Seroprevalence of SARS-CoV-2 antibodies in social housing areas in Denmark
— Source link ↗

Kamille Fogh, Alexandra Rr Eriksen, Rasmus Bo Hasselbalch, Emilie Sofie Kristensen ...+32 more authors

Institutions: Copenhagen University Hospital, Statens Serum Institut, Aarhus University Hospital, Odense University Hospital ...+1 more institutions

Topics: Seroprevalence and Risk factor

Related papers:

- Testing Denmark: A Danish nationwide surveillance study of COVID-19

- Seroprevalence of anti-SARS-CoV-2 IgG antibodies, risk factors for infection and associated symptoms in Geneva, Switzerland: a population-based study

- SARS-CoV-2 antibody prevalence and determinants of six ethnic groups living in Amsterdam, the Netherlands: a population-based cross-sectional study, June-October 2020

- SARS-CoV-2 prevalence associated to low socioeconomic status and overcrowding in an LMIC megacity: A population-based seroepidemiological survey in Lima, Peru

- Prevalence, Persistence, and Factors Associated with SARS-CoV-2 IgG Seropositivity in a Large Cohort of Healthcare Workers in a Tertiary Care University Hospital in Northern Italy.

Seroprevalence of SARS-CoV-2 antibodies in social housing areas in Denmark

Kamille Fogh[1,2] MD., Alexandra RR Eriksen[1,2] B. Med., Rasmus B Hasselbalch[1,2] MD., Emilie Sofie Kristensen[1,2] B. Med., Henning Bundgaard[3] MD., Susanne D Nielsen[4] MD., Charlotte S Jørgensen[5] PhD., Bibi FSS Scharff[6] MD. PhD., Christian Erikstrup[7] MD. PhD, Susanne G Sækmose[8] MD. PhD, Dorte K Holm[9] MSc. PhD, Bitten Aagaard[10] MD., Jakob Norsk[1,2] MD., Pernille Brok Nielsen[1,2] MD., Jonas H Kristensen[1,2] MD., Lars Østergaard[11] MD., Svend Ellermann-Eriksen[7] MD., Berit Andersen[12] MD., Henrik Nielsen[13] MD., Isik S Johansen[14] MD., Lothar Wiese[15] MD., Lone Simonsen[16], Thea K.Fischer[17] MD., Fredrik Folke[18] MD., Freddy Lippert[18] MD., Sisse R Ostrowski[6] MD. DMSc, Steen Ethelberg[19] PhD., Anders Koch[4,5] MD., Anne-Marie Vangsted[5] MPharm., Tyra Grove Krause[5] MD., Anders Fomsgaard[5] MD., Claus Nielsen[5] MSc., Henrik Ullum[5] MD. PhD., Robert Skov[5] MD., Kasper Iversen[1,2] MD.

1. Department of Cardiology, Copenhagen University Hospital, Herlev and Gentofte, Denmark*
2. Department of Emergency Medicine, Copenhagen University Hospital, Herlev and Gentofte, Denmark*
3. Department of Cardiology, Copenhagen University Hospital, Rigshospitalet, Denmark*
4. Department of Infectious Diseases, Copenhagen University Hospital, Rigshospitalet, Denmark*
5. Statens Serum Institut, Copenhagen Denmark
6. Department of Clinical Immunology, Copenhagen University Hospital, Rigshospitalet, Denmark*
7. Department of Clinical Microbiology, Aarhus University Hospital, Aarhus, Denmark**
8. Department of Clinical Immunology, Zealand University Hospital, Køge, Denmark
9. Department of Clinical Immunology, Odense University Hospital, Odense, Denmark D***
10. Department of Clinical Immunology, Aalborg University Hospital, Aalborg, Denmark
11. Department of Infectious Diseases, Aarhus University Hospital, Aarhus, Denmark**
12. University Research Clinic for Cancer Screening, Randers Regional Hospital, Randers, Denmark**
13. Department of Infectious Diseases, Aalborg University Hospital, Aalborg, Denmark****
14. Department of Infectious Diseases, Odense University Hospital, Odense, Denmark***
15. Department of Infectious Diseases, Zealand University Hospital, Roskilde, Denmark
16. Department of Science and Environment, University of Roskilde, Denmark
17. Department of Clinical Research, North Zealand Hospital, Hillerød, Denmark*****
18. Copenhagen Emergency Medical Services, Copenhagen, Denmark*
19. Statens Serum Institut, Copenhagen Denmark*****

* and Department of Clinical Medicine, University of Copenhagen, Copenhagen, Denmark
** and Department of Clinical Medicine, Aarhus University, Aarhus, Denmark
*** and Department of Clinical Research, University of Southern Denmark, Odense, Denmark
**** and Department of Clinical Medicine, Aalborg University, Odense, Denmark
***** and Department of Public health, University of Copenhagen, Copenhagen, Denmark

Corresponding author:

Kamille Fogh, kamille.fogh.01@regionh.dk

Abstract

Background

COVID-19 is suggested to be more prevalent among ethnic minorities and individuals with low socioeconomic status. We aimed to investigate the prevalence of SARS-CoV-2 antibodies during the COVID-19 pandemic among citizens 15 years or older in Denmark living in social housing (SH) areas .

Methods

As part of "Testing Denmark", a nationwide sero-epidemiological surveillance survey, we conducted a study between January 8th and January 31st, 2021 with recruitment in 13 selected SH areas in Denmark. Participants were offered a point-of-care rapid SARS-CoV-2 IgM and IgG antibody test and a questionnaire concerning previous testing (viral throat- and nasopharyngeal swab or antibody test), test results for COVID-19, demographics, household characteristics, employment, risk factors for SARS-CoV-2 infection and history of symptoms associated with COVID-19. Data on seroprevalence from Danish blood donors in same period using a total Ig ELISA assay were used as a proxy for the general Danish population.

Findings

Of the 13,279 included participants, 2,296 (17.3%) were seropositive (mean age 46.6 (SD 16.4) years, 54.2% female), which was 3 times higher than in the general Danish population (mean age 41.7 (SD 14.1) years, 48.5% female) in the same period (5.8%, risk ratios (RR) 2.96, 95% CI 2.78-3.16, p>0.001). Seropositivity was higher among males than females (RR 1.1, 95% CI 1.05-1.22%, p=0.001) and increased with age, with an OR seropositivity of 1.03 for each 10-year increase in age (95% CI 1.00-1.06, p=0.031). Close contact with COVID-19-infected individuals was associated with a higher risk of infection, especially among members of the same households (OR 5.0, 95% CI 4.1-6.2 p<0,001). Adjusted for age, gender and region living at least 4 people in a household significantly increased the OR of seropositivity (OR 1.3, 95% CI 1.1-1.6, p=0.02) as did living in a multi-generational household (OR 1.3 per generation, 95% CI 1.1-1.5, p=0.007). Only 1.6% of participants reported not following any of the national COVID-19 recommendations. Anosmia (RR 3.2 95% CI 2.8-3.7, p<0.001) and ageusia (RR 3.3, 95% CI 2.9-3.8, p<0.001) were strongest associated with seropositivity.

Interpretation

Danish citizens living in SH areas of low socioeconomic status had a three times higher SARS-CoV-2 seroprevalence compared to the general Danish population. The seroprevalence was significantly higher in males and increased with age. Living in multiple generations or more than four persons in a household was an independent risk factor for being seropositive. Results of this study can be used for future consideration of the need for preventive measures in the populations living in SH areas.

Introduction

The first confirmed case of SARS-CoV-2 infection in Denmark was reported on February 27, 2020 and by May 4th, 2021 there have been more than 254,482 confirmed cases of SARS-CoV-2 infection and more than 2491 COVID-19 related deaths in Denmark (1).

So far, the outbreak of the epidemic has had a heterogeneous regional patterns with geographical accumulations and varying incidence by gender, age, social class and employment (2). Although there is equal and free of charge access to health care for everybody in Denmark including testing for COVID-19 (viral throat- and nasopharyngeal swab), citizens' behavior may vary in different social segments. National and regional seroprevalence data offer valuable information to tailor public health policies towards the COVID-19 epidemic.

According to the Danish authorities, 15 residential areas are currently defined as social housing (SH) areas, characterized by low employment rates, low income, low education level, high crime rate and/or increased proportion of immigrants (3). Some reports suggest that ethnic minorities in a number of countries are over-represented among those infected with COVID-19, just as socioeconomic inequality is described among SARS-CoV-2 infected persons (4-6). A Danish report from October 2020 showed similar patterns, where people of non-Western background accounted for 25.7% of cases with SARS-CoV-2 infection, despite representing only 8.9% of the population (7, 8).

Vulnerable and marginalized populations, certain ethnic minorities and persons of low socioeconomic status may have difficulties receiving and following health recommendations (9). Which could lead to reduced use of protective equipment and difficulties in navigating the health care system with impaired contact, due to cultural and linguistic barriers, with the risk of being underdiagnosed. For cultural and economic reasons, individuals in SH areas may live in crowded multi-generational households with children, parents and grandparents, which has been hypothesized to increase transmission of SARS-CoV-2 (4, 10). This may not only affect their households but also people in their environment. Estimating the contributions of individual and sociocultural factors that may lead to COVID-19 outbreaks is important, and systematic screening for antibodies against SARS-CoV-2 is an important tool in the surveillance of the current pandemic.

The Danish prevalence of SARS-CoV-2 seropositivity is reported for blood donors (11), medical students (12) hospital staff (13) and in a random sample of Danish citizens (14), but not in a subpopulation that may be at increased risk of SARS-CoV-2 infection due to low socioeconomic status.

In this study we determined the prevalence of SARS-CoV-2 antibodies among Danish citizens in SH areas at national and regional levels, by the use of Point-of care rapid test (POCT) for antibodies against SARS-CoV-2 and explored possible risk factors of seropositivity.

Methods

Study design and participation

The sero-epidemiological survey of SARS-CoV-2 infection in Denmark "Testing Denmark" is a nationwide surveillance study to investigate seropositivity for SARS-CoV-2 in the Danish population throughout the country, launched in September 2020.

The prevalence of SARS-CoV-2 antibodies among Danish citizens in SH areas was assessed by use of POCT during the period January 8th and January 31st, 2021 as part of "Testing Denmark".

Recruitment sites were chosen in collaboration with non-governmental organization with an ethnic minority background, who do voluntary efforts in their local community area. We recruited participants from 13 different SH areas in Denmark (see appendix, Figure 1). Persons more than 15 years of age were invited to participate.

At all recruitment sites written information about the project were available in seven different languages; Danish, English, Arabic, Turkish, Farsi, Somali and Urdu.

Questionnaire

Participants were asked to fill in a short questionnaire provided at the recruitment site, available in the seven different languages, due to risk factors, COVID-19 related symptoms, household, employment and behavior according to general recommendations from the Danish authorities (see questionnaire in appendix).

Answers to the questionnaire and results of the POCT were managed in the Research Electronic Data Capture (REDCap), a secure web-based, electronic data capture tool, hosted at the Capital Region's server (15, 16). All personal data was kept in accordance with the general data protection regulation and data protection law stated by the Danish Data Protection Agency.

Detection of SARS CoV-2 antibodies

The OnSite COVID-19 IgG/IgM Rapid Test (CTK Biotech inc., Poway, California, United States of America) is a single use lateral flow chromatographic immunoassay for qualitative detection and differentiation of IgG and IgM antibodies to SARS-CoV-2 in whole blood, which yields results in 15 minutes. This test was used by the participant with assistance from the project personnel, according to the manufacturer's recommendations.

The manufacturer reported the test sensitivity and specificity of 96.9% (95% CI: 96.7% - 98.5%) and 99.4% (95% CI: 97.8% - 99.8%) respectively (17). A comparative study (cases=30 individuals, controls=10 individuals) showed a slightly lower sensitivity of 90.0% and a specificity of 100% (18).

Fingerprick blood and detection buffer were added to the test cassette and test results were available after 15 minutes by trained project personnel. When no control line appeared or if the reading chamber was discolored by blood the test was inconclusive. Inconclusive test results were treated as negative. Weak signals for IgM and/or IgG, were considered positive. Participants were categorized as seropositive if they had developed IgG and/or IgM anti-SARS-CoV-2 antibodies.

SARS-CoV-2 antibody levels in the general population

Since October 2020, all Danish blood donations are routinely screened for SARS-CoV-2 antibodies using the Wantai SARS-CoV-2 Ab ELISA (Beijing Wantai Biological Pharmacy Enterprise, Beijing, China). In this study we used anonymized data from January 2021, matched by period. This group was used as a proxy for the general population.

Primary outcome

The primary outcome was the proportion of the study population with a positive antibody test for SARS-CoV-2 stratified by place of testing compared to the general population.

Approvals and registrations

This study was performed as a national cross-sectional surveillance study under the authority task of Statens Serum Institut (SSI, Copenhagen, Denmark; which performs the epidemiological surveillance of infectious diseases for the Danish government) and according to Danish law does not require any formal approval from an ethics committee. This was in accordance with the regional ethics committee from the Capital region in Denmark (20057075). The study was performed in agreement with the Helsinki II declaration and registered with the Danish Data protection Authorities (P-2020-901). Participation was voluntary. All personal data obtained in REDCap was kept in accordance with the general data protection regulation and data protection law stated by the Danish Data Protection Agency.

Statistical analysis

Baseline characteristics and exposures are presented as n (%) for factors and mean (standard deviation (SD) or median (interquartile range (IQR)) for numeric variables as appropriate. Household size was presented both as the total number of persons (with a maximum of >5 according to the questionnaire) and as the number of generations in the household. The three generations were defined as individuals per household; <19, 19-64 and >65 years of age.

Unadjusted risk was presented as risk ratios (RR) with 95% confidence intervals (95% CI). To account for the possible clustering effect of participants, we chose to use logistic regression adjusting for test location (SH area) to determine the correlation between putative risk factors and seropositivity. Results of these regressions analyses were reported as odds ratios (OR) of risk factors and presented with 95% confidence intervals (95% CI). A p-value of <0.05 was considered significant. Calculation were done using R version 6.3.1 (19).

Results

Characteristics

Between January 8th and January 31st, 2021, we included a total of 13,279 participants in SH areas. The mean age of the cohort was 46.6 (SD 16.4) years and 54.2% were female. Baseline characteristics of the cohort is shown in table 1. A total of 3,236 (24.4%) completed the accompanying questionnaire, primarily in Danish (94.4%). A flowchart of participant inclusion is depicted in figure 1.

Participants were recruited from 13 selected SH areas placed in the municipalities of Copenhagen (n= 5,816), Aarhus (n=3,718), Odense (n=1,731), Hoeje Taastrup (n = 1,308), Helsingoer (n=405) and Slagelse (n= 301), illustrated in supplementary figure 1.

Seroprevalence

A total of 2,296 (17.3%) participants were seropositive for SARS-CoV-2 antibodies (IgG and/or IgM), of whom 1,594 (69,4%) were positive for IgG antibodies, 1,602 (69,8%) were positive for IgM antibodies and 899 (39.2%) were positive for both IgG and IgM antibodies. This was significantly higher than the seropositivity of 5.8% of the general population (n=22,677, age 41.7 (SD 14.1) years, 48.5% female). Supplementary figure 1 illustrates the seroprevalence in the general population and our study group. The RR range between SH areas varied from 1.1 in Ringerparken in Slagelse to 4.0 in Vollsmose in Odense.

Seropositive participants were older than seronegative participants (47.3 vs 46.4 years, p=0.03) and more likely to be male (p=0.001). Seropositivity stratified on age and gender is shown in figure 2. Both age and gender remained associated with seropositivity in the multiple logistic regression model for gender and place of testing, for an increase in age of 10 years, OR of seropositivity was 1.03 (95% CI 1.00-1.06, p=0.03) and for male gender OR 1.17 (95% CI 1.07-1.29, p=0.001)

Risk factors of infection

Seropositivity stratified by risk factors are shown in table 2. In the analysis adjusted for test location several factors were associated with an increased odds of infection. Reporting a stay of >15 minutes in a room with an infected person (OR 2.7, 95% CI 2.2-3.5, p<0.001), having someone infected in the household (OR 5.0, 95% CI 4.1-6.2, p<0.001), having bodily contact with someone infected (OR 1.2, 95% CI 1.0-1.5, p=0.03) and having a family member with COVID-19 (OR 1.2, 95% CI 1.0-1.5, p=0.03) were all associated with higher odds of infection. Seropositive participants were less likely to smoke (p<0.001), consume alcohol (p=0.04) and engage in drug use (p=0.004) (Table 1). In multivariate logistic regression adjusted for age, gender and place of testing, smoking (OR 0.61, 95%CI 0.48-0.77, p<0.001) and drug use (OR 0.44, CI 0.13-0.26, p=0.01) remained significantly associated with lower odds of seropositivity.

Figure 3 shows the risk of seropositivity stratified by the size of the participants household. There was a clear association between the size of households and seropositivity. In adjusted analysis living at least 4 people in a household was associated with a significantly increased risk of seropositivity (OR 1.3, 95% CI 1.1-1.6, p=0.02).Seroprevalence among participants living in a household with only one generation was 16.7%, with two generations 19.2% and with three or more generations 26.1%. Adjusted for age, gender and place of testing, living at least two generations in a household was associated with a significantly increased risk of seropositivity (OR 1.3, 95% CI 1.1-1.6, p=0.003) as compared to living only one generation.

Of the 3,236 participants who completed the questionnaire, 2,141 (66.2%) reported working (part time, full time and self-employed participants combined). Figure 4 shows the risk of seropositivity stratified by employment status and occupation. Though nominally increased (19.7% vs 17.0%), in the adjusted model there was no significant increase in seropositivity among participants who reported working (OR 1.2, 95% CI 1.0-1.4, p=0.06).

Seropositivity was numerically higher in participants working at a nursing homes (n=79, 22,9%), participants working in home care nursing (n=68 , 22.9%) and participants working in health care (n=315 , 22.1%). However, working in health care or at nursing home was not significantly associated to seropositivity compared to the rest of the cohort (OR 1.3, 95% CI 1.0-1.6, p=0.05).

Among the participants who completed the questionnaire, symptoms were reported by 2,355 (72.8%). We found a significant association between reporting of symptoms associated with COVID-19 and seropositivity (RR 1.5, 95% CI 1.3-1.9, p<0.001). Supplementary figure 2 shows the frequency of each symptom stratified for seropositivity. Anosmia (RR 3.2, 95% CI 2.8-3.7, p<0.001) and ageusia (RR 3.3, 95% CI 2.9-3.8, p<0.001) had the strongest correlation to seropositivity. Supplementary figure 3 is a forest plot of risk of seropositivity for each symptom.

Adherence to the general COVID-19 recommendations from the Danish authorities.

The national COVID-19 health recommendations are listed in supplementary figure 4. We found that only 53 (1.6%) participants reported not following any of the national COVID-19 recommendations, listed in the questionnaire (see appendix). Of those 41 were seronegative (77.4%) and 12 seropositive (22.6%), this was not significantly different from other participants (p=0.48). Changes in behavior in response to the COVID-19 epidemic are shown in supplementary figures 5-6. We found that the younger participants were less likely to follow general recommendations. There was no significant association between any behavioral change and seropositivity.

Discussion

In this large, national, cross-sectional study we determined the seroprevalence of SARS-CoV-2 antibodies in SH areas. The findings from our study indicate that the prevalence of seropositive participants living in SH areas in Denmark was three times higher than in the general population. Males were found to be seropositive more often than females, similar to what has been reported in other studies (12, 13). We found that seroprevalence increased with age, especially among men. Seroprevalence varied between geographical areas, being highest in the Capital region. The prevalence of self-reported symptoms in our study is consistent with previous findings with anosmia and ageusia having the strongest correlation to seropositivity (13, 14). Regarding behavioral factors we saw that seropositive participants were less likely to smoke, drink alcohol or use drugs, this may be related to the fact that older people had higher risk of seropositivity, while alcohol, drugs and smoking is expected to be more widespread among the young. Or related to the fact that people with a higher level of consumption did not participate. We found no significant difference in body-mass index (BMI) between seronegative and seropositive participants, however overall participants were overweight with a median BMI above 25.

In relation to age-related seroprevalence we do not see the same trend as in other Danish studies. The Danish National Seroprevalence Survey of SARS-CoV-2 infection by SSI described seroprevalence estimates were roughly 3 times higher in those aged 12-29 compared to 65 years and above (14) also, a study of 29,295 health-care workers in Denmark found participants younger than 30 years having the highest seroprevalence (13). A study of 1,100 retired blood donors found a lower seroprevalence in the age group >69 years (20), this was also seen in a study of ambulance staff in Sweden and Denmark which described the lowest proportion of seropositive aged 60 years and above (21)

Appropriate quarantine and separation from infected household members can be challenging in large households, and previous studies described how crowded living conditions constitute an increased risk of seropositivity (7, 8, 22, 23). Furthermore, crowded living conditions is considered a key reason why people of low socioeconomic status or from ethnic minority backgrounds in particular have been disproportionately affected by the pandemic (4, 24). Our results show that being exposed to SARS-CoV-2

due to close contact (physical contact and staying in the same room above 15 minutes as infected) or having someone infected in the household increased the risk of seropositivity significantly.

We found that the household composition was of importance, as living at least 4 people in a household or living in a multigenerational household increased the risk of seropositivity among participants. This finding is consistent with a previous preprint study on SARS-CoV-2 transmission within Danish households, which demonstrated an increased transmission risk with age (25).

Joblessness and low levels of education are more common in SH areas than in the general population and a study from Italy reported that being less educated may be a challenge under a pandemic, as the language barrier may affect the adherence to institutional recommendations such as wearing protective masks, avoid contagion and maintaining social distancing (5). In our study only 2,7% seropositive participants answering the questionnaire were without any formal education. Our findings did not indicate clear association between seropositivity and behavioral change overall, and we observed a high rate of behavioral change, especially among the elderly. Only 1.6% of participants indicated not having changed behavior in response to the COVID-19 pandemic, why study participants overall were likely to implement public health measures. Joblessness (stay at home, unemployed or on leave) was not associated with the risk of seropositivity. Joblessness can potentially be a protective factor against COVID-19 infection as more prone to stay at home and avoiding public transportation or meeting people outside the household (5).

Employment in health care or nursing (nursing homes and nursing care at home) was associated with numerically higher seropositivity, however not significantly (p=0,05). This can be due to the fact that these job functions have been less affected by restrictions of working from home and avoiding person-to person contact and thereby pose an increased risk of infection. Also, vaccination of health care workers and workers in nursing homes was introduced December 27th, 2020 by the Danish Health Authority and the Ministry of Health as part of the Danish vaccination program, why there is a small likelihood that these participants have been vaccinated and thereby present a positive POCT based on antibodies from the vaccine instead of naturally immunization.

Ethnicity

A report from the SSI about ethnicity and SARS-CoV-2 infection showed that citizens of non-Western descent were overrepresented by a factor of three in relation to the part they constitute of the Danish population, which may be due to living conditions or employment with higher risk of infection (8). Unfortunately, we could not explore differences by ethnicity, as this information was not available by questionnaire and only a fraction of the participant informed about their social security number with the possibility for obtain information about ethnicity. In future studies like this it will be beneficial to include ethnicity in the questionnaire and include a translator at the test site to prevent potential linguistic barriers in answering of the questionnaires. Selection bias due to language barriers might have affected our results despite the fact that information material and questionnaire were available in seven different languages.

Strengths and limitations

Our study has several limitations. The study design does not provide information on the point of time when participants became seropositive nor determination of time of infection. It is possible that participants who had been detected with COVID-19 earlier (viral throat- or nasopharyngeal swab or antibody test) or experienced COVID-19 like symptoms did not participate, leading to an underestimation of the seroprevalence and an potential overestimation of participants concerned about prior infection. Seropositivity can be underestimated due to the fact that antibodies in response to SARS-CoV-2 infection

can first be detected about one week after symptom onset (22, 26). Seropositivity of Danish blood donors in the same period was used as a proxy for the general population with some limitations to consider. Blood donors were in the age group 17-70 years and our study group are in the age group 15-83 years. Seroprevalence in blood donors is determined on the basis of ELISA and not POCT. In general, blood donors are in good health, why seropositivity in this group could be lower than expected. There is a tendency for health care professionals to be overrepresented as blood donors, and this group is found to have a higher risk of SARS-CoV-2 infection (13), why the seropositivity of blood donors could be higher than expected. Participants did not have to document a residential address in the SH areas, why there may be participants from other areas. There is a small risk of participants from SH areas being vaccinated prior to participation in this study and thereby seropositive based on vaccine response and not natural immunization. Vaccinated blood donors have been deducted from data.

This study had a broad national participation, which give us a representative sample of the Danish population living in SH areas of low socioeconomic status. The high participation rates across the country may reflects a keen interest in knowing the serological status supported by easily accessible testing facilities near the household, and written information in different language. Interobserver variation was limited as the POCT was read by project staff at the test sites. Serological surveys are the best tool to determine the spread of an infectious disease, particularly in the presence of asymptomatic individuals or incomplete ascertainment of those with symptoms. The POCT is a useful serological tool as it is easy to use, provides results in 15 minutes, can be performed by the participants, do not require a venous blood sample nor laboratory equipment and is less costly than ELISA, and thereby a suitable option for large sero-epidemiological studies.

Conclusion

People living in SH areas in Denmark, have a three times higher seroprevalence of SARS-CoV-2 antibodies compared to the general Danish population. Seroprevalence was significantly higher for males and increased with age. Living in multiple generations or more than four persons in a household was an independent risk factor for being seropositive. Results of this study can be used for future consideration of the need for preventive measures in the populations living in SH areas.

Contributors
The study was designed and initiated by: KF, RLS and KI
Data analysis was done by: RH and AE
The first draft was written by: KF, AE, RH, HB and KI
All authors have critically revised the manuscript and agree to be accountable for all aspects of the work.
All authors approved the final version of the manuscript.

Declaration of interests
The authors declared no potential conflict of interest with respect to the research, authorship, and/or publication of this article

References

1.		The Danish Health Authority. Current data on the development of coronavirus. 2021, April 29 [Available from: https://www.sst.dk/en/English/Corona-eng/Status-of-the-epidemic/COVID-19-updates-Statistics-and-charts.

2.		Goujon A, Natale, F., Ghio, D., Conte, A. and Dijkstra, L.,. Age, gender, and territory of COVID-19 infections and fatalities,. Publications Office of the European Union: European Commission; 2020.

3.		Danmarks Almene Boliger. Ghettolisten. 2020, December 1 [Available from: https://bl.dk/politik-og-analyser/temaer/hvem-er-paa-ghettolisten/.

4.		Sze S, Pan D, Nevill CR, Gray LJ, Martin CA, Nazareth J, et al. Ethnicity and clinical outcomes in COVID-19: A systematic review and meta-analysis. EClinicalMedicine. 2020;29:100630.

5.		Consolazio D, Murtas R, Tunesi S, Gervasi F, Benassi D, Russo AG. Assessing the Impact of Individual Characteristics and Neighborhood Socioeconomic Status During the COVID-19 Pandemic in the Provinces of Milan and Lodi. Int J Health Serv. 2021:20731421994842.

6.		Rostila M, Cederstrom A, Wallace M, Branden M, Malmberg B, Andersson G. Disparities in COVID-19 deaths by country of birth in Stockholm, Sweden: A total population based cohort study. Am J Epidemiol. 2021.

7.		Statens Serum Institut. Epidemiologism trend og fokus: Herkomst (etnicitet). 2020, May 7 [Available from: https://files.ssi.dk/COVID19-epi-trendogfokus-07052020-4eu7.

8.		Statens Serum Institut. COVID-19 og herkomst - opdateret fokusrapport. 2020, October [Available from: https://files.ssi.dk/COVID19-og-herkomst-oktober-2020.

9.		The Danish Health Authority. General Guidance. 2021, april 21 [Available from: https://www.sst.dk/en/English/Corona-eng/Prevent-infection/General-guidance.

10.		Greenaway C, Hargreaves S, Barkati S, Coyle CM, Gobbi F, Veizis A, et al. COVID-19: Exposing and addressing health disparities among ethnic minorities and migrants. J Travel Med. 2020;27(7).

11.		Erikstrup C, Hother CE, Pedersen OBV, Molbak K, Skov RL, Holm DK, et al. Estimation of SARS-CoV-2 Infection Fatality Rate by Real-time Antibody Screening of Blood Donors. Clin Infect Dis. 2021;72(2):249-53.

12.		Madsen JR, Nielsen JPS, Fogh K, Hansen CB, Nielsen PB, Lange T, et al. Anti-SARS-CoV-2 seropositivity among medical students in Copenhagen. medRxiv. 2021:2021.02.09.21251421.

13.		Iversen K, Bundgaard H, Hasselbalch RB, Kristensen JH, Nielsen PB, Pries-Heje M, et al. Risk of COVID-19 in health-care workers in Denmark: an observational cohort study. Lancet Infect Dis. 2020;20(12):1401-8.

14.		Espenhain L, Tribler S, Jørgensen CS, Holm Hansen C, Wolff Sönksen U, Ethelberg S. Prevalence of SARS-CoV-2 antibodies in Denmark 2020: results from nationwide, population-based sero-epidemiological surveys. medRxiv. 2021:2021.04.07.21254703.

15.		Harris PA, Taylor R, Minor BL, Elliott V, Fernandez M, O'Neal L, et al. The REDCap consortium: Building an international community of software platform partners. J Biomed Inform. 2019;95:103208.

16.		Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-81.

17.		CTK Biotech inc. OnSite COVID-19 IgG/IgM Rapid Test. 2020 [Available from: https://cdn2.hubspot.net/hubfs/4418101/PI-R0180C%20Rev%20B2.1.pdf.

18.		Lassaunière R, Frische, A.. Sværke Jørgensen, C. Evaluation of nine commercial SARS-CoV-2 immunoassays. medRxiv, preprint version. 2020.

19.		Team RC. R: A Language and Eviroment for Statistical Computing. 2016 [Available from: https://www.gbif.org/tool/81287/r-a-language-and-environment-for-statistical-computing.

20.		Pedersen OB, Nissen J, Dinh KM, Schwinn M, Kaspersen KA, Boldsen JK, et al. SARS-CoV-2 infection fatality rate among elderly retired Danish blood donors - A cross-sectional study. Clin Infect Dis. 2020.

21.   Laursen J, Petersen J, Didriksen M, Iversen K, Ullum H. Prevalence of SARS-CoV-2 IgG/IgM Antibodies among Danish and Swedish Falck Emergency and Non-Emergency Healthcare Workers. International Journal of Environmental Research and Public Health. 2021;18(3):923.

22.   Stringhini S, Wisniak A, Piumatti G, Azman AS, Lauer SA, Baysson H, et al. Seroprevalence of anti-SARS-CoV-2 IgG antibodies in Geneva, Switzerland (SEROCoV-POP): a population-based study. Lancet. 2020;396(10247):313-9.

23.   Roederer T, Mollo B, Vincent C, Nikolay B, Llosa AE, Nesbitt R, et al. Seroprevalence and risk factors of exposure to COVID-19 in homeless people in Paris, France: a cross-sectional study. Lancet Public Health. 2021;6(4):e202-e9.

24.   Niedzwiedz CL, O'Donnell CA, Jani BD, Demou E, Ho FK, Celis-Morales C, et al. Ethnic and socioeconomic differences in SARS-CoV-2 infection: prospective cohort study using UK Biobank. BMC Med. 2020;18(1):160.

25.   Lyngse FP, Kirkeby CT, Halasa T, Andreasen V, Skov RL, Møller FT, et al. COVID-19 Transmission Within Danish Households: A Nationwide Study from Lockdown to Reopening. medRxiv. 2020:2020.09.09.20191239.

26.   Wajnberg A, Amanat F, Firpo A, Altman DR, Bailey MJ, Mansour M, et al. Robust neutralizing antibodies to SARS-CoV-2 infection persist for months. Science. 2020;370(6521):1227-30.

Table 1: Baseline characteristics of the study cohort of people in SH areas stratified by seropositivity

Full cohort	Seronegative	Seropositive	p
n	10,983	2,296	
Age (mean (SD))	46.43 (16.4)	47.27 (16.0)	0.031
Female (%)	5,567 (54.8)	1,100 (51.0)	0.001
Questionnaire cohort			
n	2,632	604	
Body mass index (median [IQR])	25.35 [22.83, 29.03]	25.47 [23.12, 29.05]	0.476
Ever smoker (%)	727 (27.8)	121 (20.1)	<0.001
Alcohol intake (%)	2,075 (80.3)	458 (76.5)	0.039
Alcohol use (%)	140 (5.5)	21 (3.6)	0.074
Ever used drugs (%)	123 (4.7)	12 (2.0)	0.004
Education level (%)			0.842
No formal education	66 (2.5)	16 (2.7)	
Primary education	251 (9.6)	61 (10.2)	
Secondary education (youth education)	267 (10.3)	66 (11.0)	
Vocational training or short-term/ medium-term higher education	1,384 (53.2)	325 (54.3)	
Long-term higher education	605 (23.2)	126 (21.0)	
Unknown	30 (1.2)	5 (0.8)	

Alcohol intake: Intake of alcohol within the past 12 months

Alcohol use: Reporting >7 units of alcohol a week for females or >14 units of alcohol for males

Table 2: Risk factors stratified by seropositivity of the questionnaire cohort of people in SH areas

	Seronegative	Seropositive	p
n	2,632	604	
Stayed in the same room for 15 min with COVID-19 infected (%)	807 (46.7)	281 (70.8)	<0.001
Had bodily contact with COVID-19 infected person (%)	415 (20.0)	180 (39.0)	<0.001
Had worked/studied with COVID-19 infected person (%)	777 (35.1)	171 (36.5)	0.584
Had someone in the household infected with COVID-19 (%)	296 (12.2)	228 (41.3)	<0.001
Had someone in the family or friend outside household infected with COVID-19 (%)	1,445 (59.0)	352 (64.5)	0.021

Figure Legends

- Figure 1: CONSORT diagram
- Figure 2: SARS-CoV-2 seroprevalence among 11,654 individuals in SH areas by age and sex
- Figure 3: SARS-CoV-2 seroprevalence among 1,329 individuals in SH areas stratified by household size and generations in households
- Figure 4: SARS-CoV-2 seroprevalence among 3,210 individuals in SH areas stratified by employment
- Supplementary figure 1: Map of seropositivity
- Supplementary figure 2: Frequency of symptoms among 3,236 individuals in SH areas stratified by seropositivity
- Supplementary figure 3: Forest plot of risk ratios (RR) for each symptom reported by questionnaire cohort
- Supplementary figure 4: General recommendations from the Danish Health authorities
- Supplementary figure 5: Change of behavior among 3,236 individuals in SH areas during the pandemic stratified by seropositivity
- Supplementary figure 6: Change of behavior among 3,236 individuals in SH areas during the pandemic stratified by sex and age in quartiles
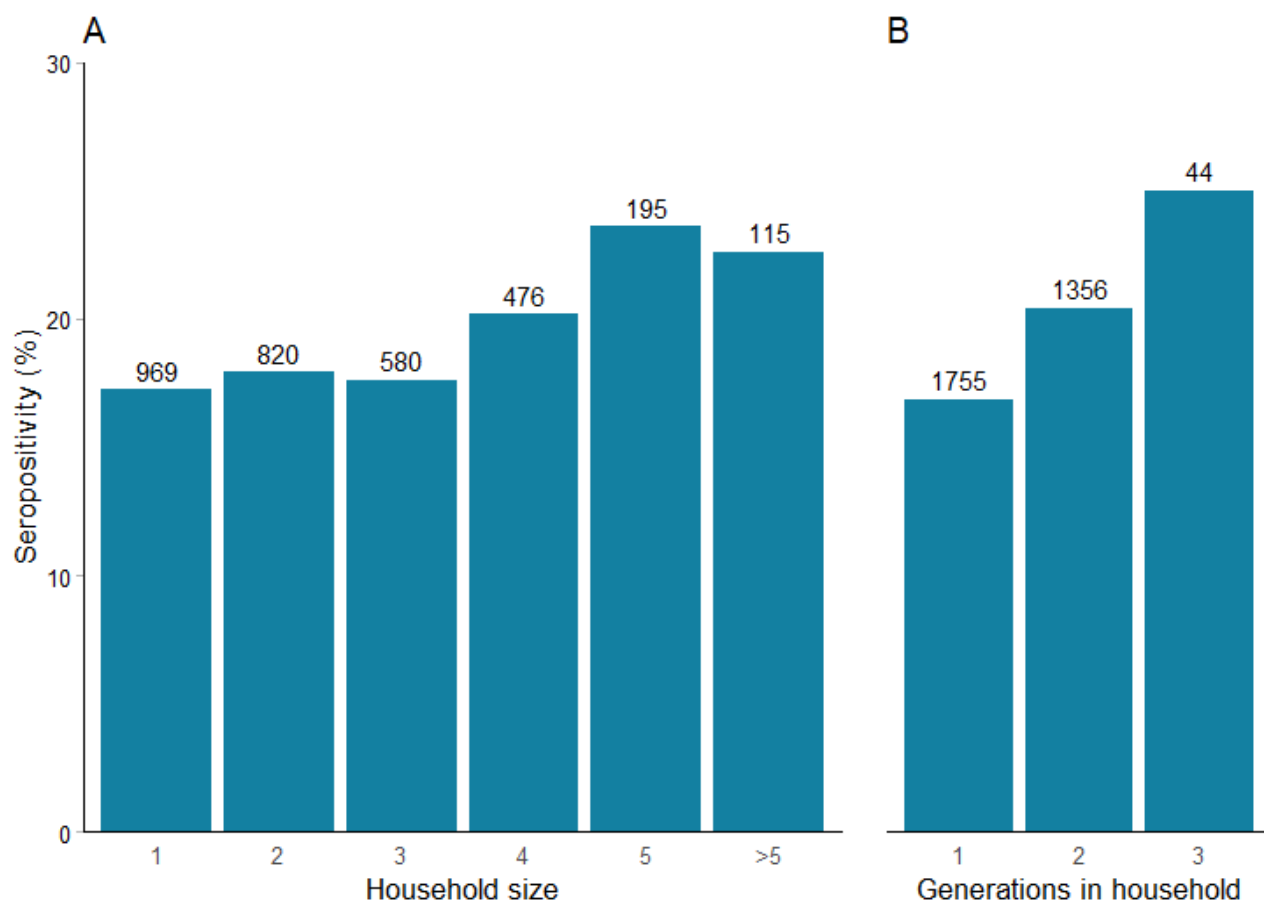
Figure 1: CONSORT diagram
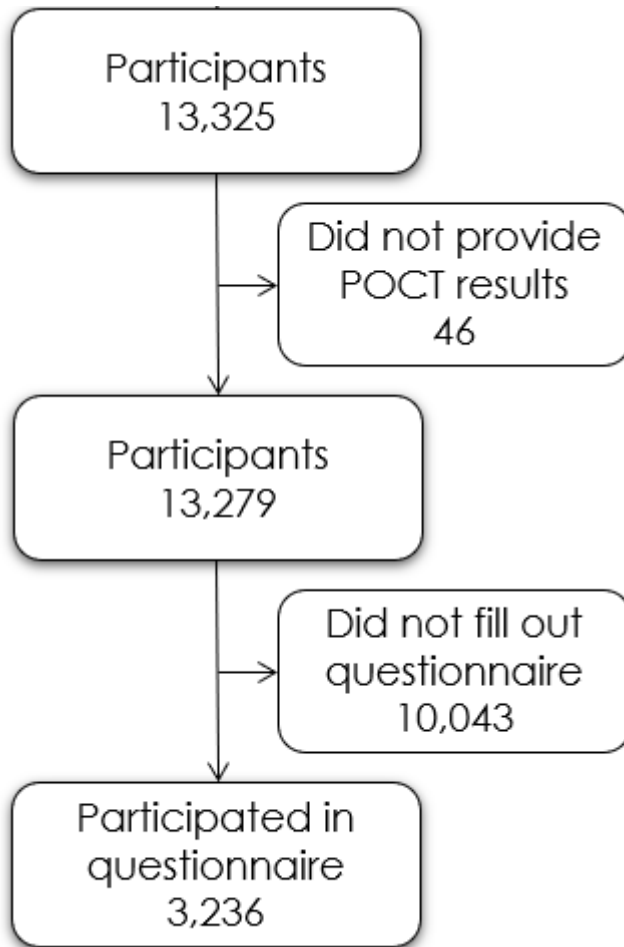
**Figure 2:** SARS-CoV-2 seroprevalence among 11,654 individuals in SH areas by age and sex
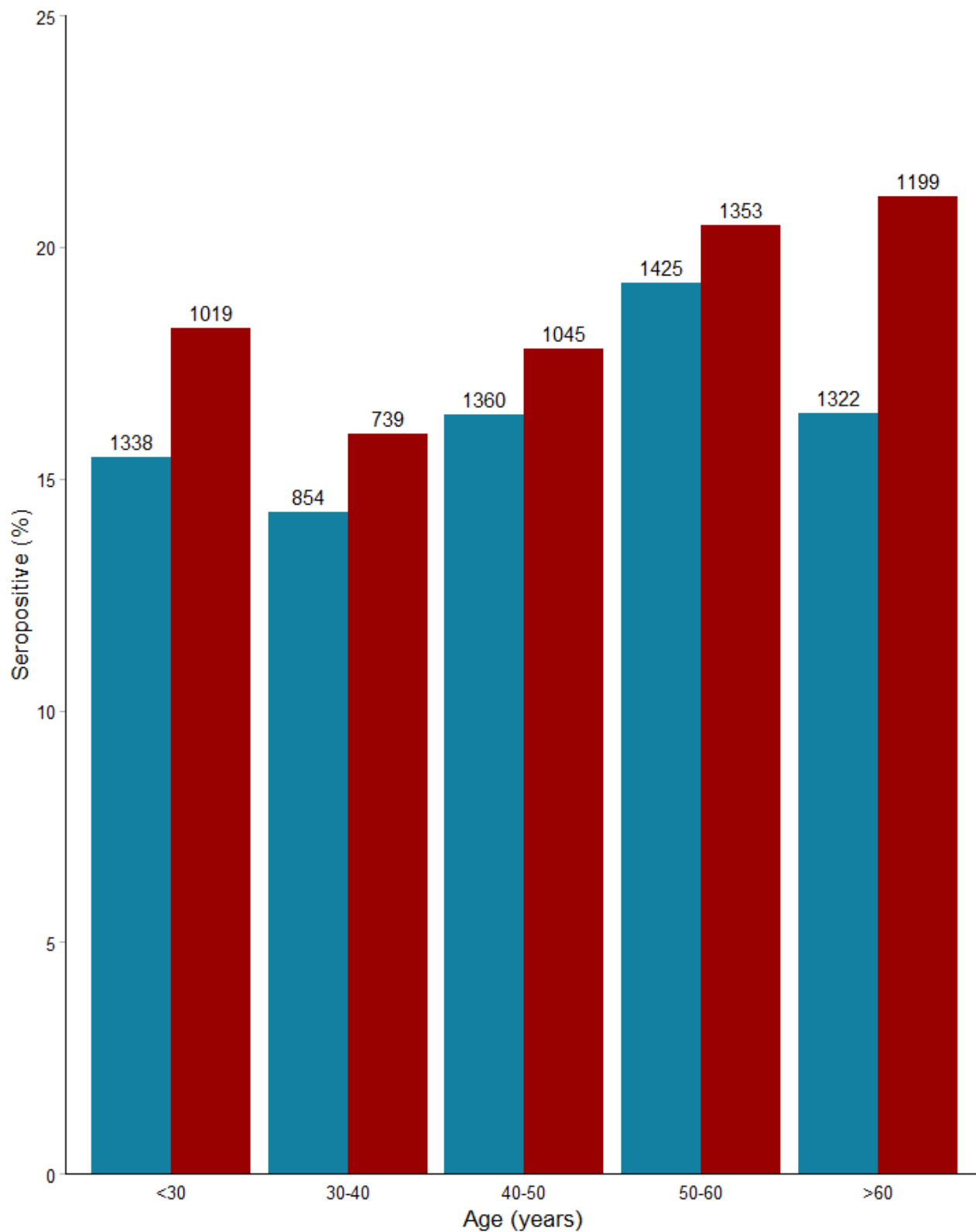
Red: male, blue: female, number of participants in each group

Figure 3: SARS-CoV-2 seroprevalence among 3,155 individuals in SH areas stratified by household size and generations in households

A: Number of household members, B: household size in terms of generations

Figure 4: SARS-CoV-2 seroprevalence among 3,210 individuals in SH areas stratified by employment from questionnaire cohort
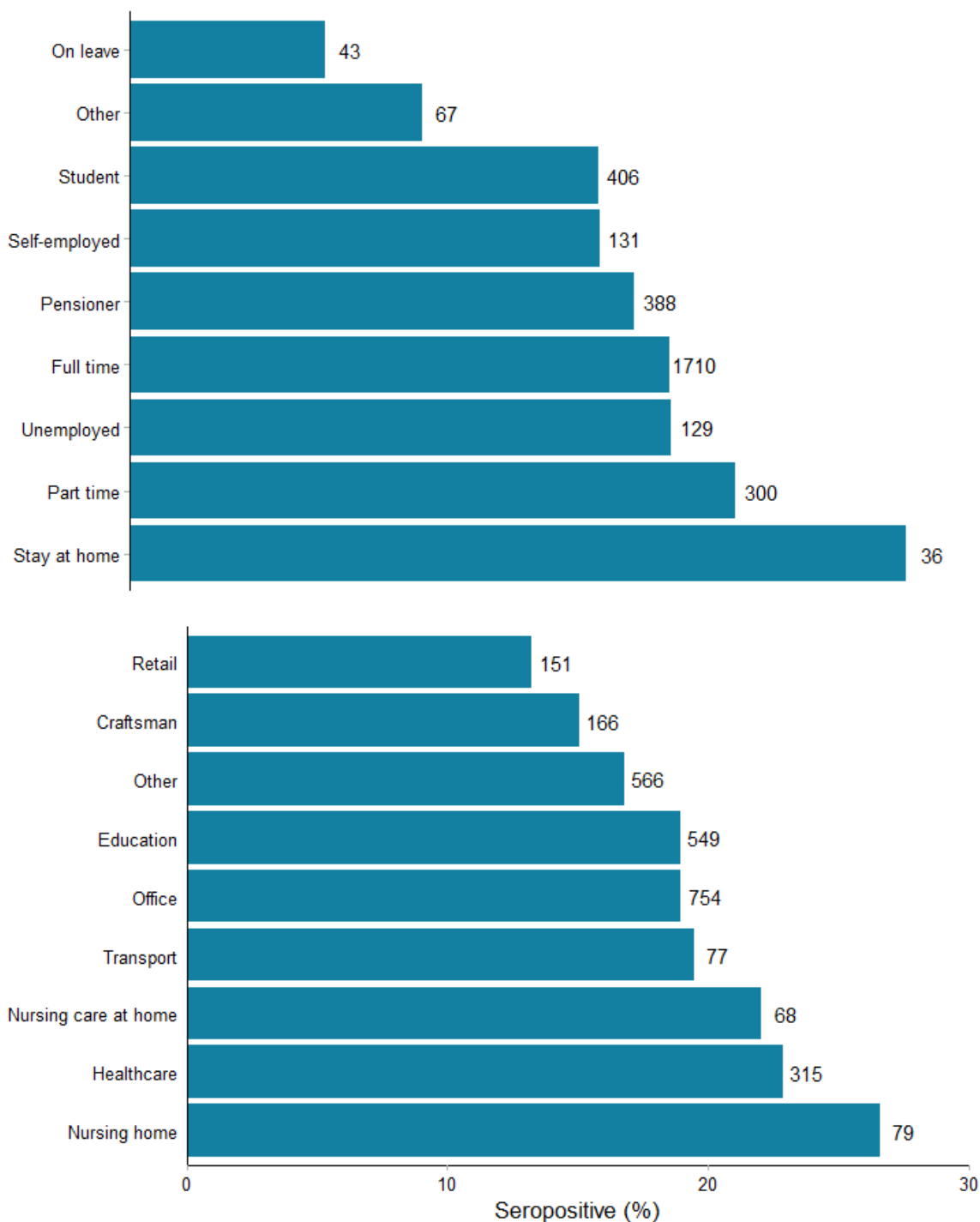
Upper: relation to job market

Lower: employment (given participant were employed)

Categories are as named in questionnaire.

Supplementary figure 1: Map of seropositivity
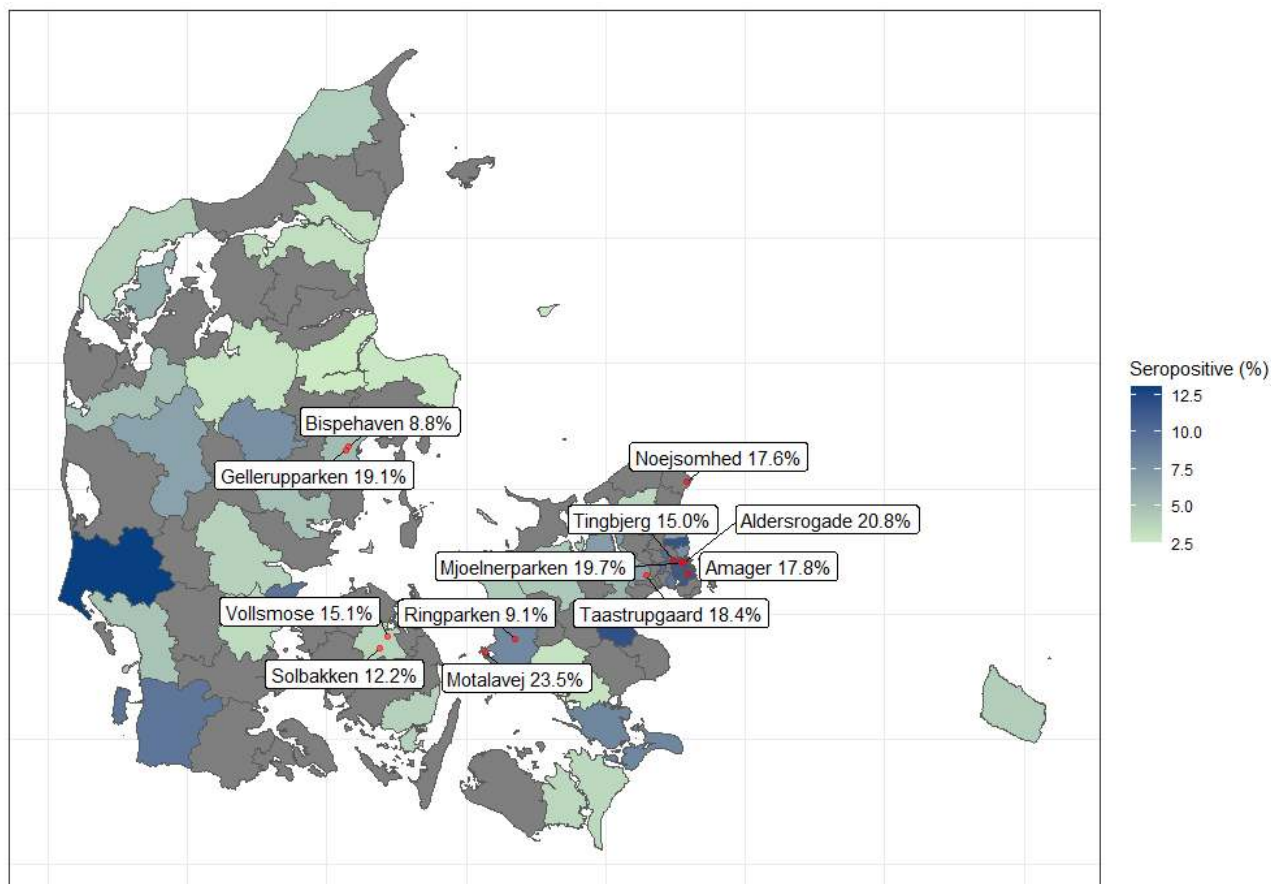
Colors indicating the general population (blood donors)

Text boxes indicating the study cohort.

Gellerupparken: Including SH area Gellerupparken and Bazar Vest

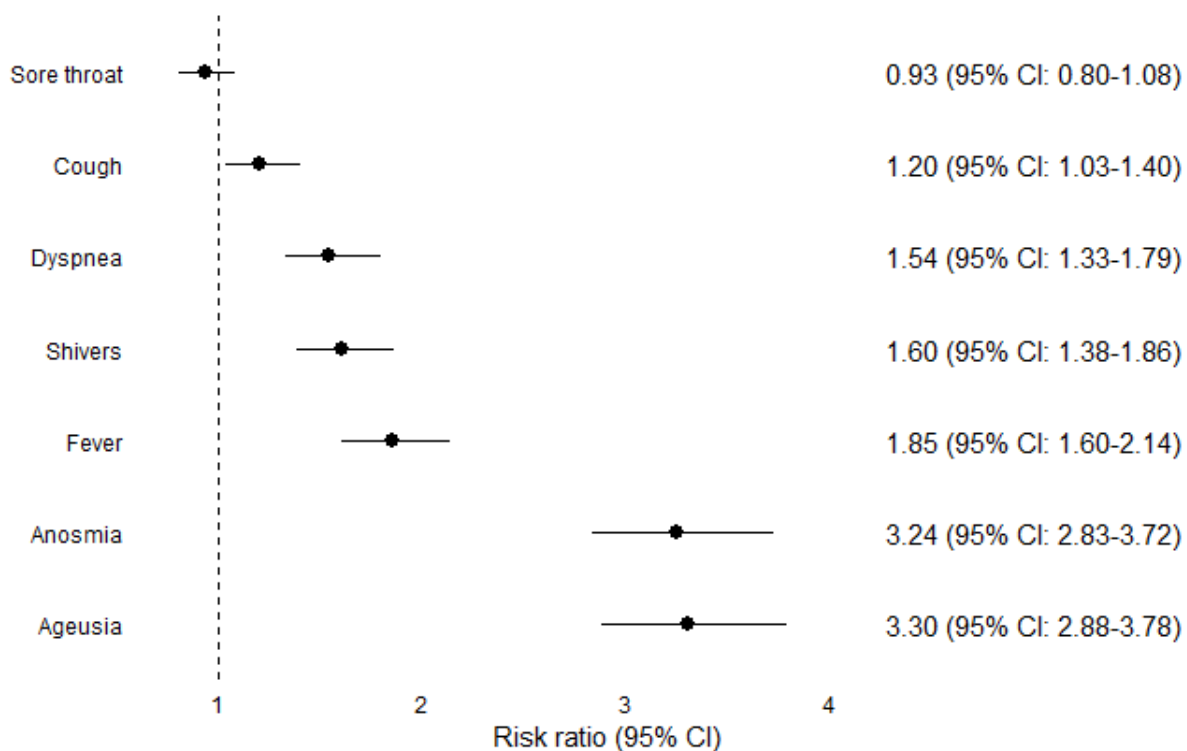*Noejsomhed: Including SH area Noejsomhed and SH area Vapnagaard*

Supplementary figure 2: Frequency of symptoms among 3,236 individuals in SH areas stratified by seropositivity

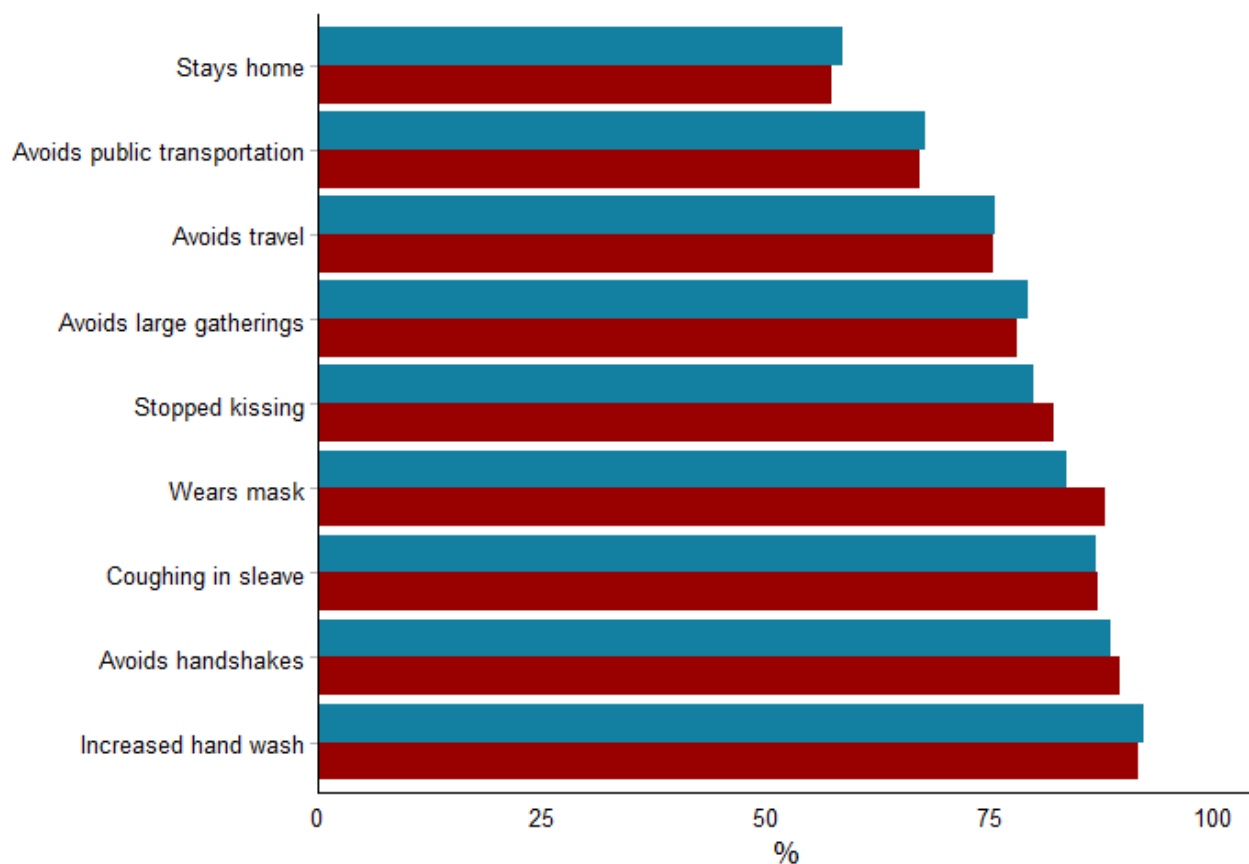*Red: Seropositive, Blue: Seronegative*

Supplementary figure 3: Forest plot of risk ratios (RR) for each symptom reported by questionnaire cohort

**Supplementary figure 4**: General recommendations from the Danish Health authorities

1	Keep a distance of 2 meters whenever possible and always at least 1 meter
2	Avoid handshakes, hugs and kisses on the cheek
3	Self-isolate and take a PCR test if you have symptoms of COVID-19
4	Open windows and doors and ventilate your home regularly
5	Avoid being too many people together indoors
6	Cough or sneeze into your sleeve
7	Wash your hands often or use hand sanitizer
8	Clean thoroughly and regularly, especially surfaces that are touched by many people
9	Persons aged 12 or more must wear face masks or shields in following locations: public transportation, wholesale and retail shops, at premises for cultural, sports and club activities, religious communities, day-care facilities, schools, education institutions, public and private hospitals and clinics and premises where clients are offered services involving physical contacts

Supplementary figure 5: Change of behavior among 3,236 individuals in Danish SH areas during the pandemic stratified by seropositivity

Red: seropositive, Blue: seronegative

Supplementary figure 6: Change of behavior among 2,871 individuals in Danish SH areas during the pandemic stratified by sex and age in quartiles
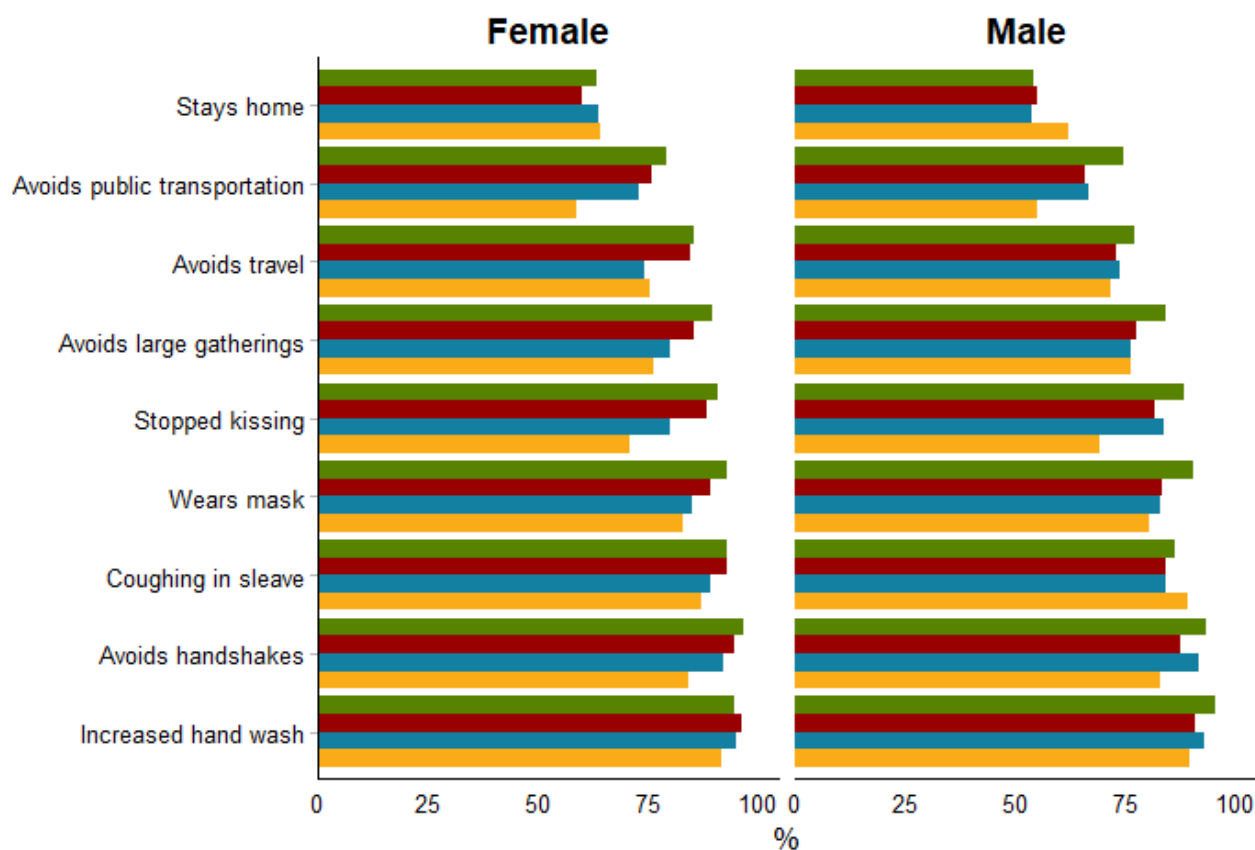
(Green – age >56 years, red – age 45-56 years, blue – age 31-45 years, yellow - <31 years)

Appendix

List of test sites:

Copenhagen	Mjoelnerparken
	Tingbjerg
	Aldersrogade
	Amager
	Taastrupgård
Helsingoer	Noejsomhed
	Vapnagaard
Slagelse	Ringparken
Korsoer	Motalavej
Aarhus	Bispehaven
	Gellerupparken and Bazar Vest
Odense	Solbakken
	Vollsmose

The questionnaire:

Introductory questions	
Do you want to state your civil registration (CPR) number?	○ Yes ○ No
What is your civil registration number (without hyphen)?	_____
Confirm your civil registration number (without hyphen)	_____
THE CIVIL REGISTRATION NUMBERS DO NOT MATCH. PLEASE CHECK ABOVE AND ENTER AGAIN (This field disappears when the civil registration numbers entered in the above fields are identical)	_____
What is your gender?	○ Male ○ Female ○ Other ○ Don't wish to answer
What is your date of birth?	_____
What is your postcode?	_____
How much do you weigh in kilograms (kg)?	_____
How tall are you in centimetres (cm)?	_____
Do you wish to do a finger prick test for COVID-19?	○ Yes ○ No ○ Don't know
May we compare the results of this survey with public registers?	○ Yes ○ No

Questions about your antibody tests

This part of the questionnaire concerns the antibody tests you have done in connection with We are testing Denmark

What is the result of your finger prick test?	○ Negative
	○ Positive for IgM
	○ Positive for IgG
	○ Positive for both IgM and IgG
	○ Inconclusive
	○ I have not done the test/the test failed

Questions about COVID-19 infection

This part of the questionnaire concerns whether you have been infected with COVID-19.

| If you were to give your best assessment, do you think/know that you have ever been infected with COVID-19? | ○ Yes, I know/think that I have had COVID-19 |
| | ○ No, I know that I haven't had/I don't think that I have had COVID-19 |

| Have you previously been tested for COVID-19? | ○ Yes |
| | ○ No |

What type of COVID-19 test have you taken?	☐ Swab (sample from throat, nose or pharynx)
Select one or both answer options	☐ Antibody test (finger prick test or blood test)
	☐ Don't know/don't wish to answer

| Was one or more of your tests positive? | ○ Yes |
| | ○ No |

Symptoms

The next questions concern your general health and whether you have had symptoms of COVID-19.

Have you had one or more of the following symptoms since 1 February?

(Select an answer for each option)

	No	Yes, slight	Yes, some	Yes, pronounced	Don't know
Fever	○	○	○	○	○
Chills	○	○	○	○	○

Impaired sense of smell	O	O	O	O	O
Impaired sense of taste	O	O	O	O	O
Sore throat	O	O	O	O	O
Cough	O	O	O	O	O
Difficulty breathing/shortness of breath	O	O	O	O	O

What do you think is/was the cause of your symptoms? Select one or more of the following answer options:	☐ COVID-19
	☐ Influenza or an influenza-like disease
	☐ Common cold
	☐ Allergy/hay fever
	☐ Asthma
	☐ Gastrointestinal infection
	☐ Other
	☐ Don't know
Which of the following conditions best describes how you felt when you were feeling the worst, while you had/suspected you had COVID-19?	O I had no symptoms
	O I was at home with symptoms, but felt well
	O I was bed-ridden at home with symptoms
	O I was admitted to hospital
	O I was admitted and on a ventilator.

Risk of COVID-19

The following questions concern how great the risk is that you have been exposed to coronavirus.

	Yes	No	Don't know	Not relevant
Have you stayed for minimum 15 minutes in the same room as an infected person?	O	O	O	O
Have you had body contact with a person infected with COVID-19?	O	O	O	O
Have you worked/studied with someone who was infected with COVID-19?	O	O	O	O
Has someone in your household been infected with COVID-19?	O	O	O .	O

Has someone in your family or a friend outside your household been infected with COVID-19?	○	○	○	○

This part concerns behaviour

Have you taken any of the following measures due to the risk of COVID-19 infection?

Select all relevant answers:

☐ I wash hands more often

☐ I cough or sneeze into my sleeve

☐ I use disposable tissues

☐ I wear disposable face masks

☐ I avoid shaking hands

☐ I avoid greeting persons by hugging and/or kissing them on both cheeks

☐ I limit my use of public transport

☐ I avoid places where many people are gathered

☐ I stay at home

☐ I work more from home

☐ I avoid travelling outside my own country and/or region

☐ None of the above

Do you smoke?

○ No

○ Yes – occasionally

○ Yes – daily, less than 10 times a day

○ Yes – daily, 10 or more times a day

○ Previously

○ Don't wish to answer

Have you consumed alcohol in the past 12 months?	○ Yes
	○ No
	○ Don't know/don't wish to answer
On how many days a week do you drink alcohol?	○ 0-1 days
	○ 2 days
	○ 3 days
	○ 4 days
	○ 5 days
	○ 6 days
	○ 7 days
How many units do you typically drink per week?	
1 unit = 1 regular beer or 1 glass of red/white wine or 1 alcoholic soft drink or 1 alcoholic cider or 1 glass of fortified wine or 1 drink/cocktail or 1 acquavit/shot	_____
Do you use euphoriant drugs?	☐ No
	☐ Yes – occasionally
	☐ Yes – often
	☐ Previously
	☐ Don't wish to answer
Did you get an influenza vaccine last autumn/winter 2019? Select one of the following answer options:	○ Yes
	○ No
	○ I don't know/don't remember
Did you get an influenza vaccine this autumn/winter 2020?	○ Yes
	○ No
	○ I don't know/don't remember
Select one of the following answer options:	

Work and education

The following questions are about your education and your work

What is your highest level of completed education? Select one of the following answer options:	○ I have no formal education ○ Primary education ○ Secondary education (youth education) ○ Vocational training or short-term/medium-term higher education ○ Long-term higher education ○ Don't know
What is your main occupation? Select one of the following answer options:	○ Full-time work ○ Part-time work ○ Self-employed ○ Student ○ Homemaker ○ Unemployed ○ On long-term sick leave or parental leave ○ Pensioner ○ Other
Which area(s) or type(s) of work best describe(s) your work? Select one or more answers	☐ Healthcare sector ☐ Nursing home ☐ Home care ☐ Shop work ☐ Office work ☐ School/other educational establishment ☐ Tradesman ☐ Transport (Bus, taxi, train or other means) ☐ Other ☐ Don't wish to answer

The following questions concern your household

Information about your household is important to enable us to assess your risk of being infected with coronavirus and getting COVID-19.

How many people in the following age groups, including yourself, live in your household?

Please select one answer for each element.

	None	1	2	3	4	5	>5	Not relevant
0-4-year-olds	○	○	○	○	○	○	○	○
5-18-year-olds	○	○	○	○	○	○	○	○
19-44-year-olds	○	○	○	○	○	○	○	○
45-64-year-olds	○	○	○	○	○	○	○	○
65+-year-olds	○	○	○	○	○	○	○	○

May we contact you later if we have elaborating further questions?

○ Yes

○ No

What is your email address?

_____

Confirm your email address

_____

THE EMAIL ADDRESSES DO NOT MATCH. PLEASE CHECK ABOVE AND ENTER AGAIN (This field disappears when the email addresses entered in the above fields are identical)

_____