Short Communication

Correlation Between the SARS-CoV-2 Seroprevalence and the Theoretical Occupational Risk (TOR) and COVID-19 Morbidity Score (MBS) Among Local Public Workers in the Centre-Val de Loire Region – CovidOr Study

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Objective: To examine whether SARS-CoV-2 seroprevalence among local public workers in Centre–Val de Loire (France) was associated with a theoretical occupational risk (TOR) score and with a COVID-19 morbidity score (MBS).

Design, setting, and participants: CovidOr was a multicentre cross-sectional study conducted before widespread vaccination (August–December 2020) across Orléans Métropole, the Centre–Val de Loire Region, and the Communes of Terres du Val de Loire (CCTVL). A total of 3,602 municipal and regional employees (18-84 years) underwent rapid serological testing (COVID PRESTO®).

Exposure and measures: TOR summarised three job-related dimensions (daily exposure to disease/infection, daily public contact, and physical proximity; 0-3 points, grouped as low, moderate, high risk). MBS quantified higher-risk comorbidities for severe COVID-19 (0-5 points). A multivariable logistic regression modelled seropositivity (dependent variable) with age, sex, TOR, known COVID-19 contact, symptoms, centre, and MBS as covariates. Bonferroni correction set α=0.625%.

Results: Seropositivity was detected in 182/3,570 analysable participants (overall seroprevalence 5.1%). Mean age was 46.4 years; 66.6% were women. Neither age (OR 1.008; 95% CI 0.988-1.029; p=0.415) nor

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sex (OR 1.153; 0.731-1.819; p=0.541) was associated with seropositivity. Seroprevalence by TOR category was 0.08% (low), 2.28% (moderate), and 2.76% (high). Although TOR showed an unadjusted association (OR 1.70; 1.146-2.549; p=0.009), it was not significant after multiplicity correction (α=0.625%). Seropositive participants had a lower MBS (OR 0.752; 0.582-0.971; p=0.029), but this also lost significance after correction. Asymptomatic infections represented 31.9% of seropositive cases. Results were robust to adjustment for centre.

Conclusions: In this large pre-vaccination cohort of local public workers (the "CovidOr Study"), neither occupational risk as captured by TOR nor comorbidity burden (MBS) was independently associated with SARS-CoV-2 seropositivity after correction for multiple testing. These findings suggest that, in this setting, workplace contact intensity and aggregated comorbidity risk did not drive infection risk, underscoring the potential predominance of non-occupational exposures and the importance of universal prevention measures.

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Introduction

Back in 2019, the SARS-CoV-2 virus, causing atypical pneumonia, appeared in Wuhan Province, in China [1]. The COVID-19 disease, caused by the SARS-CoV-2 virus, is potentially lethal and remains a major global public health concern [2]. On 11 March 2020, it was declared the first pandemic caused by a coronavirus by the WHO (World Health Organisation) [3]. The SARS-CoV-2 virus has caused more than 7 million deaths worldwide, including 168,142 in France (data from the World Health Organisation as assessed on 7 January 2024) [4].

Screening strategies were put in place and the scientific community became interested in understanding how the virus was transmitted within the population. Interest was shown in populations regularly exposed to multiple human contacts, for example in their working environment. In this context, a clinical study (CovidOr) was conducted between August and December 2020, before vaccination was widely available. Our study was the first to evaluate the SARS-CoV-2 seroprevalence among public workers in Centre-Val de Loire (France), depending on their occupation and potential interaction with the public. A descriptive analysis of the results was previously published in 2023 and suggested that no significant interaction could be observed between the workers' contact with the public during their job and SARS-

CoV-2 seroprevalence [5]. Nevertheless, a significant difference in seroprevalence was observed between the different investigating centres, in correlation with the degree of urbanisation, with a higher prevalence in more urban areas.

In this short report, we aimed to establish a correlation between a proven COVID-19 case and the participant's corresponding theoretical occupation risk (TOR), with adjustment based on their COVID-19 morbidity score (MBS).

Methods

All the methods used to carry out the CovidOr study have been described previously in [5]. We describe here only the new statistical analyses.

Ethical concerns

This study represents a secondary analysis of the CovidOr dataset previously described by Hanane et al. (BMJ Open 2023;13:e066504). Whereas the earlier publication presented a descriptive epidemiological overview of SARS-CoV-2 seroprevalence by occupation and contact with the public, the present analysis introduces two new composite indices—the theoretical occupational risk (TOR) and the COVID-19 morbidity score (MBS)—to explore potential correlates of seropositivity using multivariable modelling. This clarification ensures transparency and distinguishes this analysis as a methodologically distinct secondary study, consistent with COPE and ICMJE publication ethics.

The URC PARADICT-O was the sponsor of the CovidOr study (Registered under ID RCB: 2020-A01414-35), approved by the Dijon Est I ethics committee on 30 July 2020, and written informed consent was obtained for each participant. The management and processing of the data was carried out by the Data Protection Officer (DPO) of Orléans City Council, and according to GDPR requirements.

Statistical analyses

In addition to the descriptive analysis previously published [5], an inferential analysis was performed. The objective was to study the correlation between the SARS-CoV-2 seroprevalence and the TOR of jobs held by public workers in the Orléans Metropole, the Region "Centre-Val de Loire", and the "Communes of Terres Du Val De Loire" (CCTVL).

The TOR was calculated on the basis of the three job-related criteria suggested by the literature: daily exposure to disease and infection, daily interaction with the public during work and daily physical proximity [6]. The presence of each of these three criteria accounts for one point. The total TOR score is the sum of the individual sub-scores. LOW RISK (SCORE = 0), MODERATE RISK (SCORE = 1), HIGH RISK (SCORE $\geq$ 2)

Jobs having none of these criteria have a TOR score of zero and are classified as low COVID-19 risk occupations. Those having one criterion have a TOR score of one and were classified as moderate-risk occupations. Finally, jobs having at least two of these criteria are classified as high-risk occupations.

A multivariate binary logistic regression model was created to perform the statistical analysis. The dependent variable was “seropositivity”. The relevant independent variables were “age”, “sex”, “TOR”, “COVID-19 contact exposure”, and “COVID-19 signs and symptoms”. The variable “centre” was also introduced in the model to adjust for possible variability of SARS-CoV-2 seropositivity among different centres. It was also necessary to adjust for corresponding associated comorbidities so as to reduce bias from possible confounding factors. Therefore, the variable “morbidity score” was introduced to the model.

Tests were performed at the 95% confidence level corresponding to an alpha risk of 5%. However, due to the multiple statistical tests performed and the resulting risk of inflation of the alpha risk, an adjustment of the latter was mandatory. We chose the Bonferroni method for this purpose. Therefore, the adjusted alpha risk was 0.625%.

Sample size

A total of 3,602 volunteers agreed to participate in the study by signing the written informed consent. This is an increased sample size compared to the previous article as 374 more public workers were added to the database.

Patient and public involvement

No patients or members of the public were involved in setting the research questions or the outcome measures, nor were they involved in the design and implementation of this study. There are no plans to involve patients in the dissemination of the results; however, the results of the study will be communicated to the participants.

Results

Overall, out of 17,000 eligible local authority workers in the three investigating centres (Orléans Metropole, the region "Centre-Val de Loire", and the "Communes of Terres Du Val De Loire" (CCTVL)), 3,602 workers were included in the study. However, data were missing for 32 participants. A rapid serological test (COVID PRESTO®) was performed on all participants; 182 workers were seropositive, *i.e.,* an estimated overall SARS-CoV-2 seroprevalence of 5.1%.

The age distribution of the participants is represented in Figure 1. The minimum age was 18 years and the maximum age was 84 years. The mean age was 46.41 years. There was no significant correlation between age and seropositivity (OR=1.008, CI= [0.988:1.029], p=0.415). The gender ratio was unbalanced, with a majority of women included (n=2,397, *i.e.,* 66.55%) in Figure 2. The distribution of seropositivity pourcentage by center was illustrated in Figure 3. The SARS-CoV-2 seroprevalence was 3.49% and 1.63% for females and males, respectively, but no statistically significant difference was observed (OR=1.153, CI= [0.731:1.819], p=0.541).

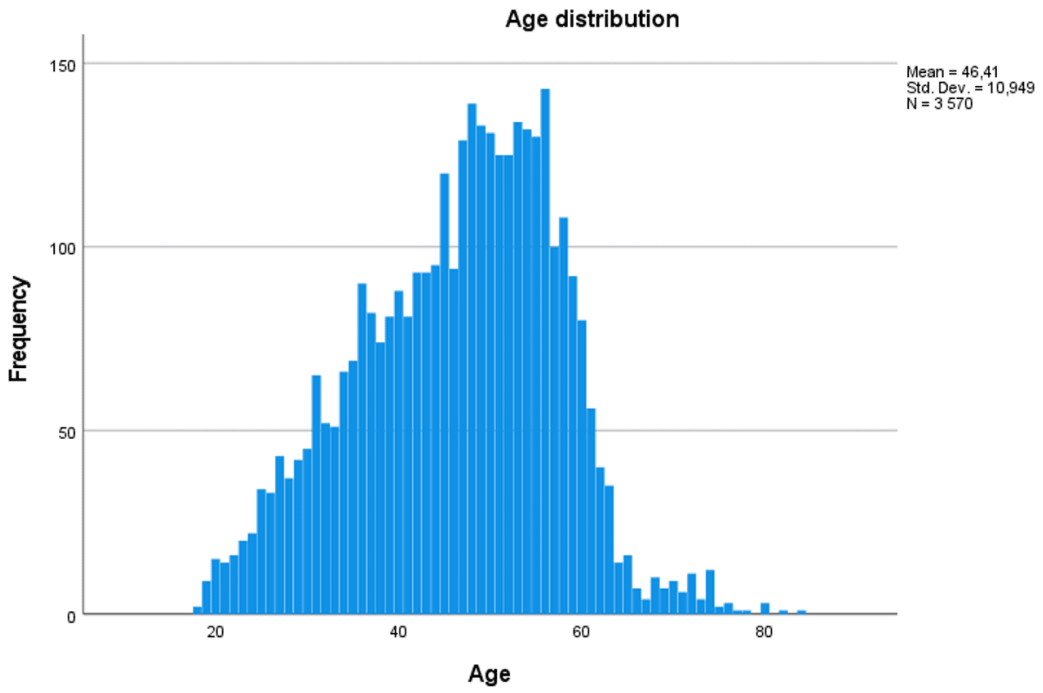

Figure 1. Age distribution of study participants.

CCTVL = Communes of Terres Du Val De Loire; CI = Confidence Interval; HIV = human immunodeficiency virus; MBS = morbidity score; N = number of participants; OR = Odds Ratio; SD = Standard Deviation.

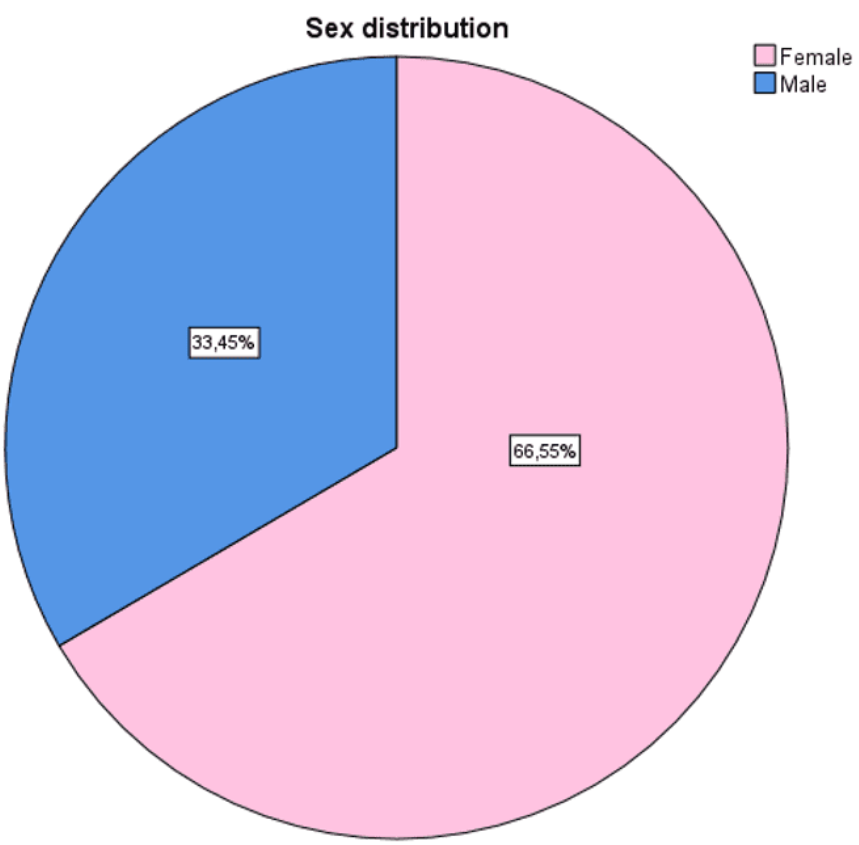

Figure 2. Sex distribution of study participants.

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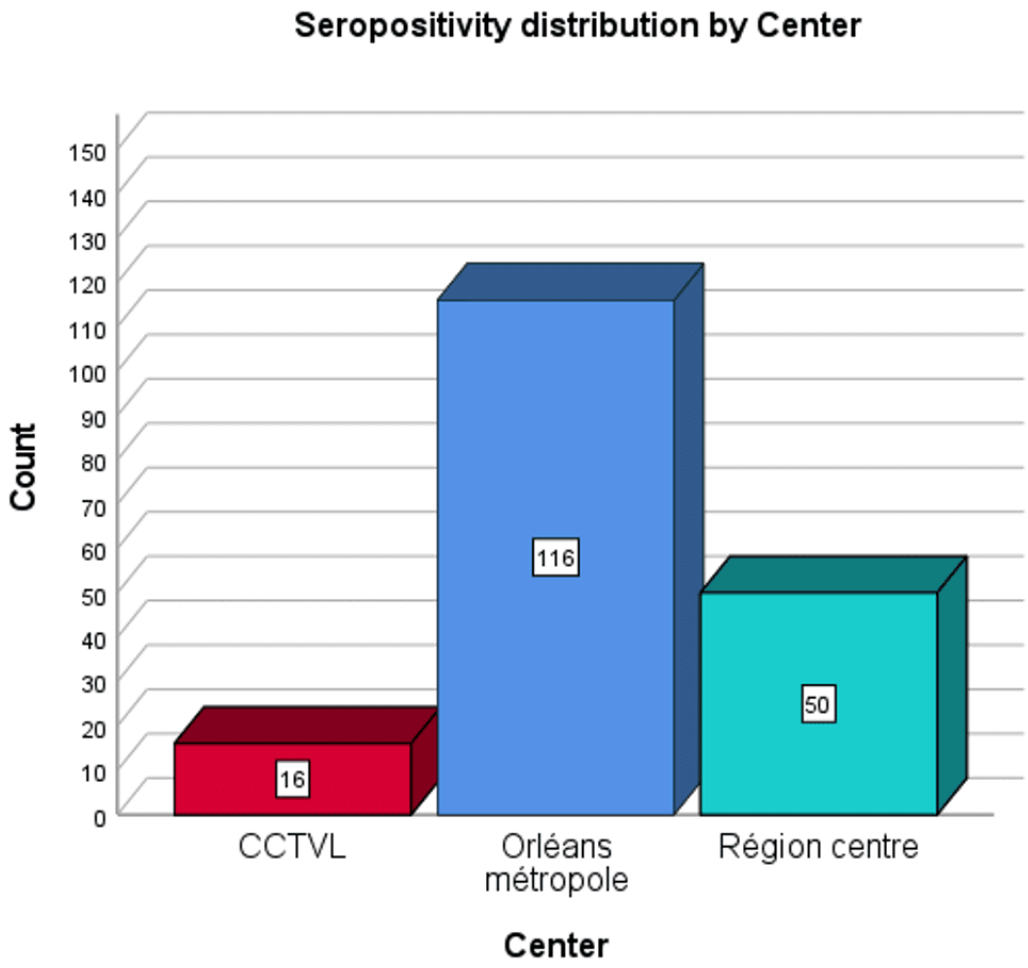

Figure 3. Seropositivity distribution by center

To adjust for possible confounding factors related to the comorbidities of the workers and to reduce selection bias, an MBS variable was introduced in the model. The Covid-19 MBS quantifies the comorbidities of the participants and their associated level of risk concerning SARS-CoV-2 infection. These risk factors are represented in Table 2 and are detailed in [7]. The Covid-19 MBS is the sum of each higher-risk comorbidity, with each one accounting for 1 point. Subjects were classified from null Covid-19 morbidity to high morbidity depending on their MBS value (Table 1). The mean MBS was 0.73. Compared to seronegative participants, seropositive participants had around a 25% decrease in their MBS (OR=0.752, CI= [0.582:0.971], p=0.029). However, after adjusting the risk alpha for multiple tests (adjusted alpha=0.625%), this decrease in MBS turned out to be statistically insignificant.

The occupations and corresponding TOR scores of the local authority workers participating in the study are reported in Table 1. Among subjects with low, moderate and high TOR scores, seroprevalence was 0.08% (n=3), 2.28% (n=81) and 2.76% (n=98), respectively. There was no significant association between SARS-CoV-2 seroprevalence and the overall TOR score for an adjusted risk alpha of 0.625% (OR=1.7, CI=[1.146:2.549], p=0.009) (Table 4).

LOW RISK (SCORE=0)	MODERATE RISK (SCORE=1)	HIGH RISK (SCORE≥2)
Administrative manager	Agent	Public Buyer
Carpenter	Reception officer	Assistant
Plumber	Library assistant	Agent
	Animal keeper	Children's care
	Office assistant	Maintenance work
	Archaeologist	Cleaning agent
	Archivist	Care assistant
	Assistant	Animator
	Executive assistant	Administrative assistant
	Volunteer	Nursery assistant
	Receptionist	ATSEM
	Business manager	Press attaché
	Prevention and safety officer	Nursery assistant
	Project manager	Librarian
	Project manager	Driver
	Team manager	Accountant
	Project manager	Advisor
	Cabinet assistant	Curator
	Technical assistant	Educator
	Coordinator	Sewage worker
	Correspondent	G.P.M
	Cook	Receptionist
	Design decision-maker	Nurse
	Apprenticeship developer	Gardener
	DGS - Director General of Services	Mauger

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LOW RISK (SCORE=0)	MODERATE RISK (SCORE=1)	HIGH RISK (SCORE≥2)
	Director	Lifeguard
	Documentalist	Doctor
	Pruner	Cultural mediator
	Electrician	Media librarian
	Electromechanic	Extracurricular
	Elected	Pre-instructor
	Investigator	Nursery nurse
	Fountain technician	Head of department
	Caretaker	Private secretary mayor-president
	Geomatician for territorial poles	Works supervisor
	Graphic designer	Social worker
	Engineer	AEC users advisor
	Instructor	
	Lawyer	
	Laboratory technician	
	Mason	
	Storekeeper	
	Operator	
	Local patrol unit	
	Painter	
	Police officer	
	Teacher	
	Referent	
	Stage manager	
	Administrative manager	

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LOW RISK (SCORE=0)	MODERATE RISK (SCORE=1)	HIGH RISK (SCORE≥2)
	Department manager	
	Job manager	
	Shooter	
	General secretary	
	Locksmith	
	Technician	
	Traffic technician	

Table 1. TOR scores and corresponding occupations

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Condition	Evidence of Impact on COVID-19 Severity
Asthma	CDC Systematic Review
Cancer ▪ Haematologic Malignancies	CDC Systematic Review Meta-Analysis/Systematic Review Cohort Study Case Series Case-Control Study
Cerebrovascular disease	Meta-Analysis Synthesis of Evidence Cohort Study
Chronic kidney disease ▪ People receiving dialysis	Meta-Analysis Cohort Studies Case Series
Chronic lung diseases limited to: ▪ Bronchiectasis ▪ COPD (Chronic obstructive pulmonary disease) ▪ Interstitial lung disease ▪ Pulmonary embolism ▪ Pulmonary hypertension	CDC Systematic Review
Chronic liver diseases limited to: ▪ Cirrhosis ▪ Non-alcoholic fatty liver disease ▪ Alcoholic liver disease ▪ Autoimmune hepatitis	CDC Systematic Review
Cystic fibrosis	CDC Systematic Review
Diabetes mellitus, type 1	Meta-Analysis

Condition	Evidence of Impact on COVID-19 Severity
	Case Series Cohort Study
Diabetes mellitus, type 2	Meta-Analysis Systematic Review Gestational Diabetes Systematic Review Case Series Longitudinal Study Cohort Study
Disabilities, including Down syndrome	CDC Systematic Review
Heart conditions (such as heart failure, coronary artery disease, or cardiomyopathies)	Meta-Analysis Cohort Study
HIV (Human immunodeficiency virus)	Meta-Analysis/Systematic Review Cohort Study Case Series
Mental health conditions limited to: ▪ Mood disorders, including depression ▪ Schizophrenia spectrum disorders	Meta-Analysis/Systematic Review
Neurologic conditions limited to dementia	Meta-Analysis/Systematic Review Cross-Sectional Study Cohort Study
Obesity (BMI >30 kg/m2 or >95th percentile in children)	Meta-Analysis Systematic Review Cohort Study
Physical inactivity	CDC Systematic Review

Condition	Evidence of Impact on COVID-19 Severity
Pregnancy and recent pregnancy	Meta-Analysis/Systematic Review Case-Control Case Series Cohort Study
Primary immunodeficiencies	CDC Systematic Review
Smoking, current and former	Meta-Analysis
Solid organ or blood stem cell transplantation	Meta-Analysis Case Series Cohort Study
Tuberculosis	CDC Systematic Review
Use of corticosteroids or other immunosuppressive medications	Meta-Analysis/Systematic Review Cohort Study Cross-Sectional Case Series

Table 2. COVID-19 Risk Factors

Clinical characteristics		Number of cases	Prevalence
Symptomatology	- Asymptomatic	58	31.87%
	- Symptomatic	124	68.13%
	Main symptoms		
	Excessive fatigue	78	42.86%
	Fever > 37.8°C	66	36.26%
	Anosmia	60	32.97%
	Ageusia	55	30.22%
	Cough	51	28.02%
	Sore throat	21	11.54%
	Rhinorrhoea	16	8.79%
	Dyspnoea	16	8.79%
	Digestive symptoms	20	10.99%
	Thoracic pain	7	3.85%
	Dermatological symptoms	4	2.2%
	Earache	3	1.65%
Contact with positive case	- Confirmed contact	84	46.15%
	- No contact	55	30.22%

Table 3. Seroprevalence and symptomatology of SARS-CoV-2 depending on clinical and biological characteristics reported in the seropositive group

Asymptomatic (no symptoms) and symptomatic (anosmia or ageusia, or at least three of the following symptoms: fever; chills; severe fatigue, sore throat, cough, shortness of breath, headache or nausea, vomiting or diarrhoea).

Statistics				
			95% C.I.for OR	
Variable	p-value	OR	Lower	Upper
Age	,415	1,008	,988	1,029
Sex (Male)	,541	1,153	,731	1,819
Theorical occupation risk	,009	1,709	1,146	2,549
Center	,000			
- Orléans métropole	,000	4,928	2,333	10,409
- Région centre	,034	2,391	1,070	5,342
Morbidity score	,029	,752	,582	,971
Exposure (yes)	,000	8,003	5,191	12,337
Signs/symptoms (yes)	,000	27,131	14,692	50,099

Table 4. Model results

Discussion

In this new analysis, we introduced the notions of "theoretical occupational risk" and "morbidity score" as they relate to SARS-CoV-2 infection. The TOR allowed the classification of the 97 jobs observed in the participants into three categories: low-, moderate- and high-risk occupations, which allowed for an improved statistical power of the study without a significant loss of information. However, this analysis did not reveal any significant correlation between occupational TOR and seroprevalence (with an adjusted alpha of 0.625%) (Tables 1 & 3).

The MBS aimed to take into account the medical history of the participants as it relates to SARS-CoV-2 infection. It allowed for the quantification of a participant's associated level of risk concerning SARS-CoV-2 infection. This further enhanced the statistical power of the study; however, the analysis did not show a significant correlation between MBS and seroprevalence. There is an observed tendency for a decrease in MBS in the seropositive participants. This could be explained by biased sampling, as 84.8% of participants had an MBS of 0 (51.7%) or 1 (32.9%), since people who had higher-risk comorbidities applied stricter protective measures. In our study, asymptomatic cases represent 31.87% of all SARS-CoV-2 infections, which remains in line with what was observed in other studies, with a range of 4% to 41% [8].

We assumed the same level of importance for the three levels of the TOR score regarding the risk of contracting COVID-19. This does not seem to be the case. We assumed the same thing for the risk factors

of COVID-19 before calculating the MBS. We had no choice but to accept this bias since there were no data from the literature to compare the intrinsic effect of each of these criteria and risk factors two by two.

The various epidemiological studies carried out in Europe during the first wave of COVID-19 showed a lower seroprevalence of SARS-CoV-2 in healthcare workers than in the general population [9]. The most significant indicator correlated with seropositivity in healthcare workers was contact with a symptomatic or non-symptomatic COVID-19 patient, without any means of prevention. However, there was no significant association between SARS-CoV-2 seroprevalence and the COVID-19 occupation risk in our study, even when taking into account the infection risk associated with specific comorbidities (Table 2).

Statements and Declarations

Funding

The study was funded by the City Council of Orléans.

Conflicts of Interest

None declared.

Authors Contribution

Conceived and designed the experiments: RS, AA, TP and AB. Recruited the participants and conducted the study: RS. Analysed the data: AA, AB, AM and RS. Wrote the manuscript: AM and RS. Manuscript review: AB, CM, RN and RS. Coordination with CCTVL: OV. Guarantor: RS.

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Declarations

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