second wave of the pandemic.

infected.

Several studies have shown significant regional variation in the prevalence of SARS-CoV-2 antibodies (Hossain et al., 2021; Rostami et al., 2021). A meta-analysis of 241 peer-reviewed articles involving 6.3 million individuals from 60 countries published from January 2020 to March 2021 showed that the global pooled seroprevalence was 9.47% (95% CI 8.99–9.95%) (Rostami et al., 2021). Seroprevalence was higher in studies conducted in Central and Southern Asia (22.91%, 19.11–26.72%) than in Europe and North America 7.29% (6.58–8.01%) and Eastern and South-eastern Asia (1.62%, 1.31–1.95%). The most common risk factors associated with higher seroprevalence rate were ethnicity, male gender, age 20–50 years, having a higher number of household contacts, and living in countries or regions with low income and human development indices (Hossain et al., 2021; Kayı et al., 2021; Rostami et al., 2021).

The Swedish Public Health Agency performed three studies of seroprevalence in Sweden during the spring of 2021. The last week of April and the first week of May 2021, 2 860 individuals randomly selected from a web-based health cohort, between the ages of 3 and 90, covering all parts of Sweden were tested. Among non-vaccinated, 18.3% had detectable antibodies against SARS-CoV-2, in the age group 20–64 years (Folkhälsomyndigheten, 2021a). The time corresponded well with the data collection in our study. A second study of seroprevalence was performed during multiple weeks in 2021 using blood samples from outpatient clinics across Sweden. The results showed a seroprevalence of 23% in Stockholm during the period 1 March to 10 March of 2021 and 53% during the period 24 May to 4 June of 2021 (Folkhälsomyndigheten, 2021c). The study did not exclude samples from vaccinated patients and thus the seroprevalence related to contraction of SARS-CoV-2 virus is unknown. Thirdly, seroprevalence was also studied in blood donors during the same time periods as for outpatient clinics. The seroprevalence in blood donors in Stockholm was 25% 1 March to 10 March of 2021 and 60% 24 May to 4 June of 2021 (Folkhälsomyndigheten, 2021b). As for the outpatient clinic study, blood samples from vaccinated blood donors were included. Mass vaccination in Sweden was ongoing during the weeks of data collection in this study and official statistics report that 34.6% of the population had received at least one dose by the end of our data collection. Another study aiming to understand the levels of past SARS-CoV-2 infection in the Stockholm population before the start of mass vaccinations, sampled healthy blood donors and pregnant women ($n = 5,100$) at random between 14 March 2020 and 28 February 2021. They reported that by the end of February 2021, 19% of the population tested seropositive (Castro Dopico et al., 2021). Studies of leftover blood samples in other countries have shown that the seroprevalence of SARS-CoV-2 was, 20.1% in Estonia in February/March 2021 (Soeorg et al., 2021) and 20.2% in the US in May 2021 (Jones et al., 2021).

Several socio-demographic factors, including education, income and country of birth have previously been linked to an increased risk of COVID-19 infection and/or serious illness (Gustafsson et al., 2022; Upshaw et al., 2021). In this study, seroprevalence was associated with gender and number of people in the household but not with other demographic and socioeconomic factors. However, the explained variance was low in the logistic regression models which indicates that the socio-demographic characteristics investigated here were not the main explanation for seropositivity. The relatively high seroprevalence as compared to other seroprevalence studies of non-vaccinated populations suggest that public transport workers are at risk. It is impossible to determine whether the public transport workers were infected at work or during leisure time. Buses as well as lunch areas, depots, and transit vehicles are work environments where crowding can be a problem. In Sweden, the public health agency recommended all adults to wear face masks on public transport if crowding could not be avoided. The Swedish COVID-19 mitigation strategy relied largely on voluntary recommendations, with some exceptions, and face mask use was not enforced (Tegnell, 2021). It is possible that countries with stricter face mask mandates and enforced lockdowns have had less COVID-19 cases among bus drivers, but this needs further investigation.

Although the seroprevalence in the sample was higher than in other Swedish samples from the same time, it is not known if the seroprevalence among other occupational groups living or working in the same area as the participants had similar seroprevalence. The proportion of non-bus drivers in the sample was relatively small and a larger number of workers with other occupations could have provided a better view of the differences between occupational groups. Because of the regional variations in the spread of the virus, generalizations to other regions and other countries are challenging. The seroprevalence among bus drivers and other public transport workers in other parts of Sweden is not known. To date, there are no published studies from other countries comparing seroprevalence among public transport workers to seroprevalence in the general population. An Italian study investigated incident cases of COVID-19 based on a positive molecular test between 1 September 2020 and 6 May 2021 in a cohort of 2,052 employees of a public transport agency. The results showed that bus drivers in Sardinia, Italy ran an elevated risk of COVID-19 (RR = 1.4, 95% C.I. 1.07-1.79) compared to age-and gender-specific incidence rates in the regional population at the same time frame (De Matteis et al., 2022). High prevalence of COVID-19 infection was also found in bus drivers in Madrid, Spain between 25 March and 11 July 2020 through a screening program for essential workers (Martínez-Cortés et al., 2022). In California, COVID-19 outbreak incidence during January 2020–May 2022 was 5.2 times as high in the bus and urban transit industry as in other industries in the state (Heinzerling et al., 2022). This strengthens the indications of an occupational risk for SARS-CoV-2 infection among bus drivers. Studies from more countries are needed to provide a complete picture of the risk among public transport workers.

Approximately one third of the bus drivers worried daily about contracting COVID-19 and transmitting it to others. Bus driving is a stressful occupation and worry about contracting COVID-19 is an additional novel stressor that can negatively impact driver health (Lemke et al., 2020). The other public transport workers had slightly lower numbers on daily worry about contagion and transmission but the differences between occupational groups were not statistically significant. Studies have shown that essential workers, including public transport workers, experienced adverse psychological effects during the COVID-19 pandemic. A common problem was fears of COVID-19 exposure, contagion, and subsequent transmission to others, especially their families (May et al., 2021; Roberts et al., 2020). Essential workers reported multiple exposure risks, including difficulties keeping distance at work, insufficient personal protective equipment, and a lack of workplace mitigation practices.

A relatively large proportion of the seropositive participants, 27%, did not believe they had been infected by COVID-19, which indicates that self-reports are not reliable in tracking COVID-19 contraction. One participant was seronegative despite a previous positive COVID-19 test for ongoing infection. This could be due to antibody levels decreasing over time or due to a false positive test. The date for testing and type of test was not known for this individual.

All participants worked for one public transport operator in the Stockholm metropolitan area. This implied homogeneous working conditions and similar exposure during working hours in the sample. The front doors of the buses had been closed since 17 March 2020 and the first rows of seats were blocked to ensure distance between the bus drivers and passengers. Infection control measures were the same for all public transport operators in the Stockholm area but varied somewhat between regions in Sweden. Closed front doors of buses were applied as a countermeasure in all regions albeit with different starting dates. As Stockholm was the region most affected in the beginning of the pandemic, they were among the first to close the front doors.

The high seroprevalence found in this study suggests that infection control measures directed at public transport workers are warranted during virus epidemics. These countermeasures could include both information and education on how to minimize exposure and spread of infection, as well as infection control measures in the physical environment. Billingsley et al. (2022) point out that buses may be hot zones for the virus as many passengers enter and exit over the course of a shift and efforts to train and provide Personal Protective Equipment (PPE) for such drivers is therefore important. Simulations and experimental studies have found that increased ventilation and face masks can effectively reduce the transmission of disease in buses (Edwards et al., 2021; Zhang et al., 2021). Systematic reviews have also shown that wearing a face mask has a great potential in controlling airborne transmitted viruses including COVID-19 (Abboah-Offei et al., 2021). Simulations using disease spread models have shown substantial and significant reduction in the number of new infections when face mask use is greater than 80% among passengers in public transport (Grzybowska et al., 2022). Such infection control measures can be employed during virus epidemics to assure bus drives' safety and reduce transmission in public transport (Nguyen and Pojani, 2021).

Concerns have been raised about the future of public transport as the fear of being infected by the Coronavirus might linger on and travel behavior may have changed permanently. It has previously been found that changes in travel behavior at the time of major life events can result in permanent changes to that behavior (Clark et al., 2014). A major challenge now is to restore trust in public transport and to encourage the use of public transport as a safe, healthy, and efficient means of travel (Musselwhite et al., 2021). Continued infection control measures such as mandatory mask wear could facilitate post-pandemic return to public transport (Hsieh and Hsia, 2022). Musselwhite et al. (2021) argued that public transport has been unjustifiably stigmatized by media, authorities and citizens during the pandemic and there is a need to correct misperceptions related to the risks associated with travel. There are conflicting results regarding how the use of public transport affects the spread of COVID-19 cases in urban areas. Several studies have, however, reported that a higher rate of public transport use is associated with a higher number of COVID-19 cases (Alidadi and Sharifi, 2022). Finding solutions to reduce the risk of virus transmission in public transportation should thus be a focus for further studies. Future work should evaluate the effectiveness of various infection control measures used in public transport focusing on both the passengers and public transport workers. This knowledge can be used to increase preparedness for future virus epidemics.

5. Conclusion

The data highlight a relatively high SARS-CoV-2 seroprevalence in bus drivers and other public transport workers in Stockholm, Sweden. These findings could imply an occupational risk for SARS-CoV-2 infection among public transport workers, which should be further investigated in other regions of the world. Infection control measures are warranted during virus epidemics to assure bus drives' safety and reduce transmission in public transport.

Based on the results of this study, we cannot conclude that socio-demographic factors were the main determinants of whether public transport workers have been infected with COVID-19 or not as the explained variance was rather low in the logistic regression models. The high seroprevalence in public transport workers could imply inadequacy of the preventive measures put in place on buses and in depots, garages, and transit areas.

Future work should evaluate the various infection control measures employed in public transport during the COVID-19 pandemic to determine which are the most effective countermeasures. The lessons learned can be used to increase preparedness for future crises.

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Author statement

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Declaration of competing interest

The authors declare that there is no conflict of interest.

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