

# SARS-CoV-2 SEROLOGICAL FINDINGS AND EXPOSURE RISK AMONG EMPLOYEES IN SCHOOL AND RETAIL AFTER FIRST AND SECOND WAVE COVID-19 PANDEMIC IN OSLO, NORWAY: A COHORT STUDY

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## Abstract

**Objectives:** The objective was to characterize and compare SARS-CoV-2 serology among Norwegian school employees and retail employees, and describe preventive measures taken at the workplaces. **Material and Methods:** A cohort of 238 school and retail employees was enrolled to an ambidirectional cohort study after the first COVID-19 pandemic wave. Self-reported exposure history and serum samples were collected at 10 schools and 15 retail stores in Oslo, Norway, sampled at 2 time-points: baseline (May–July 2020); and follow-up (January–March 2021). SARS-CoV-2 antibodies targeting both spike and nucleocapsid were detected by multiplex microsphere-based serological methods. **Results:** At baseline, 6 enrolled workers (5 in retail) presented with positive SARS-CoV-2 serology, higher than the expected 1% prevalence (3%, 95% CI: 1–6,  $p = 0.019$ ). At follow-up, school and retail groups presented 11 new seropositive cases altogether, but groups were not significantly different, although exposure and preventive measures against viral transmission at workplaces were different between groups. Self-reported medical history of COVID-19 infection showed that all but one positive SARS-CoV-2 serological findings arising between baseline and follow-up had been diagnosed with virus testing. **Conclusions:** Distribution of SARS-CoV-2 positive serology after the first wave was slightly higher than expected. Distribution of infection was not significantly different between the groups at baseline nor at follow-up, despite difference in exposure and protective measures. Nearly all new seropositive cases discovered between baseline and follow-up, had already been diagnosed, highlighting the importance of extensive viral testing among workers. *Int J Occup Med Environ Health.* 2022;35(5)

## Key words:

COVID-19, SARS-CoV-2, workplace, antibodies, schools, cohort studies

## INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by the virus termed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), potentially threatens workers' health. Although somewhat disputed [1], the origins of its pandemic spread and some of the earliest reports of COVID-19 were from an occupational setting in a fish market [2,3].

After the initial spread of the virus globally, health care workers were particularly affected. In April 2020, Italian health care workers amounted to 10% (approx. 12 000) of the nationwide total of registered cases [4]. In health care workers, adverse impact of COVID-19 has been documented [5], but not as well among other essential workers. Individual risk factors influence impact of SARS-CoV-2 [6],

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but many preventive measures have been aimed towards modifiable workplace factors [5]:

- exposure elimination (e.g., remote work, workplace closures, symptom checks);
- engineering controls (e.g., shields, irradiation, hand hygiene);
- personal protection equipment (PPE, e.g., masks, gowns, gloves);
- administrative controls (social distancing, staggered work schedules, behavioral requirements/training, surface cleaning/disinfection).

Diagnosis of SARS-CoV-2 in acutely or recently infected individuals usually involves molecular detection of viral RNA. Serological testing of SARS-CoV-2, on the other hand, has the advantage that it may be performed once viral RNA has been systemically cleared and symptoms have resolved [7]. Until now, studies relating to SARS-CoV-2 serology have largely focused on health care workers [8]. But there are some examples of studies of other groups relating to different sectors: meat processing industry workers (USA) [9]; factory workers (Germany and Croatia) [10,11]; university workers (Italy) [11]; mine workers (Ivory Coast) [12]; and airport workers (Colombia) [13]. Literature reviews suggest heterogenous seroprevalence estimates among workers' populations, ranging 0.5–10% [11].

One study of SARS-CoV-2 infection in a single grocery retail store (USA) has been published [14], besides that, few studies targeting retail employees exist. Whilst some data on SARS-CoV-2 transmission is available from educational settings [15], the main focus has been on children's role in virus transmission [16].

From an occupational health perspective, the authors aimed to gather knowledge about SARS-CoV-2 infections in vulnerable groups of workers. In this study, we evaluated the distribution of SARS-CoV-2 serology among school and retail employees against workplace factors pertaining to exposure risk and preventive measures.

The authors' approach was to establish a cohort of school employees and retail employees at baseline after the first wave of the COVID-19 pandemic in Oslo, Norway, and to follow the distribution of SARS-CoV-2 serology in these 2 potentially exposed populations.

### Study setting

During the first wave in Norway (March–June 2020), schools at all levels of education were closed, whereas retail stores were allowed to stay open. Schools reopened in mid-May 2020. By the end of June 2020, only 6.2% of the population had been diagnostically tested [17]. However, the Norwegian Institute of Public Health (NIPH) estimated that <1% of the population had been infected [18], later confirmed by serological studies [19]. After the second epidemiological wave, by the end of January 2021, NIPH estimated that 2% of the Norwegian population had been infected with SARS-CoV-2 so far [20], partly supported by serological studies [21].

## MATERIAL AND METHODS

### Eligibility criteria, ethical considerations, and follow-up

Eligible participants were workers either male or female, age >18 years. Informed consents were obtained from all participants of the study. Study approval was granted April 27, 2020 by the Regional Committee for Medical and Health Research Ethics in South-Eastern Norway (ref. No. 134064). Data handling protocol was reviewed by Norwegian Centre for Research Data and approved April 29, 2020 (ref. No. 560357). All methods were performed in accordance with the relevant guidelines and regulations. Participants were recruited at 10 schools (N = 112) and 15 retail stores (N = 126), generally located around the eastern parts of Oslo, Norway, in May 2020 and June 2020, respectively. Recruitment was done via e-mail and by handing out written information as a flyer. Baseline collection of data and blood occurred in the period May

18–July 2, 2020, whereas the follow-up occurred January 7–March 17, 2021. A research team of 2–4 people showed up at the schools and businesses during work hours and collected questionnaire data and biospecimens by appointment. Follow-up was accomplished through e-mail invitation. Participants were not presented with their serological test results from the baseline session until the follow-up session was finished.

### **Blood sampling and Luminex serological assay**

Venous blood was drawn from the cubital vein of the antecubital fossa, using plasma preparation tubes (PPT™, 9 mg K<sub>2</sub>EDTA, BD) and serum separation tubes (SST™ II, 5 ml, BD). The first tube was discarded. Tubes were immediately inverted several times. Plasma preparation tubes were then centrifuged for 10 min at 2100 × g. Serum separation tubes were left to coagulate at room temperature for min. 30 min, before being centrifuged for 5 min at 2100 × g. Aliquots of plasma and serum were stored at –80°C until analysis. Antigen detection was obtained using xMAP® SARS-CoV-2 Multi-Antigen IgG Assay (30-00127, Luminex, Austin, USA), supplemented with xMAP SARS-CoV-2 IgG Control Kit (30-00129, Luminex). Assay sensitivity/specificity was reported by the producer in terms of positive agreement (PPA) >96% and negative percent agreement (NPA) >99% in samples taken >14 days following symptom onset or positive RNA diagnostics. The assay had also been validated for detection in dried blood spots [22]. Prior to analysis, samples were diluted 1:400.

The assay was performed according to the manufacturer's instructions, and the following data analysis was conducted using software provided by the manufacturer (xMAP SARS-CoV-2, CN-SW77-01, Luminex). Samples were defined as SARS-CoV-2 IgG positive with nucleocapsid (N) target antigen levels above threshold, together with one other target antigen level above threshold: spike subunit (S1); and/or the receptor-binding domain (RBD).

Besides using the positive control kit supplied by the manufacturer, additional verification was performed with negative pre-COVID-19 pandemic plasma and RNA-positive infected individuals' samples. SARS-CoV-2 vaccines are based on the spike antigen (RBD and S1) alone, and not the N-antigen, thus vaccinated individuals become classified as seronegative using this assay.

### **Questionnaire**

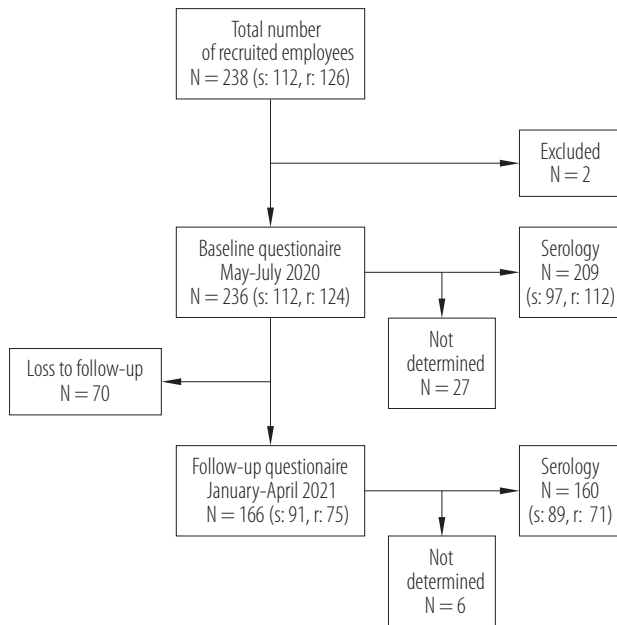
In conjunction with blood sampling, participants were asked to answer a questionnaire about personal symptoms, previous COVID-19 diagnosis and workplace measures aimed to prevent viral transmission at the workplace. The questionnaire was completed on site via their smartphone or alternatively a tablet. At follow-up, participants were asked about vaccination status.

### **Statistics**

The null hypothesis H<sub>0</sub>: p<sub>B</sub> = p<sub>0</sub> = 1 and alternative H<sub>1</sub>: p<sub>B</sub> > p<sub>0</sub>, where p<sub>0</sub> represents the cumulated proportion of infected in the general population at baseline assumed to be 1%, and p<sub>B</sub> the proportion of infected in a subgroup of workers. Estimates showed that N = 90 was needed in each group to detect a 10% deviation from p<sub>0</sub> with a power of 80% and type 1 error rate of 5%. The power estimates were made prior to sampling. Statistical tests were used as indicated with Graphpad 9 (binomial test, Fisher's exact test or Mann-Whitney U test).

### **RESULTS**

We aimed to define the distribution of SARS-CoV-2 infections under the first pandemic wave in a cohort of 2 working populations. A cohort of potential eligible workers, male and female, age 18–70 years (N = 238) were recruited from 10 schools (N = 112) and 15 retail stores (N = 126) in Oslo, Norway by written consent (Figure 1). At baseline, 236 eligible participants completed questionnaires (1 withdrew consent, and 1 was not able to con-



S – school; r – retail.

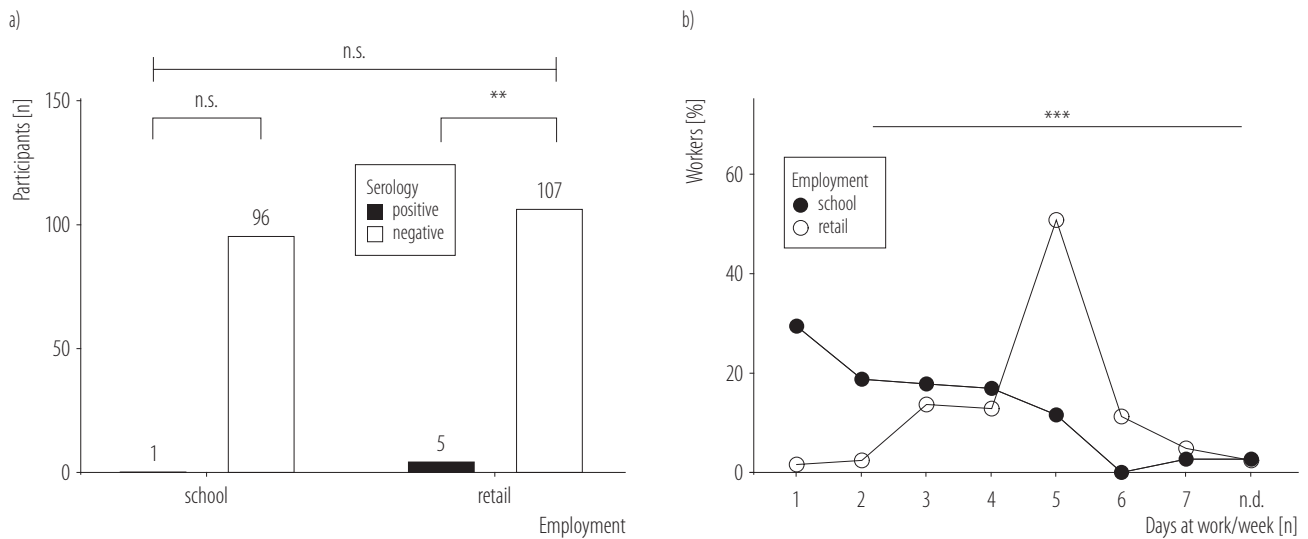
**Figure 1.** Schematic overview of participants in the study among school and retail employees in Oslo, Norway (May 2020–March, 2021)

sent), serology was obtained from 209 (27 were missing due to failed blood sampling, which was a result of restricted indoor access at workplaces and thus challenging light and temperature conditions for venipuncture). At follow-up 166 participants completed questionnaires and serology was obtained from 160 (N = 6 cases of failed blood sampling, whereas 70 participants were lost from baseline to follow-up and did not respond to contact made by e-mail), i.e., the follow up rate was 70% (81% for school, 60% for retail). Withdrawal from the study was not a source of participants loss from the study.

Among employees in the school group age was higher (M = 45 years) than in the retail group (M = 36 years). There were 85 females and 27 males in the school group, whereas in the retail group there were 64 females and 60 males. First, we assessed the distribution of SARS-CoV-2 infections which had occurred during the first epidemiological wave in retrospect, using serological analyses of blood samples (N = 209). For this period, we had hypothesized

that 1% of the general Oslo-population had been infected. Multiplex microsphere-based SARS-CoV-2 serology of plasma samples showed that baseline distribution of seropositive within the whole workers' cohort deviated from the anticipated level (3% incidence, 95% CI: 1–6,  $p = 0.019$ ) (Figure 2a).

Inspecting the 2 groups of workers separately, SARS-CoV-2 serology distribution among school employees was not significantly different from the assumed distribution (1% incidence, 95% CI: 0.1–6,  $p = 0.623$ ), whereas the retail employees' distribution was significantly different from the expected (4% incidence, 95% CI: 2–10,  $p = 0.005$ ). The distributions of positive test results between the 2 workers' cohorts were compared directly with each other using Fisher's exact test. The distribution of positive SARS-CoV-2 serology was not significantly different between the study groups (school employees relative to retail employees: OR = 0.22, 95% CI: 0.02–1.68,  $p = 0.219$ ). Participants reported the average weekly number of days present at the workplace for the 3 months preceding the base line blood sample. As expected, school employees had significantly lower physical attendance at work than retail employees (Mann-Whitney U test,  $p < 0.001$ ) (Figure 2b). About 50% of school employees reported  $\leq 2$  days of physical workplace presence per week, whereas 65% of the retail employees reported  $\geq 5$  days. Second, by prospective design, 8 months later and after the passing of a second epidemiological wave, we identified individuals that had undergone COVID-19 infection by serological analyses of follow-up blood samples collected from the cohort (N = 166; loss to follow-up of 70). The number of SARS-CoV-2 seropositive cases at follow-up was increased from baseline (Figure 3a). School incidence was 8% over the 8-month follow-up period, whereas for retail incidence was 6%. Direct comparison of school and retail prevalence at follow-up, showed that there was no significant difference between the groups (OR = 1.43, 95% CI: 0.4–4.5,  $p = 0.756$ ). A single employee

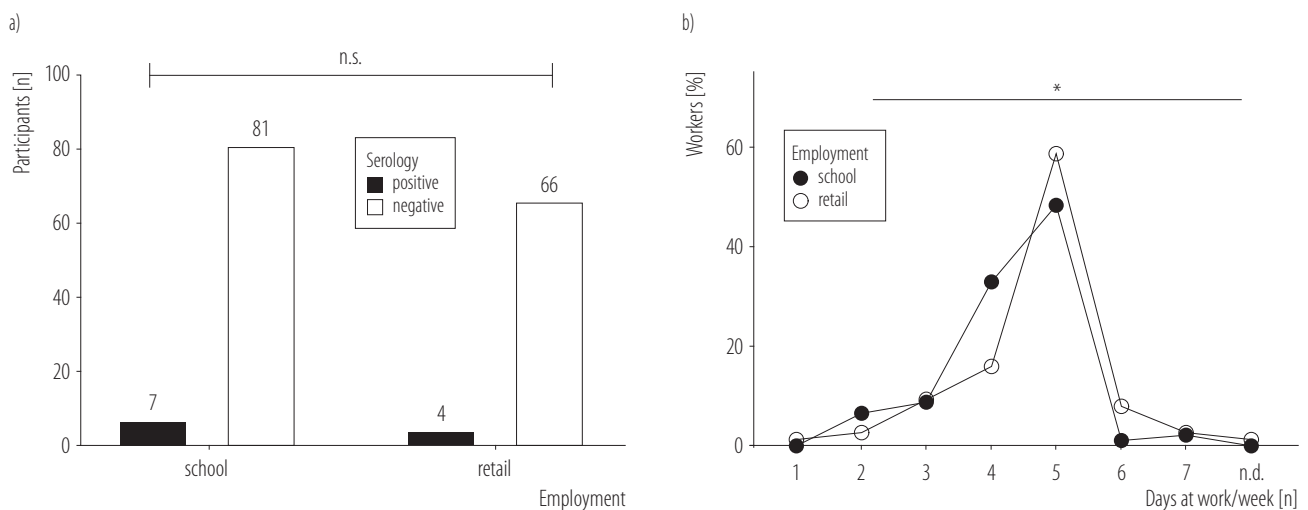


n.d. – 3 non-responders in each group; n.s. – not significant.

\*\*  $p \leq 0.01$ ; \*\*\*  $p \leq 0.001$ .

The distribution of positive SARS-CoV-2 serology was compared between the study groups with Fisher's exact test. The unadjusted distribution of serology evaluated within each group was compared with the expected level of 1% seropositive in the general Oslo population using Binomial Test. Mann-Whitney test between the school and retail groups.

**Figure 2.** a) Baseline SARS-CoV-2 serology from a workers' cohort sampled among school and retail employees b) retrospective self-reported physical attendance at the workplace 3 months prior to the blood sampling at baseline; Oslo, Norway (May 18–July 2, 2020)



n.d. – 1 non-responder in the retail group; n.s. – not significant.

\*  $p \leq 0.05$ .

**Figure 3.** a) Follow-up SARS-CoV-2 serology in the cohort in school and retail employees at 8 months follow-up (two-sided Fisher's exact test) b) retrospective self-reported physical attendance at the workplace 6 months prior to the blood sampling at follow-up (Mann-Whitney test between the school and retail groups)

**Table 1.** Retrospective SARS-CoV-2 diagnostics aligned with serological laboratory findings for 236 workers in schools and retail stores in Oslo county, Norway (May–March 2021)

Serology cases	Self-reported RNA test [n]					
	baseline			follow-up		
	positive	negative	no test	positive	negative	no test
Positive	0	0	6	10	2	1
Negative	0	11	190	0	102	43

Self-reported virus test diagnostics (RNA) vs. laboratory determined serology (Ab). Participants were grouped according to self-reported RNA diagnostic results and its distribution was compared with the distribution of positive and negative serological results.

self-reported SARS-CoV-2 vaccination at follow-up, but tested seronegative as expected based on assay characteristics (see Material and Methods). At follow-up, participants ( $N = 166$ ) reported the average weekly number of days present at the workplace since the baseline sampling (Figure 3b). Now, 50% of school employees reported physical presence at their workplace  $\geq 5$  days/week. Employees in the retail group still spent more time at the workplace; 70% of the retail employees reported  $\geq 5$  days (Mann-Whitney U test,  $p = 0.0219$ ) (Figure 3b).

Self-reported results of diagnostic SARS-CoV-2 RNA tests prior to baseline were aligned with the serological data to determine the level of undiagnosed SARS-CoV-2 infections in the cohort (Table 1). At baseline, 11 participants self-reported that they had been RNA-tested for ongoing infection; none of these tests had been positive. Of 196 participants who self-reported that they had not been RNA-tested prior to baseline, 6 individuals tested positive for SARS-CoV-2 serology. Virus testing became more available in the period between baseline and follow-up, hence at follow-up 114 participants self-reported that they had been RNA-tested for ongoing infection. Among these, 10 participants reported RNA-positive test, and all these were confirmed seropositive in our analyses at follow-up (Table 1). Three seropositive participants either

received an RNA-negative result between baseline and follow-up (2 participants) or had not been RNA-tested (1 participant in the retail group).

We aimed to map preventive measures taken against viral transmission at workplaces. Participating employees responded to the question: “Which COVID-19 preventive measures have been implemented at your workplace?” by ticking a list of potential measures (Table 2). Responses were different between school and retail employees: at baseline social distancing, contacts limitation, hand washing/disinfection, and surface washing/disinfection were more frequent among school than retail employees. On the contrary, retail employees more often reported the use of personal protective equipment (PPE) and protective shields at baseline than school employees did. At follow-up, previous differences in social distancing and surface washing/disinfection were gone. A few participants reported symptom checks at work, and this was similar between the 2 groups. Similarly, a few also reported no measures; at baseline, this rate was higher in retail than among school employees.

## DISCUSSION

This study of SARS-CoV-2 serology in a cohort of Norwegian school and retail employees has given us new knowledge of the infectious distribution in 2 groups of employees with potentially high occupational exposure to the virus. Antibody measurements showed no significant difference in seropositive prevalence between the 2 groups at baseline after the first epidemic wave, nor at follow-up after the second wave. Compared to the assumed distribution of cases in the general population we noted at baseline that the number of cases in the cohort was higher than hypothesized. This was due to elevated occurrence of seropositive among retail employees in particular, whereas data on the school employee group showed more moderate levels. This difference in serology among the groups corresponded to a difference in attendance at the work-

**Table 2.** Preventive measures taken against viral transmission as reported by individual employees at schools and retail stores in Oslo county, Norway (May 2020–March 2021)

Preventive measure	Participants [%]					
	baseline		p	follow-up		p
	school (N = 112)	retail (N = 124)		school (N = 91)	retail (N = 75)	
None	0	7	**	0	4	n.s.
Social distancing	96	75	***	88	81	n.s.
Contacts limitation	96	21	***	67	36	***
Hand washing/disinfection	98	87	**	99	91	*
Symptom checks	8	4	n.s.	7	9	n.s.
Personal protective equipment (PPE)	6	23	***	4	89	***
Protective shields	18	38	***	14	51	***
Surface washing/disinfection	96	83	**	87	88	n.s.

n.s. - non significant.

\*  $p \leq 0.05$ ; \*\*  $p \leq 0.01$ ; \*\*\*  $p \leq 0.001$ .

Fisher's exact test.

place during the first wave. A general school closure was enforced in Oslo during the first wave, whereas no general closures were imposed in retail. Matching serology with self-reported diagnostic test results showed low new incidence of undiscovered disease at follow-up. Serology uncovered a minor rate of undiagnosed cases in these populations of Oslo workers, hence the practice and level of diagnostic testing appeared to be adequate.

In this ambidirectional cohort study with baseline and follow-up serology, we aimed to observe SARS-CoV-2 infections, in retrospect from the origin of the pandemic until baseline (first wave), and prospectively from baseline until follow-up 8 months later (second wave). The design has potential to uncover links between infection rates and exposure to occupation as a risk factor. New knowledge from this study confirms that effective alleviation kept COVID-19 transmissions relatively low in the Norwegian population during the first wave. However, low infection rates combined with the modest number of participants recruited in our study imposes limitations

on the conclusions we can draw. The power estimates for the retrospective and prospective analyses to uncover the rate of undiagnosed cases in school and retail workers were based on scenarios made in April 2020 when this study was designed. Initially, we feared that the general population would face higher rates of disease transmission. We anticipated many infected workers in retail, as these individuals had exposure to potential transmission from customers and colleagues. Diagnostic testing capacity was insufficient at this stage, during the first wave, and many parameters were unknown. However, in contrast to the scenarios encountered in many other countries across the world, COVID-19 infection rates stayed relatively low in Norway [17,20].

As the approach of this study was to visit workplaces to collect data on occupational health, authorization and organization at the workplaces was required. We achieved a feasible mode of data collection through recruiting participants in groups from a limited number of workplaces, 10 schools and 15 retail stores. These were an arbitrary se-

lection of representative workplaces in Oslo, not a random sample of individuals drawn from the entire workers' population, and thus might be affecting the study's external validity. Sampling can affect results, as outbreaks of COVID-19 show clustering. On the other hand, with just a few workplaces to recruit from, more focus was put into encouraging participants, as well as streamlining sampling procedures to their work situation. This possibly leads to engaging participants that otherwise would not be motivated to participate and is therefore likely to reduce selection bias. Potentially, loss to follow-up imposes limitations by affecting study validity, depending on how big of a loss, and how it is distributed. Here, we encountered 30% loss to follow-up in the whole cohort, but most of the lost participants were lost from the group of retail employees. None of the participants withdrew from the study, but several were temporarily laid off, and some had started in other jobs, did not have the time, or did not answer our efforts to schedule follow-up sessions. Differential loss to follow-up can introduce bias that would lead to underestimation of prevalence, and therefore it is important to examine the possibility of an association between participant loss and contraction of COVID-19. Although we cannot exclude the possibility, we do not have observations to support a pattern of diminished work ability in the participants lost to follow-up. Based on the assumption that younger people experience more changing work markets, the lower mean age among retail employees could influence selectively on loss to follow-up. Otherwise, major differences introducing bias seem implausible between the participants lost to follow-up and the participants who completed the follow-up.

It is fundamental to this study that antibody measurements are reliable to detect individuals that have undergone SARS-CoV-2 infection. Post et al. [23] concluded in their systematic review that SARS-CoV-2-specific IgM rises in the acute phase and peaks 2–5 weeks after disease onset, followed by a decline over 3–5 weeks until unde-

tectable level in many cases. The IgG peaks 3–7 weeks after disease onset, then plateaus or moderately declines at a persisting level [23]. Studies report a lasting level of antibody up to 6–12 months [24], but the full duration and protective capacity of the immune response to SARS-CoV-2 is still unknown. Gudbjartsson et al. [25] found a high seroprevalence (91%) in >1000 persons recovered from a SARS-CoV-2 infection. The same tendency has been confirmed in later publications [26]. Serology based on antibody tests, may therefore serve as a useful tool for detection of prior SARS-CoV-2 infections. In this study we measured SARS-CoV-2 antibodies targeting both spike and nucleocapsid using a multiplex microsphere-based serological method. Most available assays detect 1 type of antibody, either directed against N, S1, or RBD proteins [7]. The multiplex assay used in our study detects all 3 simultaneously, which is an advantage, given that high specificity is crucial, particularly with low prevalence.

A major finding of the present study was the scarcity of seropositive cases without COVID-19 diagnosis after the second wave. At follow-up, we observed only 1 seropositive participant that had not been diagnosed with COVID-19, the remaining had been diagnosed earlier or detected at baseline in our study. Hence, our data do not support the notion that undiagnosed SARS-CoV-2 infections were commonly occurring among workers in Oslo's schools and retail stores during the second wave. The results from the second wave stood in contrast to the results from the first wave; at that point none of the seropositive reported that they had been diagnosed with COVID-19. Hence, with widespread testing nearly all cases are diagnosed. In the beginning of the COVID-19 pandemic in Norway, SARS-CoV-2 diagnostic RT-PCR test capacity was strictly limited. Patients admitted to hospital or other health care facilities with COVID-19 symptoms, health care professionals with symptoms, and symptomatic cases with underlying risk factors were prioritized for testing. Cases with known exposure and non-severe



symptoms were not prioritized, and asymptomatic cases were not tested at all. Test capacity gradually improved during 2020. It is therefore likely that cases of COVID-19 infection, both asymptomatic and symptomatic, went undetected during the first wave, spring of 2020. A possible interpretation of our findings uncovers a low rate of asymptomatic cases. It is also possible that with enhanced awareness in the public and low threshold for testing, most cases are discovered. Oran and Topol [27] approximated in their review of several cohorts tested for SARS-CoV-2 (up until May 2020), that the asymptomatic infection rate may be as high as 45%. However, this review presented cross-sectional studies alongside longitudinal studies, and did not distinguish between asymptomatic and presymptomatic infection (subjects that are asymptomatic at the time of testing but will subsequently develop symptoms). In a recent review Buitrago-Garcia et al. [28] address this issue and conclude that the overall estimate of the proportion of people who remain asymptomatic through the course of infection is 20%.

Another finding of our study was a higher distribution of seropositive than expected among retail employees, while this was not the case for school employees at baseline. Magnusson et al. [29] have investigated the prevalence of COVID-19, based on diagnostic RT-PCR testing, in the Norwegian working population during the first and second wave of infection in Norway. During the first wave (February–July 2020), health care professionals and bus and taxi drivers had increased odds of COVID-19 infection compared to the average of the working population, while school workers had no, or even a reduced risk of COVID-19 when compared to the rest of the working population. This may be explained by reduced occupational exposure during the school closure in March, as well as a long summer vacation (June and July). This is reflected in our baseline data; the distribution of seropositive among school employees was not significantly different from the assumed distribution, and school employ-

ees reported a low level of physical attendance at work compared to retail employees. Our finding of a higher than expected distribution of seropositive among retail employees is not reflected in the study by Magnusson et al. [29], but one must keep in mind that diagnostic testing was strictly limited during the first wave.

The hypothesized 1% infected after the first wave was perhaps an underestimation of the true level, as studies of seroprevalence based on analyses of residual sera in the same period were estimated to be approx. 4% in Oslo [19]. Thus, it is also possible that the retail group in our study reflects the general distribution of SARS-CoV-2 infections in Oslo better, and that the incidence among school employees was low possibly due to the closure. During the second wave (July–November 2020) the odds of COVID-19 infection were higher for bartenders, waiters, transport conductors and travel stewards, according to Magnusson et al. [29]. Sales shop assistants and school workers were among the occupations with a moderately increased risk of COVID-19 during the second wave. However, the risk for school workers was up to double in Oslo county. In our study, we indeed find that at follow-up after the second wave, the distribution of seropositive in our cohort is higher than the assumed overall distribution. Stratification of new seropositive cases from baseline to follow-up indicated significantly increased new incidence among the school employees, while this was not the case for retail employees. Magnusson et al. argue that the supposed increased risk for school workers may be biased by frequent testing in this occupational group [29]. However, in our study we hardly find any undiagnosed cases in any of the groups studied during the second wave. Furthermore, it has not been clarified what school closures may contribute to COVID-19 control [30].

## CONCLUSIONS

Seroprevalence in the study cohort was higher than the assumed level after the first wave, mainly due to a high inci-

dence among retail employees relative to school employees, possibly linked to workplace attendance/remote work. In contrast, attendance at the workplace during the period from baseline to follow-up (second wave) was similar between the 2 groups. Distribution of positive serology was not statistically different between school and retail employees at baseline nor at follow-up. Among the new cases between baseline and follow-up, we could barely find any that were undiagnosed; hence the level of diagnostic testing in these workers populations seemed adequate.

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