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# COVID-19 seroprevalence among local authority workers from Orléans Métropole, the Community of Communes of the Terres du Val de Loire, the local public service management centre of the Loiret department and the Region Centre Val de Loire: a prospective epidemiological study

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## ABSTRACT

**Objective** To evaluate the SARS-CoV-2 seroprevalence among local authority workers, depending on their position and potential interaction with the public.

**Methods** A cohort of volunteer participants was recruited among local authority workers of the Centre Val de Loire region in France, to be tested using a rapid serological test (COVID-PRESTO). The collected data were analysed by comparing different parameters including, gender, age, position held, and contact or not with the public. The study was carried out from August to December 2020 and included 3228 participants (n=3228), from 18 to 65 years old.

**Results** The seroprevalence of SARS-CoV-2 among local authority workers was estimated at 3.04%. No significant difference could be observed according to the position held by the workers and whether they were or not in contact with the public. Nevertheless, a significant difference was observed between the different investigating centres, in correlation with the geographical location.

**Conclusion** Contact with members of the public was not a critical parameter for SARS-CoV-2 seroprevalence as long as protective measures are applied. Among the population included in the study, childcare workers were more at risk of getting infected by the virus.

**Trial registration number** NCT04387968

## STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study is a large epidemiological survey (n=3228).
⇒ A systematic rapid COVID-19 serological testing was performed in a large population sample.
⇒ The study provides an informative evaluation of the impact of public contact working in COVID-19 contamination.
⇒ The classification of symptomatic and asymptomatic patients relies on recalling memory.
⇒ The study did not include contact tracing and it was impossible to determine nature of the contact cases (work, friends, family, etc).

## INTRODUCTION

In December 2019, a new virus called SARS-CoV-2[1] causing atypical pneumonia appeared in the capital of Wuhan Province, China. It belongs to the family of COVID-19 that caused the SARS epidemic between 2002 and 2003[2] and Middle East Respiratory Syndrome, first detected in the Middle East in 2012 and still ongoing.[3]

The COVID-19 disease, caused by this SARS-CoV-2 virus, is potentially lethal and a major global public health concern. On 11 March 2020, it was qualified as the first pandemic caused by the COVID-19 by the WHO.[4]

After an average incubation period of 5.2 days,[5] patients may experience symptoms such as fever, cough and fatigue that are similar to those seen in other acute respiratory infections. For some patients, symptoms more characteristic of COVID-19 have been observed, in particular, sudden loss of smell (anosmia) and taste (ageusia).[6] Other more

severe symptoms, such as dyspnoea, may lead to acute respiratory distress.[7]

As of 2 December 2022, the epidemiological indicators for monitoring the pandemic show a persistent high level of global circulation of SARS-CoV-2. There have been more than 6.6 million deaths worldwide, including 155 407 in France.[8]

In response to this growing pandemic, serological tests such as the COVID-PRESTO rapid orientation diagnostic test (RODT) have been developed to detect specific IgG and IgM antibodies to SARS-CoV-2 in human blood, serum or plasma.[9] Antigenic tests, such as the COVID-VIRO test, have also been developed to detect the presence of SARS-CoV-2 antigens in upper airway of patients.[10]

Until March 2020, the French National Authority for Health did not recommend the use of serological self-tests due to the lack of scientific data available on their reliability as well as the difficulty of their use and interpretation of their results by users. However, RODTs were considered as valuable tools for carrying out epidemiological studies and for completing the reference diagnostic offer requiring heavy technical platforms (automated tests such as ELISA or PCR).[11]

In May 2020, the incidence rate estimated by Santé Publique France was 7.3 per 100 000 inhabitants in W21 (week 21) in the Loiret department.[12] The local authorities, that is, the Loiret management centre, the Community of Communes of Terres Du Val De Loire (CCTVL), the regional council and Orléans metropole, have decided to offer the 'COVID-PRESTO' rapid serological screening test to their local authority workers independently from their return to work following the national lockdown that ended on 10 May 2020.

The PARADICT-O Clinical Research Unit (URC) was created on this occasion to carry out this project as part of an epidemiological surveillance study validated by a clinical research protocol.[13]

The URC PARADICT-O initiated the 'CovidOr' clinical research project in collaboration with the infectious diseases department of the CHRO (Orléans Regional Hospital Centre), the CHU of Tours and the University of Paris Saclay.

The CovidOr study is a prospective regional epidemiological study of a cohort with minimal risks and constraints classified as Jardé 2 (French Public Health Code). This study seeks to estimate the seroprevalence of anti-SARS-CoV-2 antibodies using the 'COVID-PRESTO' test on all local authority workers, that is, 17 000 potential volunteers. This population may be representative of workers living in the Centre Val de Loire region. Although COVID-PRESTO is only a qualitative test, its reported sensitivity and specificity are close to those of quantitative tests such as the ELISA.[14]

Our study was the first in the Orléans community to estimate the seroprevalence of COVID-19 infection. We aimed to establish the correlation between a proven COVID-19 contact and the position held, depending on whether there was contact with the public or not. This study also allowed for a catch-up diagnosis in people who were already symptomatic and were not already tested.

Overall, CovidOr is an epidemiological surveillance of anti-SARS-CoV-2 immunity in the targeted population.

## METHODS

### Population and study design

The studied population was composed of local authorities' employees aged from 18 to 65 and working for one of the following organisations: Orléans Métropole, the CCTVL and the Région Centre Val de Loire.

Potential participants were informed about the CovidOr study via their respective local collectivity. Participants were included after the signature of an informed consent form validated by the ethics committee CPP Dijon Est 1.

Each investigating centre managed the recruitment of the volunteers. For Orléans Métropole workers interested in the CovidOr study, these had to register on a dedicated website managed by Orléans City Council (WeezEvent). They were then offered an appointment to take part in the study in one of the three Orléans Métropole rooms made available for this purpose. The CCTVL staff, were also invited to make an appointment on a website and a room in Meung sur Loire was dedicated to inclusions. Regional workers interested in the study also registered on the WeezEvent website and chose their room from among the 29 provided according to the proximity of their workplace.

On arrival, the agent was welcomed by a multidisciplinary team trained in the study protocol and composed of clinical study technicians, nurses and investigating physicians. The inclusion criteria were checked by the investigating physician who was also in charge of informing the agent about the study, its objectives and his rights and collecting his or her consent. The visit lasted about 30 min.

A COVID-PRESTO rapid serological test (RODT) was performed by collecting a drop of blood from the participant's finger.

If the serological test revealed the presence of type M antibodies, proving recent infection, an antigenic virological test, COVID-VIRO, was proposed to the agent to confirm the diagnosis.

The agent answered the proposed survey, and the anonymised data were recorded in the electronic observation book in accordance with the legislation in force.

At the end of the visit, the test result was given to the participant by the investigating physician, who also informed the participant of his or her immune status with respect to the SARS-CoV-2 infection.

### 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 specific study. There are no plans to involve patients

in dissemination of the results, however, the results of the study will be communicated to the participants.

### Sample size calculation

Calculation of the number of subjects needed: for an OR: 2 with an alpha risk of first species at 0.05 and a beta risk of second species at 0.90, for a two-sided test, the expected number of subjects was 179 cases and 716 controls at least.

### Statistical analysis

The sample collection protocol was standardised to allow statistical processing of data obtained under the same conditions with different agents. The calculation of the prevalence of immunised agents was done in population of agents in contact with the public and compared with population of agents without contact with the public. Calculations of anti-SARS-CoV-2 IgM attack rates were made in the populations of agents in contact with the public and compared with the populations of agents without contact with the public. Expected level of statistical significance: tests were performed at the 95% CI (alpha=5% risk).

The electronic Case Report Form was produced by PSASS and the software used for data analysis was the 2015 Minitab.15 software, under the responsibility of the study's epidemiologists.

### Test processing

The tests used in this study are the COVID-PRESTO rapid diagnostic test (Ref.: TR-COV-001; TR-COV-002), for the detection of anti-COVID-19 antibodies in blood, and the COVID-VIRO antigenic test (Ref.: TR-COV-006) for the detection of SARS-CoV-2 antigen by nasopharyngeal swab.

These are qualitative tests that comply with European standards and have been validated by the French National Drug Safety Agency (ANSM).

Both tests are manufactured in France by the AAZ-LMB laboratories.

The persons who were authorised to carry out these tests are doctors, pharmacists and nurses. All the people involved in this study were trained by Dr Thierry Prazuck, Head of the Infectious Diseases Department at the CHRO in Orléans, and his team on the standardised procedure for the two tests. The tests were carried out in compliance with the required preventive measures, such as wearing a mask, single-use gloves and disinfection of the confined space after each visit.

COVID-PRESTO (TR-COV-001, lot 2004177, expire date 31 March 2022) is a rapid test that detects the presence of IgG or IgM antibodies in capillary blood. It involves an immunochromatographic reaction between a drop of blood collected from the fingertip (whole blood) and anti-human IgM antibodies (IgM test line), anti-human IgG antibodies (IgG test line) and rabbit IgG (C control line).

The blood drop is added to the sample well (S) and the buffer to the buffer well (B) (figure 1).

A positive result is indicated by a burgundy-coloured band which confirms the reactivity of the test. The absence of coloured band in the test region indicates a negative result.

The control line should change from blue to red to indicate that the sample volume was sufficient and that migration onto the membrane was carried out correctly.

The result is read after 10 min of reaction. Several results are possible:

IgM−/IgG−: not immunised, not contaminating, so in principle, the individual has never been in contact with the virus.

IgM+/IgG−: not yet immunised and contaminating.

IgM+/ IgG+: immunised and contaminating.

IgM−/IgG+: immunised and no longer contaminating.

The test is invalid if the control band remains blue.

The staining intensity may vary and is proportional to the concentration of antibodies contained in the sample.

The test is 100% specific for IgM and 98.3% specific for IgG. In blood samples collected between D10 and D14 after the onset of symptoms, the tested sensitivity of this test was 80% for IgM and 100% for IgG beyond 14 days.[15]

Equipment used to perform the test: gloves, single-use lancet, 10 mL micropipette, cotton wool, test cassette and buffer.

In case of an IgM(+)IgG(−) result the participant may probably still be infectious. IgM appears on the fifth day after the onset of symptoms and infectivity starts on average 2 days before the onset of symptoms and up to 7–10 days after the onset of symptoms.[15] In this case, the COVID-VIRO antigenic test is offered.

COVID-VIRO is a highly sensitive immunochromatographic test for the detection of SARS-CoV-2 nucleocapsid antigen using monoclonal antibodies. The antibodies are fixed in the T-zone of the test strip. A coloured line appears if antigen is present in the sample (figure 2). The COVID-VIRO test displays a sensitivity of 96.6% (reference method: SARS-CoV-2 PCR), which reached 98.4% for people with significant viral excretion (Ct<33).

If the patient consents, a nasopharyngeal swab is taken using a swab. The sample is collected from the back of the nose.

About 10 drops of the buffer are added to the extraction tube in which the swab is dipped and rotated (at least six times) and then pressed against the bottom and walls of the tube.

A filter tip is inserted into the tube in a leak-proof manner. Then four drops of the sample are placed in the well (S) of the cassette. The test is read after 15 min, and several results are possible:

C+T+: positive test.

C+T−: negative test.

C−: invalid result.

The intensity of the staining can vary. It is proportional to the concentration of the antigen contained in the sample.

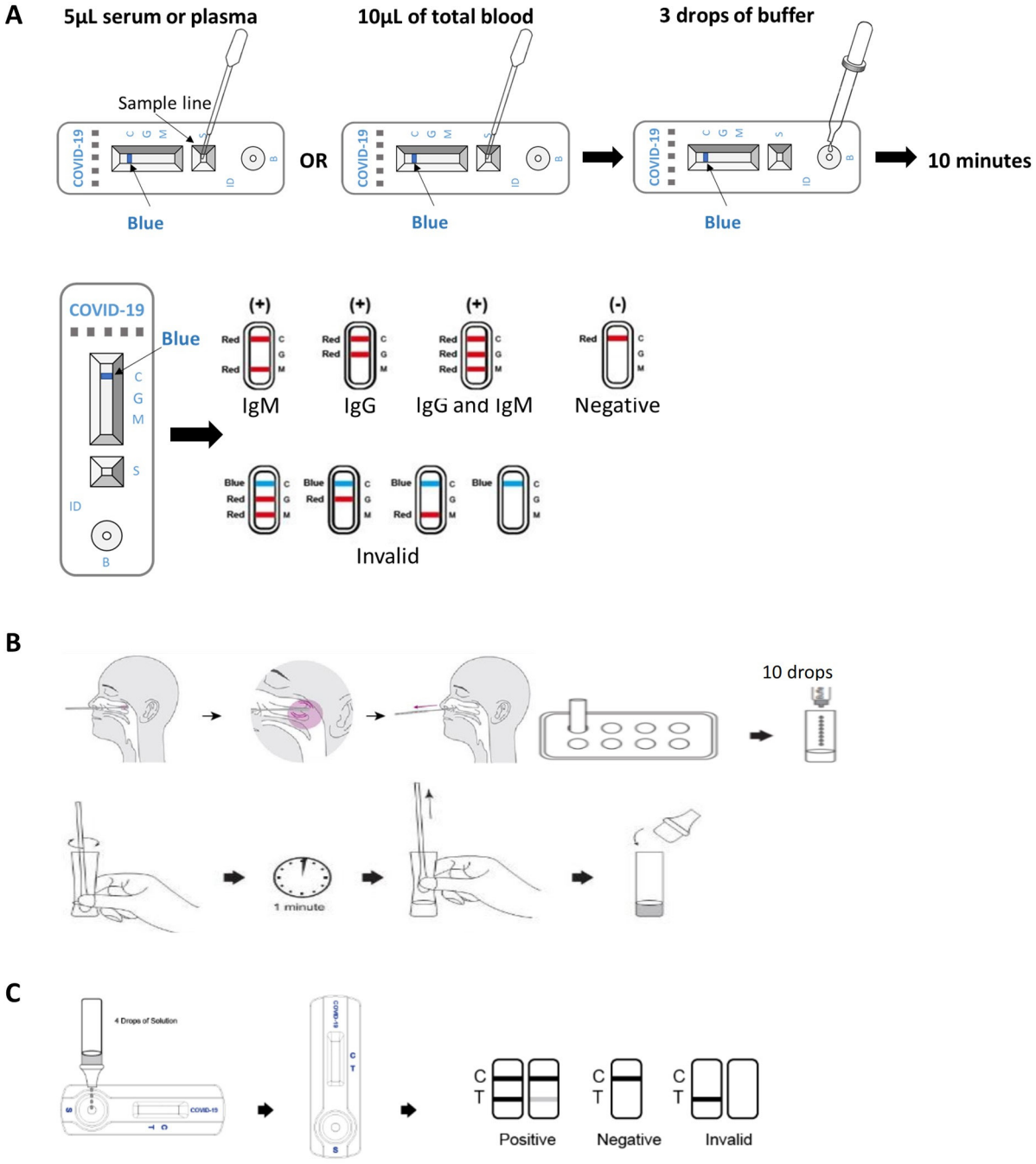


**Figure 1** COVID-PRESTO and COVID-VIRO test processing and interpretation. (A) COVID-PRESTO test carrying out and interpretation; (B) collection and preparation of the sample for the COVID-VIRO antigenic test; (C) COVID-VIRO test carrying out and interpretation.

Material used to perform the test: gloves, sterile nasopharyngeal swab, extraction tube, filter tip, tube holder, test cassette and buffer.

## RESULTS

Overall, out of 17000 eligible local authority workers in the three investigating centres, 3328 workers were included in the study. The COVID-PRESTO test was performed in all participants, 101 workers were seropositive, that is, an estimated seroprevalence of 3.03%.

The distribution of age is represented in figure 2A. There was no significant difference of seropositivity for SARS-CoV-2 between workers aged under 24 and people over 65, but seroprevalence was significantly higher in the 44–64 age group than in the other groups (p=0.013).

The gender ratio was unbalanced, with a majority of women included (n=2221,ie, 66.74%), as shown in figure 2B. The SARS-CoV-2 seroprevalence was of 3.24% and 2.62% for females and males, respectively, but not significant difference was evidenced (p=0.337).

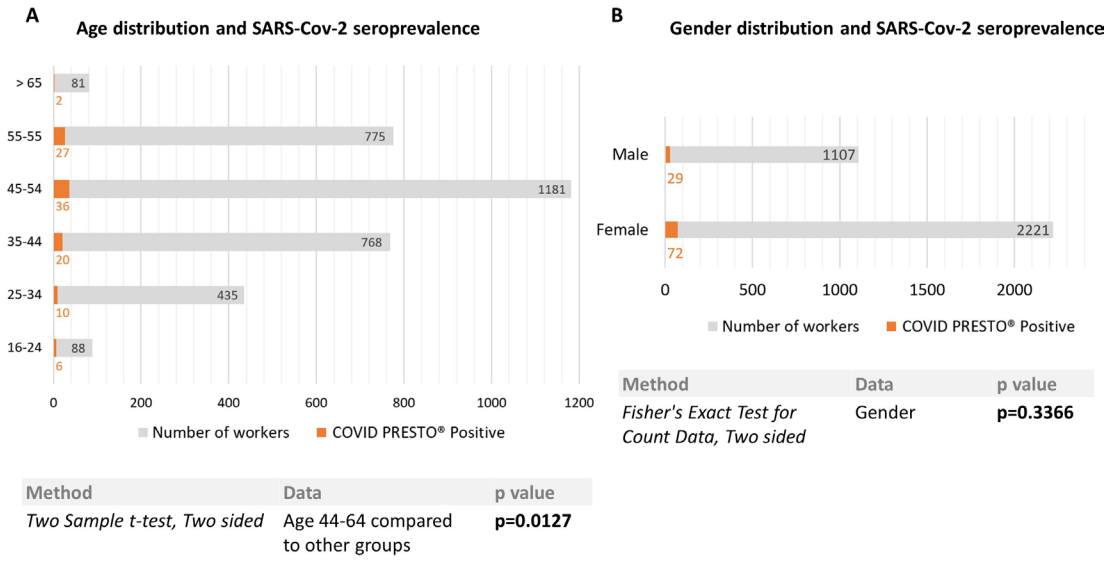


**Figure 2** Demographic characteristics and SARS-CoV-2 seroprevalence. (A) Distribution of workers ages and proportion of COVID-PRESTO positive tests; (B) distribution of workers genders and proportion of COVID-PRESTO positive tests.

The occupations of the local authority workers participating in the study are reported in figure 3A. The maintenance workers were the most represented category (n=719, ie, 21.60%), followed by childcare workers (n=398, ie, 11.96%). A total of 74.43% of the participants worked in contact with the public (n=2477), figure 3B. The seroprevalence was of 3.53% among workers that were not in contact with the public (n=30) and of 2.87% among those who were (n=71). There was no significant difference of SARS-CoV-2 seroprevalence between the two groups (p=0.354).

Regarding the SARS-CoV-2 seroprevalence in relation to population density and geographical location, the study highlighted some discrepancy between the different investigating centres. Indeed, 3.71% of the workers were seropositive (n=48) in the Orléans Metropole centre, whereas they were 3.69% (n=47) in the Centre Val de Loire Region centre and 0.79% (n=7) in the CCTVL (figure 4).

The clinical signs most frequently reported in the seropositive group (n=101) were excessive fatigue (n=52, ie, 51.49%), influenza-like symptoms (n=52, ie, 43.56%), anosmia and ageusia (n=33, ie, 32.67%).

In the seropositive group, 27.72% (n=28) of the participants were completely asymptomatic, as shown in table 1.

In the seropositive group (n=101), an RT-PCR test was performed on 59 workers because they were symptomatic or contact cases. For 29 workers the result was negative, that is, one person out of two.

## DISCUSSION

This study has been conducted in May 2020, and the analysis of the results should be put in perspective with

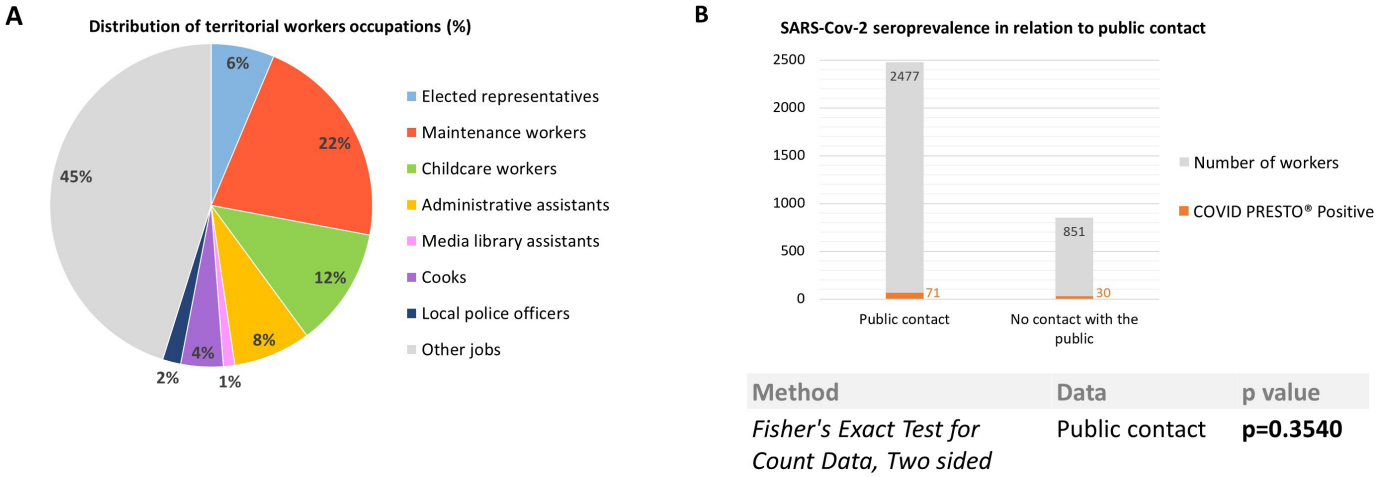


**Figure 3** Relation between occupation and SARS-CoV-2 seroprevalence. (A) Distribution of local authority workers occupation; (B) proportion of COVID-PRESTO positive tests among workers depending on their occupation being or not in contact with the public.

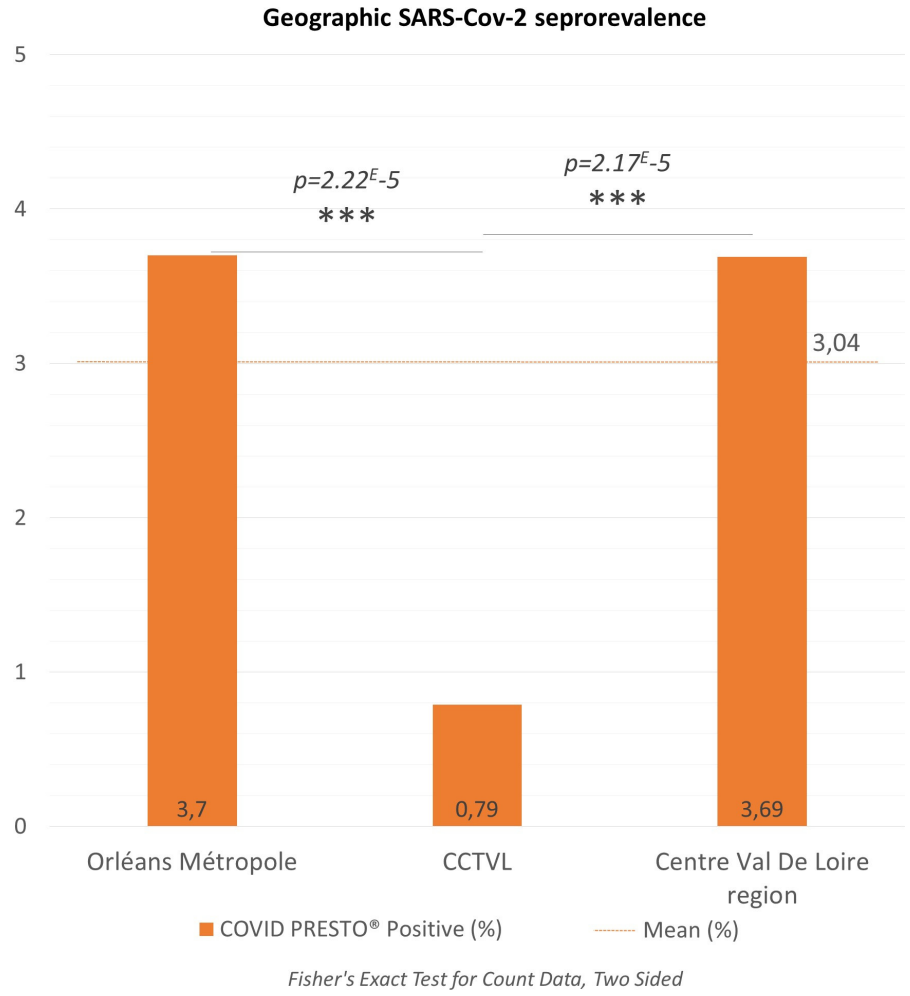


**Figure 4** SARS-CoV-2 seroprevalence in the different local territories. CCTVL, Community of Communes of Terres Du Val De Loire.

the seroprevalence associated with the first wave of the COVID-19 pandemic, in the context of the absence of vaccination at that time.

The main objective of the CovidOr study was to determine whether the percentage prevalence of COVID-19 infection measured in Orléans Metropole, the CCTVL, and the Centre Val de Loire Region, was lower than 5.7%, the national prevalence estimated by Santé Publique France in May 2020.[12] Indeed, the results of this epidemiological survey of seroprevalence for SARS-CoV-2 indicate that the prevalence of antibodies against this COVID-19 was 3.04% among local authority workers of the Loiret department, the Centre Val de Loire region and the CCTVL, the Loiret department and the Centre Val de Loire region were less affected than the Grand-Est region and the Ile De France region.

We were also able to observe marked regional differences between Orléans and its periphery. The prevalence in the investigating centres in urban areas such as the Centre Val De Loire Region and Orléans Metropole was four times higher compared with smaller communes recorded in the CCTVL investigating centre.

It can be explained on the one hand by the low incidence of COVID-19 pandemic in peripheral areas such as the CCTVL and on the other hand by the inclusion period carried out exclusively in summer (from 24 August 2020 to 24 September 2020) for the CCTVL centre.

Indeed, it is in line with the data in the literature which specifies that increased SARS-CoV-2 transmission is usually observed in winter and autumn.[16 17]

The mechanisms associated with this seasonality are both virus and host related. Changing weather conditions favour the survival of respiratory viruses in the environment at lower or moderate levels of temperature, ultraviolet radiation, humidity, precipitation and wind, and increase host susceptibility through reduced immunity, fragile respiratory mucosa and mucus changes. There is also a modification in the behaviour of individuals, favouring indoor activities and social interactions that are more in favour of transmission.[18–20]

This epidemiological study conducted by the PARADICT-O clinical research unit in the occupational medicine department aimed to correlate the rate of infection depending on the position held according to whether it was in contact with the public or not to determine the

**Table 1** Seroprevalence and symptomatology of SARS-CoV-2 depending on clinical and biological characteristics reported in the seropositive group

| Clinical and biological characteristics | | Cases (n) | Prevalence (%) |
|---|---|---|---|
| Symptomatology | Asymptomatic | 28 | 27.72 |
| | Symptomatic | 73 | 73.27 |
| | From less than 14 days before the study | 13 | 17.58 |
| | For more than 14 days before the study | 61 | 85.92 |
| | Symptoms | | |
| | Excessive fatigue | 52 | 51.49 |
| | Influenza like symptoms or T>37.8°C | 44 | 43.56 |
| | Anosmia | 33 | 32.67 |
| | Ageusia | 33 | 32.67 |
| | Cough | 31 | 30.69 |
| | Other | 26 | 25.74 |
| | Rhinorrhea | 15 | 14.85 |
| | Sore throat | 13 | 12.87 |
| | Dyspnoea | 11 | 10.89 |
| | Digestive symptoms | 10 | 9.90 |
| | Thoracic pain | 6 | 5.94 |
| | Dermatological symptoms | 3 | 2.97 |
| | Earache | 3 | 2.97 |
| Contact with positive case | Confirmed contact | 40 | 39.60 |
| | No contact | 61 | 60.39 |
| Status of RT-PCR test | Not done | 42 | 41.58 |
| | Negative | 29 | 49.15 |
| | Positive | 30 | 50.85 |
| | Dated less than 3 months ago | 28 | 93.33 |
| | Dated more than 3 months ago | 2 | 6.66 |

Asymptomatic (no symptom) 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.

positions in the local civil service most exposed to the risk of infection during the COVID-19 pandemic.

As stated by WHO and shown in some other studies, due to frequent or close social interactions and the possibility of asymptomatic transmission, the risk of SARS-CoV-2 transmission in certain occupations could be increased.[21–23]

However, several studies suggest that the seroprevalence of SARS-CoV-2 is not higher among workers most at risk, when people are trained, and protective measures are applied. The team of Varona *et al*[24] demonstrated in 2021, in a cross-sectional analysis of 6190 hospital workers that seroprevalence (anti-SARS-CoV-2 IgG) in hospitals in four regions of Spain was only slightly higher than the national level despite the high exposure of caregivers.

Moreover, the team of Fromberg *et al*[25] in Northern Denmark found that patients had a threefold increased risk of being SARS-CoV-2 positive when they were in contact. According to the results of the ComCov study conducted by the Institut Pasteur, the occupational categories most at risk are, in ascending order of excess risk, public service executives, engineers and technical managers, administrative and commercial managers, company managers with 10 or more employees, intermediate professions in health and social work, and drivers.[26]

The occupational categories least at risk are, in decreasing order of risk, public service executives and public service employees, company administrative employees, pensioners, intermediate administrative occupations in the public service, direct services to individuals, police and military personnel, school teachers and primary school teachers, intermediate administrative and commercial occupations in companies, teachers and scientific occupations, and farmers.[27]

Our study found no significant difference in the risk of becoming infected with the SARS-CoV-2 according to the type of occupation held. Nevertheless, a high rate of seropositivity was observed among maintenance workers (3.71%). This could be explained by the impossibility of protecting themselves by home working and

the obligation to travel to keep their jobs, as well as the absence of alternatives to public transport.[28] Among childcare workers, 2.38% were seropositive, which we explain by the high frequency of asymptomatic forms among children (30%) on the one hand, and the absence of masks among these, on the other hand. Indeed, the 2009 Jefferson study showed that wearing an N95 mask (like FFP2) reduced the risk of infection by SARS-CoV-1 by 91%; wearing a surgical mask by 68%.[29] In 2021, the team of Simón Sacristán *et al*[30] showed that the seroprevalence among hospital staff members was higher when people were not trained in COVID-19 prevention (18.6% vs 14.5% p<0.035). Furthermore, the Irish team Faller *et al* found that the seroprevalence of SARS-CoV-2 in asymptomatic caregivers was low using an Abbot 'CMIA' rapid immunoassay during the first wave of the pandemic, in 800 workers at particular risk of SARS-CoV-2 infection.

The results of this study show that the proportion of positive tests was not influenced by contact with the public. This is similar to other studies which confirmed that most people would be at risk of exposure outside their work environment and particularly in contact with people in the same household where protective measures are less applied. As an example, the team of Peremiquel-Trillas *et al*[31] found there was no significant difference in seroprevalence of SARS-CoV-2 in a hospital between home office working and face-to-face working. The only determining factor was living at home with a COVID-19 positive patient.

The team of Adriaenssens *et al*[32] found that SARS-CoV-2 seroprevalence was 15.1% during the first epidemic wave among general practitioners in Belgium, and that preventive measures dictated by occupational medicine were effective in reducing the risk of being infected.

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. The most significant indicator correlated with positivity in healthcare workers was contact with a symptomatic or non-symptomatic COVID-19 patient, without any means of prevention.

The proportion of asymptomatic infections reported in different studies varies considerably from 4% to 41%. Here, asymptomatic cases represent 27.72% of all SARS-CoV-2 infections.[33]

The most frequently reported symptoms in the seropositive workers in our study were fatigue or excessive tiredness (51.49%), influenza-like syndrome with aches, fever and rhinorrhoea (43.56%), anosmia and ageusia (32.67%). These results are consistent with those of a recent study which concluded that the most frequent symptoms were fatigue, myalgias and fever, anosmia and ageusia, respectively.[34]

Nearly half of the seropositive participants had a negative RT-PCR test, which could be explained by early or delayed PCR tests giving a negative result or by imperfect sensitivity of PCR tests.[35]

The CovidOr study is the first multicentre epidemiological study conducted in local authorities in the Loiret department and the Centre Val De Loire region, and aimed at determining the seroprevalence of anti-SARS-CoV-2 antibodies in the local authority sector. A strong point of our study is the random selection of participants from 250 different professions listed in the civil service, which allowed us to have large sample of an active population ranging from 18 to 67 years old.

The remarkably high participation of local authority workers reflects their keen interest in knowing their serological status.

Despite these strengths, our study has several limitations. First, the symptomatology related to SARS-CoV-2 infection involved recalling memories. This memory bias could lead to inaccurate classification when organising samples between symptomatic or asymptomatic forms. Second, we could not explore the type of contact (work colleague, person in the same household, etc) with a person with COVID-19 in the positive participants, as this information was not available. Second, the nature of the contact with a person infected with COVID-19 was not available. Therefore, we could not explore whether contact persons were either work colleagues, friends or family in the same household, for example.

In conclusion, our study provides an estimate of the spread of SARS-CoV-2 among public service employees in the Loiret department, the Centre Val De Loire region and the CCTVL, showing remarkable differences between areas of higher and lower prevalence. One-third of infections appear to be asymptomatic, while one out of two seropositive participants had a negative RT-PCR.

Overall, serological surveys are the best tool to determine the spread of an infectious disease, especially in the presence of asymptomatic cases or incomplete identification of those with symptoms.

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**Contributors** Conceived and designed the experiments: RS, AA, TP, AB and NR. Recruited the participants and conducted the study: RS, GH and ZA. Analysed the data: AA, AB and RS. Wrote the manuscript: HG. Manuscript review: AB, RS. Coordination with CCTVL: VO. Guarantor: RS.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not applicable.

**Ethics approval** This study involves human participants. The URC PARADICT-O is the promoter of the Covid0r study. This study is registered with the ANSM (Agence Nationale de Surveillance du Médicament) under the ID RCB: 2020-A01414-35. It was approved by the Dijon Est I ethics committee on 30 July 2020 and written informed consent was obtained for each participant. A commitment to comply with the data processing reference methodology MR-001 was obtained by the CNIL on 18 May 2020 in accordance with the General Data Protection Regulation (GDPR). The management and processing of the data was carried out by the DPO (Data Protection Officer) of Orléans City Council.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon reasonable request.



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