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Occupational risk of SARS-CoV-2 infection: a nationwide register-based study of the Danish workforce during the COVID-19 pandemic, 2020–2021

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ABSTRACT

Objective Most earlier studies on occupational risk of COVID-19 covering the entire workforce are based on relatively rare outcomes such as hospital admission and mortality. This study examines the incidence of SARS-CoV-2 infection by occupational group based on real-time PCR (RT-PCR) tests.

Methods The cohort includes 2.4 million Danish employees, 20–69 years of age. All data were retrieved from public registries. The incidence rate ratios (IRRs) of first-occurring positive RT-PCR test from week 8 of 2020 to week 50 of 2021 were computed by Poisson regression for each four-digit Danish Version of the International Standard Classification of Occupations job code with more than 100 male and 100 female employees (n=205). Occupational groups with low risk of workplace infection according to a job exposure matrix constituted the reference group. Risk estimates were adjusted by demographic, social and health characteristics including household size, completed COVID-19 vaccination, pandemic wave and occupation-specific frequency of testing.

Results IRRs of SARS-CoV-2 infection were elevated in seven healthcare occupations and 42 occupations in other sectors, mainly social work activities, residential care, education, defence and security, accommodation and transportation. No IRRs exceeded 2.0. The relative risk in healthcare, residential care and defence/security declined across pandemic waves. Decreased IRRs were observed in 12 occupations.

Discussion We observed a modestly increased risk of SARS-CoV-2 infection among employees in numerous occupations, indicating a large potential for preventive actions. Cautious interpretation of observed risk in specific occupations is needed because of methodological issues inherent in analyses of RT-PCR test results and because of multiple statistical tests.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Epidemiological studies suggest that the workplace contributes to the COVID-19 pandemic.
⇒ Results are mostly based on studies of less frequent outcomes such as COVID-19 morbidity or mortality, which limit inference about risk in specific occupations.

WHAT THIS STUDY ADDS

⇒ The risk of COVID-19 infection was increased in 49 out of 205 specific occupations.
⇒ The majority of employees at risk were working within health care and residential care, social work, education, defence and security, accommodation, transportation and various service activities.
⇒ The relative risk in healthcare, residential care and defence/security declined across pandemic waves, while the relative risk in education and social work increased during the pandemic.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Preventive actions targeting the workplace may contribute substantially to alleviate disease occurrence in the ongoing COVID-19 and similar future pandemics.

INTRODUCTION

Less than 3 years have elapsed since the still ongoing COVID-19 pandemic started. During this short time span, numerous epidemiological studies have consistently demonstrated that a range of occupations are associated with an increased risk of being infected with SARS-CoV-2.[1–5] The reasons may include higher frequencies of close social contacts at the workplace, caring for infected patients and less possibility to maintain sufficient distancing and efficiently use personal protective equipment.[6 7] Other risk factors such as mode of transportation when commuting to work might also be of importance. Previously identified at-risk occupations include healthcare workers, teachers, bus and taxi drivers, meat packers, retail sale workers, bartenders and police officers.[1–4 8] The majority of studies have investigated risk across occupations using relatively rare outcomes such as COVID-19-related admission to hospital[9–11] or mortality.[4 9 10 12–16] However, these approaches fail to address less severe non-hospital demanding cases and may thus underestimate risk of infection. Considering reports on delayed return to work[17] and of post-COVID-19 conditions with persistent ill health following cases without acute critical disease,[18] we find that this is of importance, not the least in occupations with many young and healthy employees who are less likely to be hospitalised but at equal or higher risk of infection.

We have recently reported increased occupational risk of severe COVID-19 in terms of COVID-19-related hospital admission among workers in the healthcare, social care and transportation sectors.[8] Based on the same cohort and time period, in this paper, we unravel the risk of asymptomatic and less severe COVID-19 using real-time PCR (RT-PCR) test as the outcome. Hereby, a strong gain is achieved in statistical power, which enables detection of potentially increased risk in occupations with too few (or too young and healthy) employees to allow analyses of hospital admissions. The capacity for free and on-demand COVID-19 RT-PCR testing covering all residents in Denmark was established during autumn 2020. By late spring 2021, the number of tests peaked at 0.8 million/week among 2.4 million employees (own data). While the cumulative incidence for COVID-19-related hospital admission in the workforce during the first almost 2 years of the pandemic in Denmark was 0.17%,[8] the corresponding rate of at least one positive PCR test was 10.7% (own data).

The objective of this paper was to estimate the relative risk of SARS-CoV-2 infection conferred by specific occupations independently of COVID-19 vaccination and PCR test frequency. Infection was defined by a positive PCR test and the reference group by an independent expert-rated job exposure matrix (JEM).

METHODS

Population and data

The study population was a nationwide register-based cohort of all Danish residents 20–69 years of age, who by 31 December 2019 were gainfully employed (n=2 451 542). It was extricated as a subset of the Danish Occupational Cohort with exposure data,[19], which includes a range of demographic, social, occupational and health characteristics. Records were merged by the 10-digit unique personal identification number assigned by the Danish authorities. Additional information on vital data, SARS-CoV-2 tests and COVID-19 vaccinations was provided by Statistics Denmark and the National Board of Health Data from baseline week 8, 2020, to the end of follow-up week 50, 2021. Details on the cohort and its key variables have been published in a previous paper.[8]

Occupational data

Jobs are classified by Statistics Denmark according to the Danish Version of the International Standard Classification of Occupations (DISCO)-08,[20] which is close to identical with the international classification ISCO-08 (423 four-digit codes, coverage 86% of all gainfully employed) and the Danish version of the Statistical Classification of Economic Activities in the European Communities (DB07)[20] (22 one-digit sections and 88 two-digit divisions, coverage >99%).

Population characteristics

Population characteristics retrieved from Statistics Denmark by 31 December 2019 included sex, age, duration of education in years, country of birth, hospital admission for 1 or more of 11 chronic diseases during 2010–2019, geographical residential area and the number of household members sharing the same residence including children. Information on health behaviours is not available in public registries with national coverage. We assigned sex-specific and age-specific probability of current smoking and estimates of body mass index (kg/m^2) using data from large Danish survey samples executed in 2010 and 2013.[21] These JEM-derived variables predict mortality and ischaemic heart disease independently of other risk factors in the Danish population of employees.[22]

SARS-CoV-2 test results

SARS-CoV-2 infection was identified by RT-PCR tests performed at Statens Serum Institut in Copenhagen or at an accredited hospital laboratory.[23] The specificity of the RT-PCR test is extremely high (99.9%),[24] while the sensitivity in the general Danish population is unknown but believed to be above 80%.[24] The sensitivity mainly depends on stage of infection and sampling procedure. In the early phase of the pandemic, RT-PCR tests were carried out for diagnostic purposes and for tracing of close contacts, but from autumn 2020, the test capacity was expanded and tests free of charge were offered to the entire population regardless of symptoms and contacts.[24] Some 29.1 million tests were conducted in the study population until 14 December 2021, of which 1% were positive (own data).

Antigen tests (rapid home tests)

Antigen tests (rapid home tests) have in particular been recommended in periods and geographical regions with a high load of viral transmission, and in age and occupational groups considered at high risk. The antigen test targets viral proteins. It has been suggested by a Danish authority (Statens Serum Institut) that both sensitivity and specificity are inferior compared with the RT-PCR test.[25] Therefore, it is recommended that a positive antigen test is confirmed by a RT-PCR test. While antigen tests done as part of the nationwide and publicly funded test set-up are included in the national database of test results, results of privately bought and used antigen tests were not. In this population, only 72% of positive antigen test results were confirmed when a PCR test was performed within 2 days. In order to give priority to specificity over sensitivity, results of antigen tests were not included in the outcome measure.

Reference group

The reference group was defined by an independent expert-rated COVID-19 JEM.[6] It includes eight workplace characteristics, each rated on a scale from 0 (low SARS-CoV-2 exposure) to 3 (high exposure). The initial protocol for this study used a sum score across all eight dimensions of 0 to define the reference group. However, following external reviews and the publication of a JEM-validation study,[26] only the four dimensions with the strongest association with the independent measure of infection defined the reference group (sum score 0 of the four dimensions that directly address risk of virus transmission at the workplace: number and nature of social contacts at the workplace, contamination of workspaces and work outside or home).

Statistical analysis

We used Poisson regression to examine the incidence rate ratios (IRRs) of first-occurring positive SARS-CoV-2 RT-PCR test across all waves from week 8 of 2020 to week 50 of 2021 for each of the 205 non-reference four-digit DISCO-08 job codes with more than 100 male and 100 female employees. Employees with missing DISCO-08 codes and small occupations were kept as separate categories. The time unit was 1 week, and weeks after the first positive RT-PCR test, death, emigration or retirement were censored. The applied Poisson regression can be seen as a special case of Cox regression to model time to event data by including risk time as an offset in the model. Hereby, it is assumed that the baseline hazard is constant within each wave of the COVID-19 pandemic in Denmark. Since we do not have repeated observations—each individual contributes only once to the outcome—there is no need for robust estimation techniques.

Analyses were adjusted by a priori selected characteristics regardless of association with exposures[27]: age, duration of education, country of birth, geographical area, chronic disease, size of the household, body mass index, smoking and pandemic wave defined as calendar periods delimited by weeks with the lowest number of positive RT-PCR tests between pandemic peaks (for covariate categories, see table 1). In order to estimate the direct effect of occupation independent of COVID-19 vaccination (two doses with at least 21 days in between) and average occupational test frequency, we also adjusted for these variables. An outline of assumed causal pathways is provided in online supplemental figure 1.

Risk estimates were first adjusted for age and sex, then by the full list of the forementioned covariates except occupational testing frequency. In a final step, risk estimates were also adjusted for the average RT-PCR test frequency during the follow-up period for each four-digit DISCO-08 occupational code.

In supplementary analyses, we explored the risk of SARS-CoV-2 infection in each pandemic wave using the same statistical model as outlined previously except that vaccination, which in Denmark was initiated at the end of December 2020, was not included in analyses of the first two waves. Analyses were restricted to occupations with overall elevated risk grouped into main economic sectors (n=49).

Considering the many comparisons and risk of type II error, we applied a significance level of 0.01 rather than the conventional 0.05. All analyses were carried out in SAS V.9.4 by access to a secured platform at Statistics Denmark.

RESULTS

The study population included 2 451 542 employees who were traced for SARS-CoV-2 test results through 220 633 049 person-weeks of follow-up. The RT-PCR testing frequency and the proportion of employees testing positive at least once varied strongly during the study period (figure 1), as did the average testing frequency across occupational groups (data not shown). The average number of RT-PCR tests per employee was 11.9 (median 8.0, range 0–223). In the entire study population, 10.7% tested positive at least once during the follow-up period (table 1). Among the 261 203 employees with a positive RT-PCR test, only 1917 (0.01%) had a second positive test later than 90 days (to exclude the possibility of ongoing first infection) after the first positive test (71% were tested on average 9.5 months later).

The reference population comprised 461 762 employees working in 77 occupations with a balanced sex distribution (49.4% men). Various types of office clerks and administrative jobs comprised the majority of reference occupations (online supplemental table 1). With few exceptions, the occupation-specific testing frequency was lower in men than in women (the average number of tests per employee across all reference occupations during follow-up was 13.3 in women and 10.5 in men).

While the infection rate was within the same range among men and women, it was strongly related to several covariates in both sexes—lower in the high age range and in employees with chronic disease, higher in the capital region, among foreign-born employees from non-Western countries and among employees with high probability of low body mass index. Moreover, the infection rate increased with the number of household members and with the average number of RT-PCR tests performed in the occupational group of the employee (table 1).

Among the 205 non-reference four-digit DISCO-08 occupational codes with more than 100 male and 100 female employees (n=1 569 737 employees with 141 235 382 weeks of follow-up), the fully adjusted risk was increased in 63 occupations without adjustment for the average occupation-specific RT-PCR test frequency and in 49 with adjustment for test frequency. An overview of the latter is provided in figure 2 with occupations grouped according to descending size within two-digit economic sector codes (DB07). Details with respect to number of male and female employees, occupational test frequency and risk estimates before and after adjustment for covariates and test frequency are listed in online supplemental table 2, which also includes occupations with elevated fully adjusted risk before but not after adjustment for occupational test frequency.

Most employees at risk were working in social activities (eg, early childhood educators equivalent to child pedagogues), residential care (eg, home-based personal care workers), education (eg, primary school teachers), healthcare (eg, nursing professionals) and defence and security (eg, police officers), but several occupations within other sectors were also associated with increased risk of SARS-CoV-2 infection. These included—listed in order of descending adjusted risk estimate—food machine operators, athletes and sports players, bartenders, transport conductors, bus and tram drivers, religious professionals and hairdressers, among several others (figure 1 and online supplemental table 2). The magnitude of adjusted increased IRRs ranged from 1.13 to 2.00. According to these fully adjusted risk estimates, 32.1% of the male workforce and 49.0% of the female workforce were at increased risk of SARS-CoV-2 infection, given the selected reference group and the chosen statistical model.

Some occupations were associated with decreased risk of SARS-CoV-2 infection—38 before adjustment for test frequency, 12 after adjustment. Most of these employees were manual workers within construction (with the DISCO-08 code label civil engineering labourers), electricians and heavy truck and lorry drivers (online supplemental table 2). Most occupations with decreased risk that vanished after adjustment for test frequency were within the construction and manufacturing sectors (online supplemental table 3).

Adjustment of the sex-adjusted and age-adjusted risk estimates by all other covariates resulted in a slight average increase of the IRR by 0.019 but with large variation (SD 0.138). Further adjustment of with the occupational PCR test frequency reduced the risk estimate by an average 0.032 (SD 0.120).

Risk across pandemic waves is displayed in figure 3 (overview) and online supplemental table 4 (details) for occupations with elevated fully adjusted risk grouped by main economic sector. The relative risk in healthcare, residential care and defence/security declined across waves and approached or reached the background level in the latest wave, while the relative risk in education and social work increased during the pandemic.

Table 1 Prevalence of at least one positive SARS-CoV-2 RT-PCR test by characteristics of Danish male and female employees during the COVID-19 pandemic from week 8 of 2020 to week 52 of 2021

	Men		Women	
Characteristic	**Total (N)**	**Ever positive RT-PCR test (%)**	**Total (N)**	**Ever positive RT-PCR test (%)**
Sex, % ever testing RT-PCR positive	1 274 370	10.3	1 178 172	10.9
Age (years)				
20–<30	260 918	13.6	236 569	14.1
30–<40	275 776	11.2	249 010	12.3
40–<50	298 547	10.6	284 747	11.5
50–<60	297 951	8.5	287 463	8.5
60+	141 178	6.5	120 383	6.5
Geographical region				
Capital	410 947	15.2	401 203	15.7
Zealand	176 827	10.2	162 902	11.1
South	238 305	7.1	212 381	7.3
Central	297 423	7.9	267 526	8.1
North	150 868	7.7	133 160	7.9
Duration of education (years)				
≤10	295 236	11.0	394 354	11.2
>10–13	569 720	9.3	444 206	9.7
>13–16	280 763	12.5	277 423	12.5
>16	97 509	9.5	43 613	11.5
Missing	31 142	9.8	17 576	10.9
Country of birth				
Denmark	1 095 062	9.5	1 027 040	10.0
Other Western countries	39 782	9.6	33 592	10.4
Eastern Europe	57 468	13.9	45 736	15.4
Low-income countries	81 899	20.7	70 718	21.6
Missing	159	27.0	86	25.6
Number of hospital admissions, 2010–2020[4]				
0	1 107 771	10.6	950 570	11.1
1	126 235	9.4	188 757	10.5
≥2	30 364	8.6	37 845	9.9
Probability of tobacco smoking (JEM assigned)				
<10%	26 352	10.7	72 229	9.9
10–<20%	475 984	10.1	618 042	10.6
20%+	556 205	10.5	351 505	11.8
Missing	215 929	10.9	135 396	10.9
Body mass index (kg/m^2) (JEM assigned)				
<25	217 499	13.4	531 232	12.0
≥25	840 942	9.4	510 544	9.8
Missing	215 929	10.7	135 396	10.9
Number of household members				
1	244 767	8.7	175 841	9.5
2	409 460	9.2	419 905	9.3
3	233 389	10.7	230 766	11.1
4+	386 754	12.5	351 160	13.4
Average number of RT-PCR tests in the employee's occupation (four-digit DISCO-08 code) during follow-up, quintiles				
0–9	327 945	8.8	55 889	8.2
>9–10	339 452	10.8	265 947	11.0
>10–12	269 442	10.3	191 274	10.1
>12–14	228 990	11.1	287 274	10.6
>14–28	108 541	12.9	376 788	11.9
Second COVID-19 vaccination obtained				
1 January 2021–30 June 2021	373 343	8.2	436 546	8.7
1 July 2021–14 December 2021	752 894	9.9	631 132	10.4
Less than two vaccinations by 14 December 2021	148 133	18.7	109 494	22.8

DISCO, Danish Version of the International Standard Classification of Occupations; JEM, job exposure matrix; RT-PCR, real-time PCR.

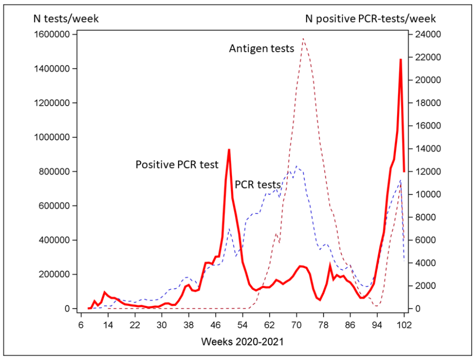

Figure 1 Weekly number of SARS-CoV-2 RT-PCR and antigen tests (left axis, dashed lines) and number of positive RT-PCR tests (right axis, solid line) among employees (n=2 451 542) in Denmark from week 8 of 2020 to week 50 of 2021. RT-PCR, real-time PCR.

DISCUSSION

In this study of the entire Danish work force, the IRR of SARS-CoV-2 infection during 2020–2021 was elevated in 49 occupational groups comprising 40.3% of the workforce. All elevated adjusted IRR estimates were up to but not exceeding doubling of the relative risk. Decreased risk was observed in 12 occupations. Increased risk was mainly apparent in child and social care, health, education and services entailing many and/or close contacts, but occupations with increased risk were encountered in most of the major economic sectors. Findings are not directly comparable to results in other studies that typically use broader grouping of employees—for instance, into essential and all other workers lumped together—but obvious discrepancies are not apparent.

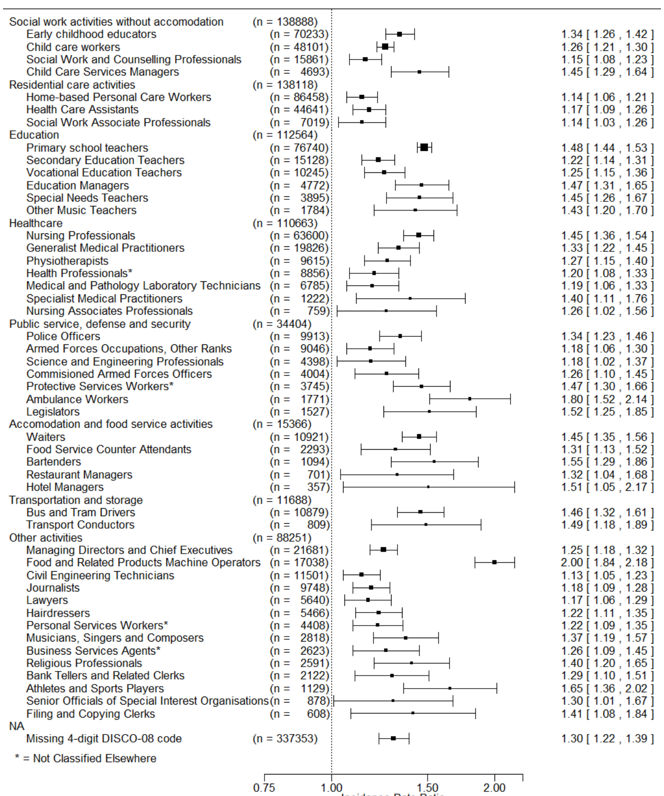

Figure 2 Adjusted* incidence rate ratios above 1.0 and p value of <0.01 for first positive SARS-CoV-2 real-time PCR test during the pandemic in 2020–2021 by four-digit DISCO-08 codes. †Ordered by main economic sector (two-digit DB07) and descending number of employees in occupational groups within economic sectors. *Adjusted for sex, age, education, hospital admissions for chronic disease, country of birth, geographical region, number of household members, tobacco smoking, body mass index, COVID-19 vaccination, pandemic period and occupational test frequency. †The reference is low-level exposed employees according to a COVID-19 job exposure matrix. DISCO, Danish Version of the International Standard Classification of Occupations.

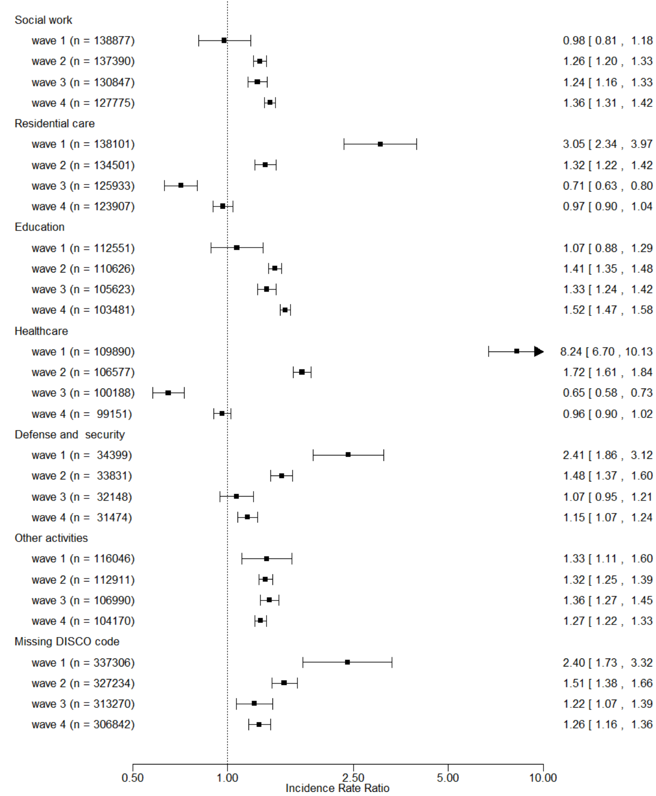

Figure 3 Adjusted incidence rate ratio (with 99% CI) of SARS-CoV-2 infection across pandemic waves for at-risk[1] occupations grouped by economic sector. [1]At-risk occupations include 49 occupations with elevated, fully adjusted risk estimate (including adjustment for occupational PCR test frequency). The reference group is low-level exposed employees according a COVID-19 job exposure matrix. DISCO, Danish Version of the International Standard Classification of Occupations.

Strengths of the study are primarily a large cohort with national coverage through the first almost 2 years of the pandemic and, with few exceptions, complete data from independent data sources. In the following, the focus is on various limitations.

Adjustment for testing frequency across occupations did not take indications for testing into account. Higher testing frequency will identify more employees with infection and should be adjusted for if a high testing frequency is caused by request to be tested in some occupations more than in others. For instance, a negative test may have been requested repeatedly by health authorities or employers at some workplaces more than others. On the contrary, if a high testing frequency is reflecting a high rate of SARS-CoV-2 infection in a particular occupation, adjustment will erroneously attenuate risk estimates. In our study, adjustment for test frequency attenuated otherwise fully adjusted risk estimates to insignificant levels in 14 out of 63 occupations. Some of these, therefore, may be subject to overadjustment and may be truly associated with increased risk of infection. On the other hand, some of the 49 occupations that survived adjustment for occupational test frequency may falsely be associated with increased risk because of residual confounding.

For the same reasons, estimates for some occupational groups may be biased towards decreased risk of infection. While it is conceivable that working may in some instances protect the employee from background infection if work is performed with limited contact to other people as, for instance, in lorry drivers (online supplemental table 2), residual confounding relating to testing behaviour may be part of the explanation. Therefore, the apparently low infection rates in some occupations in construction and manufacturing may be caused by higher testing frequencies in asymptomatic individuals in the reference group. This would fit with the observation that adjustment for testing strongly attenuated risk estimates to non-significant levels for many occupations in the construction sector (online supplemental table 3). It is also possible, however, that the risk is in fact reduced in some of these occupations because construction workers often are working outdoors[28] and may for that reason be less exposed. The JEM-based reference group does not include outdoor workers (online supplemental table 1).

Restricting analyses to persons who ever performed a test during specified periods (labelled test-negative design[29 30]) is not a promising option in this dataset with tremendous variation of test frequencies (figure 1). Conditioning on testing can result in collider bias and will inevitably produce spurious associations,[31] which cannot be resolved unless all employees are tested repeatedly and systematically or tested completely at random.[32]

In spite of unresolved methodological limitations related to analyses of non-random SARS-CoV-2 test results, findings are in fair agreement with risk of COVID-19-related hospital admission estimated from analyses of the same cohort.[8] Among the 16 occupations with more than 2000 employees who were found to be at risk of COVID-19-related hospital admission, 12 were also found to be at risk according to RT-PCR test results or, expressed by number of employees, 95.8% working in occupations at increased risk of hospital admission were also at increased risk of testing positive (384 648/401 651). On the other hand, 37 occupations were at increased risk according to RT-PCR testing but not according to hospital admission. This is most likely explained by the much stronger statistical power of RT-PCR test analyses compared with analysis of the relatively rare hospital admissions. These occupations include several specific jobs within healthcare, prison and security guards, police officers, waiters and bartenders, luggage porters, musicians and many others. It should be acknowledged, however, that some of these associations may be random findings due to multiple testing and uncontrolled bias because of wide differences in reasons for testing and in testing frequency.

At the bottom line, unresolved limitations inherently related to analysis of testing results call for cautious interpretation of risk for specific occupations which must be construed in the light of findings in earlier studies applying other methodological approaches[2 3 10 33–36] and independent assessment of workplace risk factors, for instance, using job exposure matrices.[6 37]

It is well established that men are more likely to develop serious COVID-19 than women,[8 38] but there are no indications that men more easily become infected with SARS-CoV-2. That substantially more women than men seem to be at risk from workplace exposure simply reflects that many at-risk occupations are dominated by women. However, the extent of occupational exposure may differ between men and women within the same occupational group. Even at the four-digit level, the DISCO-08 codes may include several different specific occupations. There are 423 four-digit codes but about 2200 specific occupational titles entailing different work tasks and potentially different risk of exposure. The sex distribution across these occupational titles within DISCO-08 groups may not be balanced.

The relative risk in healthcare workers declined substantially across the pandemic, a development also observed in other studies.[5 37] This may be explained by increased access to and use of adequate personal protection gear and early vaccination. The same applies to residential care activity. That the relative risk in education and social work (including childcare) seemed to increase after the first wave may be related to easing of the initial strict lockdown. It should be kept in mind that the background level of infections in the society is adjusted for by computation of the wave-specific relative risk. Therefore, a lower relative risk at later waves in periods with a higher prevalence of infection in the background population may be associated with a higher absolute risk of infection.

Despite methodological limitations, the study corroborates most findings of occupationally increased risk of COVID-19-related hospital admissions and adds a number of occupational groups to the list of potential at-risk jobs—at least partly due to higher statistical power allowing estimation of risk in more rare occupations and among younger and more healthy employees.

CONCLUSION

The study corroborates some earlier findings on increased occupational risk of COVID-19 and indicates a modestly increased risk of SARS-CoV-2 infection among employees in several occupations that have not been identified in earlier studies using more rare outcomes. Methodological limitations call for cautious interpretation of risk of specific occupations which must be assessed in the light of findings in earlier studies. Nevertheless, the study indicates that risk of SARS-CoV-2 infection is far from limited to healthcare, social care and other essential occupations and that preventive action is warranted for a sizeable proportion of in particular the female workforce during possible forthcoming pandemics.

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Data availability statement Data may be obtained from a third party and are not publicly available. The pseudonymised database used for the presented analyses is hosted by Statistics Denmark and is not publicly available. Permission to access the database can be granted by researchers at a research institution authorised by Statistics Denmark. On request, the corresponding author can assist interested researchers to gain access.

Author note Permissions to retrieve and analyse pseudonymised data through Statistics Denmark were obtained from the Knowledge Centre on Data Protection Compliance under the records of processing regarding health science research projects within the Capitol Region of Denmark (P-2020-897), Statistics Denmark (P-708121) and the National Board of Health Data (FSEID-00005368).

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ONLINE SUPPLEMENTAL MATERIAL

Occupational risk of SARS-CoV-2 infection: a nationwide register-based study of the Danish workforce during the Covid-19 pandemic 2020-21

Running head: Occupational risk of SARS-CoV-2 infection

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Abstract

Objectives Most earlier studies on occupational risk of Covid-19 covering the entire workforce are based on relatively rare outcomes such as hospital admission and mortality. This study examines the incidence of SARS-CoV-2 infection by occupational group based upon real-time polymerase chain reaction tests (RT-PCR).

Methods The cohort includes 2.4 million Danish employees, 20-69 years of age. All data were retrieved from public registries. The incidence rate ratios (IRR) of first-occurring positive RT-PCR test from week 8 of 2020 through week 50 of 2021 were computed by Poisson regression for each 4-digit DISCO-08 job code with more than 100 male and 100 female employees (n=205). Occupational groups with low risk of workplace infection according to a job exposure matrix constituted the reference group. Risk estimates were adjusted by demographic, social and health characteristics including household size, completed Covid-19 vaccination, pandemic wave and occupation-specific frequency of testing.

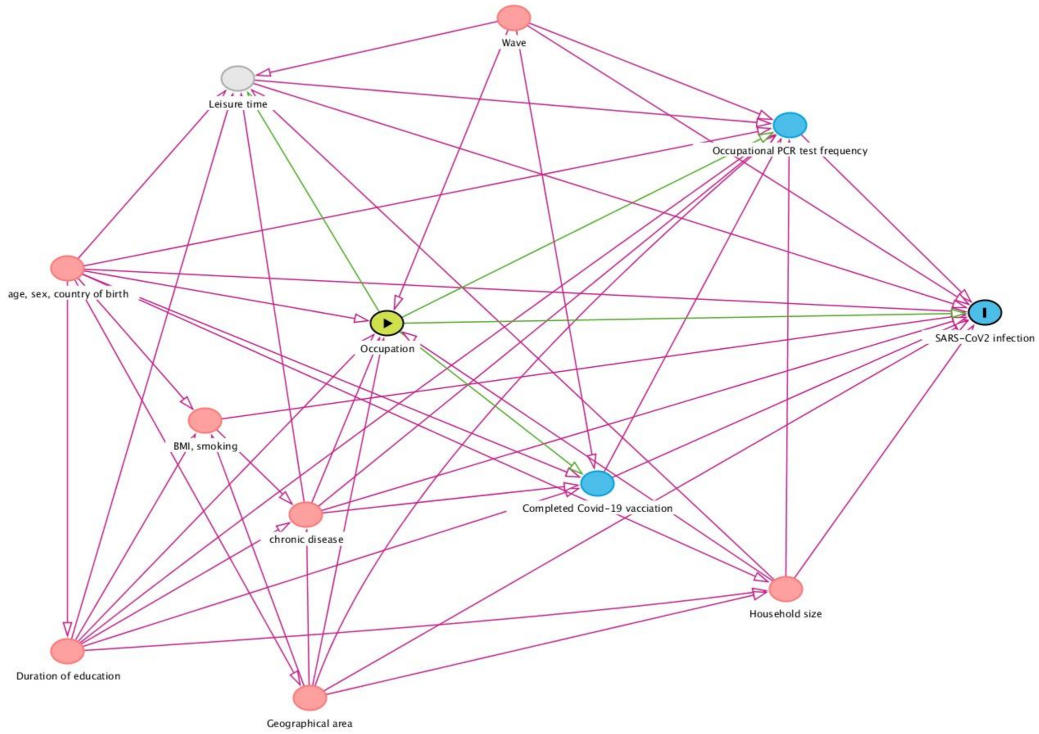
Results IRRs of SARS-CoV-2 infection were elevated in seven healthcare occupations and 42 occupations in other sectors, mainly social work activities, residential care, education, defense and security, accommodation and transportation. No IRRs were exceeding 2.0. The relative risk in healthcare, residential care and defense/security declined across pandemic waves. Decreased IRRs were observed in 12 occupations.

Discussion We observed a modestly increased risk of SARS-CoV-2 infection among employees in numerous occupations indicating a large potential for preventive actions Cautious interpretation of observed risk in specific occupations is needed because of methodological issues inherent in analyses of RT-PCR test results and because of multiple statistical tests.

Journal reference main text

Bonde JPE, *et al. Occup Environ Med* 2023;0:1–7. doi: 10.1136/oemed-2022-108713

Supplemental Figure S1. Directed acyclic graph (DAG). A national follow-up study of occupational risk of SARS-CoV2 infection 2020-2021.



Red circles symbolize potential confounders (ancestor of both exposure *and* outcomes). Grey circle named “leisure time” symbolizes an unobserved mediating factor (on the causal path from exposure (occupation) to outcome (infection). Blue circles “occupational PCR test Frequency” and “Completed Covid-19 vaccination” symbolize observed potential mediating factors. In order to estimate the direct effect of occupation on SARS-CoV2 infection not mediated by occupational PCR test frequency and Covid-19 vaccination, we adjust for all potential confounders and mediators except for the unobserved variable “leisure time”.

Supplemental table S1. Characteristics of the reference population[1] in a Danish follow-up study of occupational risk of SARS-CoV-2 infection.

Occupation	DISCO-08 code	N employees	% Women	Mean PCR-tests[2]
General Office Clerks	4110	96 640	74.8	12.4
Commercial Sales Representatives	3322	33 549	35.5	12.7
Software Developers	2512	25 789	23.3	10.3
Accounting Associate Professionals	3313	20 991	69.7	13.0
Stock Clerks	4321	14 390	22.8	9.9
Systems Analysts	2511	13 923	21.7	9.6
Accountants	2411	13 234	44.5	12.7
Clerical Support Workers Not Elsewhere Classified	4419	12 768	65.1	12.0
Sales and Marketing Managers	1221	11 240	23.8	12.8
Accounting and Bookkeeping Clerks	4311	11 158	78.7	13.5
Advertising and Marketing Professionals	2431	10 733	57.7	11.8
Buyers	3323	10 393	50.3	13.7
Payroll Clerks	4322	8677	31.9	9.5
Statistical, Finance and Insurance Clerks	4312	8660	67.4	11.8
Management and Organization Analysts	2421	8561	45.5	11.6
Information and Communications Technology User Support	3512	8048	22.8	10.7
Credit and Loans Officers	3312	7564	55.9	12.4
Financial Analysts	2413	7196	38.7	10.8
Contact Centre Salespersons	5244	6297	49.3	11.6
Draughtspersons	3118	6231	50.8	11.8
Finance Managers	1211	5940	35.8	13.3
Policy and Planning Managers	1213	5482	46.4	11.5
Personnel and Careers Professionals	2423	5448	64.3	12.2
Contact Centre Information Clerks	4222	5045	50.5	9.8
Building Architects	2161	4992	44.6	10.8
Technical and Medical Sales Professionals (excluding ICT)	2433	4932	33.2	12.1
Economists	2631	4855	48.9	11.6
Policy Administration Professionals	2422	4574	48.1	11.2
Software and Applications Developers and Analysts Not Elsewhere	2519	4398	27.9	10.6
Education Methods specialists	2351	4243	70.8	13.4
Employment Agents and Contractors	3333	4193	66.7	10.7
Systems Administrators	2522	4084	17.2	10.9
Transport Clerks	4323	3796	34.3	12.8
Government Tax and Excise Officials	3352	3602	66.8	8.3
Information and Communications Technology Sales Professionals	2434	3460	30.3	10.8
Web and Multimedia Developers	2513	3270	30.6	10.0
Information Technology Services Managers	1330	3094	15.4	12.1
Public Relations Professionals	2432	3040	60.3	11.7
Insurance Representatives	3321	3031	33.8	11.5
Database and Network Professionals Not Elsewhere Classified	2529	2870	21.6	10.6
Personnel Clerks	4416	2696	79.9	13.0
Applications Programmers	2514	2452	20.4	9.5
Research and Development Managers	1223	2291	24.9	12.2
Securities and Finance Dealers and Brokers	3311	2238	36.7	11.1
Product and Garment Designers	2163	2215	73.5	13.1
Computer Network and Systems Technicians	3513	2044	11.0	11.2
Graphic and Multimedia Designers	2166	2039	52.0	11.1
Data Entry Clerks	4132	1930	56.5	12.1
Training and Staff Development Professionals	2424	1862	70.8	12.6
Payroll Clerks	4313	1688	87.8	13.8

Legal and Related Associate Professionals	3411	1605	78.2	12.8
Information and Communications Technology Operations	3511	1511	15.0	11.0
Client Information Workers Not Elsewhere Classified	4229	1424	59.8	12.5
Telephone Switchboard Operators	4223	1349	83.7	13.7
Valuers and Loss Assessors	3315	1188	17.3	11.4
Translators, Interpreters and Other Linguists	2643	1184	69.5	11.8
Database Designers and Administrators	2521	994	23.0	9.6
Landscape Architects	2162	972	58.3	10.5
Government Social Benefits Officials	3353	968	88.0	11.8
Cartographers and Surveyors	2165	962	25.7	13.3
Computer Network Professionals	2523	958	14.4	11.9
Advertising and Public Relations Managers	1222	818	45.4	11.0
Conference and Event Planners	3332	764	71.6	12.8
Survey and Market Research Interviewers	4227	740	51.8	10.0
Statistical, Mathematical and Related Associate Professionals	3314	668	39.1	10.7
Debt Collectors and Related Workers	4214	663	68.9	13.0
Trade Brokers	3324	536	37.9	11.9
Inquiry Clerks	4225	465	57.0	11.6
Town and Traffic Planners	2164	369	38.5	11.8
Authors and Related Writers	2641	312	55.4	10.2
Web Technicians	3514	295	35.9	11.0
Typists and Word Processing Operators	4131	257	48.6	12.6
Library Clerks	4411	241	62.2	11.9
Coding, Proofreading and Related Clerks	4413	202	75.7	9.5
Medical Records and Health Information Technicians	3252	166	65.1	14.2
Meteorologists	2112	153	32.7	11.9
Visual Artists	2651	152	48.7	8.8

[1] The reference group comprised occupations defined at the 4-digit DISCO-08 level that according to the job exposure matrix[1] are not expected to be associated with exposure to SARS-CoV-2 (sumscore of 4 dimensions on virus transmission = 0).

[2] The average number of PCR tests per employee and occupation during the follow-up period.

Bonde JPE, *et al. Occup Environ Med* 2023;0:1–7. doi: 10.1136/oemed-2022-108713

Supplemental table S2. Occupations with increased risk of SARS-CoV2 infection (incidence rate ratio IRR with 99% CI) relative to occupations with low likelihood of exposure according to a Covid-19 job exposure matrix. Upper panel: 49 occupations with fully adjusted elevated IRR ; lower panel: 15 occupations where adjustment for occupational test frequency attenuated risk to a non-significant level.

MAIN ECONOMIC SECTOR (DB07 2- digit codes)											
Occupation. 4-digit DISCO-08 codes (descending number employees)	Code	N	% women	Tests[0]	IRR[1]	IRR[2]	99% CI		IRR[3]	99% CI	
SOCIAL WORK ACTIVITIES, n = 138 888											
Early childhood educators	2343	70 233	80.1	14.4	1.41	1.46	1.4	1.5	1.34	1.3	1.4
Childcare workers	5311	48 101	80.7	12.6	1.43	1.34	1.3	1.4	1.26	1.2	1.3
Social Work and Counselling Professionals	2635	15 861	88.2	12.1	1.03	1.12	1.0	1.2	1.15	1.1	1.2
Child Care Services Managers	1341	4693	76.5	14.4	1.50	1.59	1.4	1.8	1.45	1.3	1.6
RESIDENTIAL CARE ACTIVITIES, n =138 118											
Home-based Personal Care Workers	5322	86 458	90.4	21.5	1.46	1.30	1.3	1.3	1.14	1.1	1.2
Health Care Assistants	5321	44 641	78.9	18.1	1.37	1.34	1.3	1.4	1.17	1.1	1.3
Social Work Associate Professionals	3412	7019	73.4	10.7	1.22	1.15	1.0	1.3	1.14	1.0	1.3
EDUCATION, n = 112 564											
Primary school teachers	2341	76 740	66.8	13.0	1.42	1.56	1.5	1.6	1.48	1.4	1.5
Secondary Education Teachers	2330	15 128	55.3	10.9	1.05	1.18	1.1	1.3	1.22	1.1	1.3
Vocational Education Teachers	2320	10 245	44.4	11.4	1.06	1.21	1.1	1.3	1.25	1.1	1.4
Education Managers	1345	4772	45.2	11.9	1.28	1.43	1.3	1.6	1.47	1.3	1.6
Special Needs Teachers	2352	3895	63.3	14.5	1.34	1.61	1.4	1.8	1.45	1.3	1.7
Other Music Teachers	2354	1784	46.7	11.2	1.32	1.39	1.2	1.7	1.43	1.2	1.7
HEALTH CARE, n = 110 663											
Nursing Professionals	2221	63 600	96.0	21.3	1.39	1.58	1.5	1.6	1.45	1.4	1.5
Generalist Medical Practitioners	2211	19 826	57.5	15.9	1.28	1.47	1.4	1.6	1.33	1.2	1.5
Physiotherapists	2264	9615	77.2	25.5	1.18	1.39	1.3	1.5	1.27	1.1	1.4
Health Professionals Not Elsewhere Classified	2269	8856	89.8	22.8	1.09	1.31	1.2	1.4	1.20	1.1	1.3
Medical and Pathology Laboratory Technicians	3212	6785	89.3	19.5	1.28	1.30	1.2	1.4	1.19	1.1	1.3
Specialist Medical Practitioners	2212	1222	39.9	12.3	1.41	1.37	1.1	1.7	1.40	1.1	1.8
Nursing Associates Professionals	3221	759	62.1	17.2	1.80	1.40	1.1	1.7	1.26	1.0	1.6
DEFENSE AND SECURITY, n =34 404											
Police Officers	5412	9913	17.8	14.5	1.43	1.47	1.4	1.6	1.34	1.2	1.5
Armed Forces Occupations. Other Ranks	0310	9046	12.3	13.2	0.90	1.24	1.1	1.4	1.18	1.1	1.3
Science and Engineering Professionals	0210	4398	6.8	14.2	0.93	1.31	1.1	1.5	1.18	1.0	1.4
Commissioned Armed Forces Officers	0110	4004	8.6	13.4	1.05	1.34	1.2	1.5	1.26	1.1	1.4
Protective Services Workers Not Elsewhere Classified	5419	3745	22.1	9.5	1.38	1.30	1.2	1.5	1.47	1.3	1.7
Ambulance Workers	3258	1771	10.6	10.2	1.31	1.75	1.5	2.1	1.80	1.5	2.1
Legislators	1111	1527	38.2	11.1	1.41	1.47	1.2	1.8	1.52	1.2	1.8
ACCOMODATION AND FOOD, n = 15 366											
Waiters	5131	10 921	59.0	9.9	1.43	1.29	1.2	1.4	1.45	1.3	1.6
Food Service Counter Attendants	5246	2293	58.5	9.5	1.21	1.17	1.0	1.3	1.31	1.1	1.5
Bartenders	5132	1094	44.3	9.3	1.60	1.38	1.1	1.7	1.55	1.3	1.9
Restaurant Managers	1412	701	37.2	10.2	1.56	1.34	1.1	1.7	1.32	1.0	1.7
Hotel Managers	1411	357	51.5	11.9	1.50	1.46	1.0	2.1	1.51	1.0	2.2
TRANSPORTATION, n = 11 688											
Bus and Tram Drivers	8331	10 879	15.3	7.9	1.47	1.16	1.1	1.3	1.46	1.3	1.6
Transport Conductors	5112	809	37.9	12.3	1.82	1.52	1.2	1.9	1.49	1.2	1.9
OTHER ACTIVITIES, n = 88 251											
Managing Directors and Chief Executives	1120	21 681	14.9	11.5	1.21	1.21	1.1	1.3	1.25	1.2	1.3
Food and Related Products Machine Operators	8160	17 038	28.5	7.9	1.52	1.59	1.5	1.7	2.00	1.8	2.2
Civil Engineering Technicians	3112	11 501	15.0	12.1	1.01	1.11	1.0	1.2	1.13	1.0	1.2
Journalists	2642	9748	49.5	11.4	1.19	1.15	1.1	1.2	1.18	1.1	1.3
Lawyers	2611	5640	48.7	11.0	1.15	1.14	1.0	1.3	1.17	1.1	1.3
Hairdressers	5141	5466	88.9	10.3	1.24	1.20	1.1	1.3	1.22	1.1	1.3
Personal Services Workers Not Elsewhere Classified	5169	4408	39.7	10.1	1.43	1.23	1.1	1.4	1.22	1.1	1.4
Musicians. Singers and Composers	2652	2818	57.7	12.9	1.43	1.47	1.3	1.7	1.37	1.2	1.6
Business Services Agents	3339	2623	55.6	12.1	1.27	1.22	1.1	1.4	1.26	1.1	1.5

	Religious Professionals	2636	2591	55.3	11.7	1.19	1.36	1.2	1.6	1.40	1.2	1.6
	Bank Tellers and Related Clerks	4211	2122	68.0	12.2	1.30	1.26	1.1	1.5	1.29	1.1	1.5
	Athletes and Sports Players	3421	1129	15.5	19.8	1.52	1.81	1.5	2.2	1.65	1.4	2.0
	Senior Officials of Special Interest Organisations	1114	878	40.9	13.0	1.48	1.40	1.1	1.8	1.30	1.0	1.7
	Filing and Copying Clerks	4415	608	62.0	12.0	1.36	1.36	1.0	1.8	1.41	1.1	1.8
	MISSING 4-DIGIT DISCO-08 CODE	-	337 353	40.0	9.2	1.07	1.12	1.1	1.2	1.30	1.2	1.4
Table S2 continued												
ADJUSTMENT BY OCCUPATIONAL PCR TEST FREQUENCY ATTENUATES IRR TO NON-SIGNIFICANT LEVELS, n = 97 700												
	Special Teaching Professionals	2357	33 881	72.4	14.5	1.10	1.19	1.1	1.3	1.04	1.0	1.1
	Financial and Investment Advisers	2412	18 636	47.7	12.7	1.07	1.11	1.0	1.2	1.06	1.0	1.1
	Dental assistants and therapists	3251	8253	98.7	14.3	1.26	1.14	1.0	1.2	1.03	0.9	1.1
	Psychological Therapists	2634	8072	78.1	15.1	0.97	1.13	1.0	1.2	1.03	0.9	1.1
	Clearing and Forwarding Agents	3331	7257	37.7	14.3	1.07	1.20	1.1	1.3	1.06	1.0	1.2
	Travel Attendants and Travel Stuarts	5111	3811	62.5	13.1	1.50	1.19	1.1	1.3	1.09	1.0	1.2
	Receptionists (general)	4226	3620	87.5	13.1	1.31	1.20	1.1	1.4	1.11	1.0	1.3
	Real Estate Agents and Property Managers	3334	3134	52.4	13.8	1.20	1.19	1.0	1.4	1.09	0.9	1.3
	Prison Guards	5413	2742	35.2	13.6	1.27	1.32	1.1	1.5	1.16	1.0	1.3
	Personal Care Workers in Health Services	5329	2654	77.9	15.8	1.34	1.19	1.0	1.4	1.04	0.9	1.2
	Medical Imaging and Equipment Operators	3211	2646	71.1	20.0	1.14	1.23	1.1	1.4	1.12	1.0	1.3
	Financial and Insurance Services Branch Managers	1346	1332	25.6	14.0	1.21	1.33	1.1	1.7	1.20	1.0	1.5
	Film. Stage and Related Directors and Producers	2654	1315	48.6	13.9	1.43	1.30	1.1	1.6	1.14	0.9	1.4
	Actors	2655	347	49.0	17.7	1.81	1.55	1.1	2.1	1.36	1.0	1.9

[0] Average number of PCR tests per employees and occupation from start of follow-up.

[1] Adjusted for sex and age (10 year groups).

[2] In addition to sex and age, adjusted for duration of education at baseline (5 groups), number of hospital admissions for one or more of 11 chronic diseases in the 10 years preceding start of the pandemic (3 groups), country of birth (4 groups), geographical region (5 groups), number of household members (4 groups), probability of tobacco smoking (3 groups), bodymass index (2 groups), completed Covid-19 vaccination (time varying variable, yes/no) and pandemic wave (4 groups).

[3] In addition to the above fully adjusted risk estimates, adjusted for the occupation-specific average number of PCR-tests during follow-up (up to and including last week before censuring) per employee (quintiles).

Supplemental table S3. Occupations with reduced risk of SARS-CoV2 infection ordered by descending size.

	Occupation. 4-digit DISCO-08 codes (descending number employees)	Code	N	% Women	Tests[0]	IRR[1]	IRR[2]	99% CI		IRR[3]	99% CI	
FULLY ADJUSTED IRR WITH p-value < 0.01, N = 121 785												
	Civil Engineering Labourers	9312	24 198	11.2	7.5	0.65	0.69	0.6	0.7	0.87	0.8	1.0
	Building and Related Electricians	7411	23 498	1.5	10.4	0.87	0.91	0.9	1.0	0.90	0.8	1.0
	Heavy Truck and Lorry Drivers	8332	23 114	1.6	6.0	0.59	0.66	0.6	0.7	0.83	0.8	0.9
	Engineering Professionals Not Elsewhere Classified	2149	10 145	27.4	12.2	0.80	0.88	0.8	1.0	0.91	0.8	1.0
	Chemical and Physical Science Technicians	3111	9663	73.9	14.3	0.93	0.85	0.8	0.9	0.78	0.7	0.9
	Industrial and Production Engineers	2141	8130	16.9	12.4	0.72	0.82	0.7	0.9	0.85	0.8	0.9
	Mechanical Engineers	2144	5817	9.5	12.4	0.79	0.85	0.8	1.0	0.81	0.7	0.9
	Gardeners Horticultural and Nursery Growers	6113	5180	28.4	8.0	0.64	0.66	0.6	0.8	0.84	0.7	1.0
	Electronics Engineering Technicians	3114	4745	8.8	12.0	0.80	0.83	0.7	1.0	0.86	0.7	1.0
	Electrical and Electronic Equipment Assemblers	8212	4086	52.3	11.5	0.86	0.86	0.7	1.0	0.85	0.7	1.0
	Mathematicians, Actuaries, and Statisticians	2120	2028	37.1	10.5	0.90	0.78	0.6	0.9	0.80	0.7	1.0
	Sociologists, Anthropologists and Related Professionals	2632	1181	63.8	11.1	0.72	0.73	0.6	1.0	0.75	0.6	1.0
ADJUSTMENT WITH OCCUPATIONAL TEST FREQENCY ATTENUATES IRR TO NON-SIGNIFICANT LEVELS, N = 213 846												
	Carpenters and Joiners	7115	29 978	1.2	7.4	0.80	0.87	0.8	0.9	1.13	1.0	1.2
	University and Higher Education Teachers	2310	29 501	47.8	9.8	0.81	0.82	0.8	0.9	0.96	0.9	1.0
	Motor Vehicle Mechanics and Repairers	7231	18 033	1.6	8.9	0.76	0.80	0.7	0.9	1.01	0.9	1.1
	Cooks	5120	13 072	36.6	8.5	1.00	0.88	0.8	0.9	1.11	1.0	1.2
	Plumbers and Pipe Fitters	7126	12 712	1.0	8.2	0.92	0.90	0.8	1.0	1.13	1.0	1.2
	Metal Working Machine Tool Setters and Operators	7223	12 200	7.6	9.1	0.72	0.83	0.8	0.9	1.04	0.9	1.2
	Blacksmiths, Hammersmiths and Forging Press Workers	7221	11 270	2.5	8.9	0.71	0.85	0.8	0.9	1.07	1.0	1.2
	Building Construction Labourers	9313	11 123	2.2	6.7	0.80	0.77	0.7	0.8	0.97	0.9	1.1
	Manufacturing Labourers Not Elsewhere Classified	9329	10 663	25.6	8.0	0.79	0.83	0.8	0.9	1.04	0.9	1.2
	Painters and Related Workers	7131	9332	31.9	7.3	0.82	0.78	0.7	0.9	0.99	0.9	1.1
	Assemblers Not Elsewhere Classified	8219	7062	26.4	9.5	0.74	0.87	0.8	1.0	0.98	0.9	1.1
	Stationary Plant and Machine Operators Not Elsewhere Classified	8189	6962	15.9	8.9	0.82	0.87	0.8	1.0	1.10	1.0	1.3
	Metal Processing Plant Operators	8121	5859	19.0	7.2	0.64	0.74	0.6	0.9	0.93	0.8	1.1
	Toolmakers and Related Workers	7222	4465	2.8	9.1	0.64	0.76	0.7	0.9	0.96	0.8	1.1
	Chemical Products Plant and Machine Operators	8131	4368	26.2	9.4	1.01	0.85	0.7	1.0	0.96	0.8	1.1
	Occupations with <100 male and <100 female employees	9998	4140	37.9	10.4	0.85	0.90	0.9	0.9	1.00	1.0	1.1
	Wood Processing Plant Operators	8172	3853	18.3	7.0	0.61	0.76	0.6	0.9	0.96	0.8	1.2
	Service Station Attendants	5245	3798	54.6	9.2	0.92	0.83	0.7	0.9	0.94	0.8	1.1
	Butchers, Fishmongers and Related Food Preparers	7511	3688	35.5	7.9	0.77	0.82	0.7	1.0	1.03	0.9	1.2
	Bakers, Pastry-cooks and Confectionery Makers	7512	3403	35.0	8.1	0.72	0.74	0.6	0.9	0.93	0.8	1.1
	Packing, Bottling and Labelling Machine Operators	8183	2166	47.8	8.8	0.84	0.81	0.7	1.0	1.04	0.8	1.3
	Livestock and Dairy Producers	6121	1662	22.7	4.7	0.48	0.66	0.5	0.9	0.87	0.7	1.1
	Woodworking Machine Tool Setters and Operators	7523	1588	12.3	6.8	0.45	0.60	0.4	0.8	0.76	0.6	1.0
	Mixed Crop and Animal Producers	6130	1078	27.9	5.7	0.61	0.73	0.5	1.0	0.94	0.7	1.3
	Printers	7322	936	16.2	8.4	0.55	0.63	0.4	0.9	0.80	0.6	1.2
	Garden and Horticultural Labourers	9214	934	32.1	8.1	0.61	0.66	0.5	0.9	0.86	0.6	1.2

[0] Average number of PCR tests per employees and occupation from start of follow-up.

[1] Adjusted for sex and age (10 year groups).

[2] In addition to sex and age, adjusted for duration of education at baseline (5 groups), number of hospital admissions for one or more of 11 chronic diseases in the 10 years preceding start of the pandemic (3 groups), country of birth (4 groups), geographical region (5 groups), number of household members (4 groups), probability of tobacco smoking (3 groups), bodymass index (2 groups), completed Covid-19 vaccination (time varying variable, yes/no) and pandemic wave (4 groups).

[3] In addition to above fully adjusted risk estimates adjusted for the occupation-specific average number of PCR-tests during follow-up (up to and including last week before censuring) per employee (quintiles).

Bonde JPE, *et al. Occup Environ Med* 2023;0:1–7. doi: 10.1136/oemed-2022-108713

Supplemental table S4. Adjusted incidence rate ratio (IRR with 99% CI) of SARS-CoV-2 infection across pandemic waves for at-risk occupations grouped by economic sector compared with a job-exposure matrix derived reference group[1].

Economic sector (2-digit DB07 codes)	Pandemic wave	N	Tests[0]	IRR[1]	IRR[2]	99% CI		IRR[3]	99% CI	
SOCIAL WORK										
	1	138 877	0.42	1.09	1.12	0.9	1.3	0.98	0.8	1.2
	2	137 390	2.87	1.41	1.45	1.4	1.5	1.26	1.2	1.3
	3	130 847	5.74	1.34	1.37	1.3	1.5	1.24	1.2	1.3
	4	127 775	4.37	1.39	1.45	1.4	1.5	1.36	1.3	1.4
RESIDENTIAL CARE										
	1	138 101	0.62	4.82	3.37	2.9	4.0	3.05	2.3	4.0
	2	134 501	4.52	1.92	1.67	1.6	1.8	1.32	1.2	1.4
	3	125 933	6.84	0.97	0.83	0.8	0.9	0.71	0.6	0.8
	4	123 907	4.79	1.07	1.08	1.0	1.1	0.97	0.9	1.0
EDUCATION										
	1	112 551	0.36	0.98	1.13	0.9	1.4	1.07	0.9	1.3
	2	110 626	2.77	1.30	1.46	1.4	1.5	1.41	1.3	1.5
	3	105 623	4.98	1.20	1.39	1.3	1.5	1.33	1.2	1.4
	4	103 481	4.02	1.42	1.57	1.5	1.6	1.52	1.5	1.6
HEALTHCARE										
	1	109 890	0.68	7.67	10.78	9.5	12.3	8.24	6.7	10.1
	2	106 577	4.92	1.82	2.16	2.1	2.3	1.72	1.6	1.8
	3	100 188	8.16	0.62	0.76	0.7	0.8	0.65	0.6	0.7
	4	99 151	5.79	0.93	1.04	1.0	1.1	0.96	0.9	1.0
DEFENSE AND SECURITY										
	1	34 399	0.44	1.74	2.59	2.0	3.3	2.41	1.9	3.1
	2	33 831	2.86	1.32	1.62	1.5	1.8	1.48	1.4	1.6
	3	32 148	5.10	1.03	1.13	1.0	1.3	1.07	0.9	1.2
	4	31 474	3.88	1.05	1.20	1.1	1.3	1.15	1.1	1.2
OTHER ACTIVITIES										
	1	116 046	0.35	1.84	1.64	1.4	1.9	1.33	1.1	1.6
	2	112 911	2.52	1.41	1.34	1.3	1.4	1.32	1.3	1.4
	3	106 990	4.91	1.44	1.35	1.3	1.4	1.36	1.3	1.5
	4	104 170	3.86	1.19	1.18	1.1	1.2	1.27	1.2	1.3
MISSING DISCO-08 CODE										
	1	337 306	0.30	1.11	1.91	1.5	2.5	2.40	1.7	3.3
	2	327 234	2.03	1.06	1.26	1.2	1.4	1.51	1.4	1.7
	3	313 270	3.72	1.08	1.04	0.9	1.2	1.22	1.1	1.4
	4	306 842	3.12	1.07	1.15	1.1	1.2	1.26	1.2	1.4

[0] Average number of PCR tests per employees and occupation from start of follow-up.

[1] Adjusted for sex and age (10 year groups)

[2] In addition to sex and age, adjusted for duration of education at baseline (5 groups), number of hospital admissions for one or more of 11 chronic diseases in the 10 years preceding start of the pandemic (3 groups), country of birth (4 groups), geographical region (5 groups), number of household members (4 groups), probability of tobacco smoking (3 groups), bodymass index (2 groups), completed Covid-19 vaccination (time varying variable, yes/no) and pandemic wave (4 groups).

[3] In addition to above fully adjusted risk estimates adjusted for the occupation-specific average number of PCR-tests during follow-up (up to and including last week before censuring) per employee (quintiles).

Reference

1. Oude Hengel KM, Burdorf A, Pronk A, et al. Exposure to a SARS-CoV-2 infection at work: development of an international job exposure matrix (COVID-19-JEM). *Scand J Work Environ Health* 2022;48(1):61-70. doi: 10.5271/sjweh.3998 [published Online First: 2021/11/18]