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Risk of COVID-19 in different groups of healthcare professionals between February 2020 and June 2021 in Finland: a register-based cohort study

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SUMMARY

Background: During the Coronavirus Disease 2019 (COVID-19) pandemic, healthcare workers (HCWs) have been a risk group for COVID-19.
Aim: To assess the cumulative incidence in different groups of HCWs and the risk factors and outcomes of COVID-19 in HCWs between February 2020 and June 2021 in Finland.
Methods: We linked two national registers, National Infectious Diseases Register (NIDR) and Register of Social Welfare and Healthcare Professionals (Terhikki), using national identity codes. COVID-19 cases were identified from NIDR notifications made by laboratories and physicians, and their healthcare professions from Terhikki. We categorized healthcare professions into seven groups and calculated cumulative incidences using Kaplan-Meier estimate during three periods (1/2/2020−30/6/2020, 1/7/2020−31/12/2020, 1/1/2021−30/6/2021). We identified risk factors in a multivariable model using Cox's regression.
Findings: We identified 8,009 COVID-19-cases among HCWs, with cumulative incidence of 1.79%; 83% were female, median age was 40.9 years (interquartile range, 31.2−51.6). Most COVID-19-cases occurred in nursing assistants (53%) and nurses (17%), with the highest cumulative incidences 2.07% (95%CI, 2.01−2.13%) and 1.82% (95%CI, 1.73−1.91%), respectively. Risk factors were male sex (hazard ratio (HR) 1.2; 95%CI, 1.1−1.3), foreign native language (HR 2.5; 95%CI, 2.2−2.9) and foreign country of birth (HR 1.2; 95%CI, 1.1−1.4). Physician notification data was available for 6,113/8,009 cases (76.3%); 244/6,113 (4.0%) were hospitalized and 37/6,113 (0.6%) in intensive care.
Conclusion: Nurses and nursing assistant, especially men and professionals with foreign background, were at higher risk of COVID-19. This should be specifically addressed during training and implementing infection control measures to protect themselves and patients.

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Introduction

Since the start of the Coronavirus Disease 2019 (COVID-19) pandemic, healthcare workers (HCWs) have been at an increased risk of COVID-19 as they continued working on the frontline throughout the pandemic [1–5]. There are two nationwide studies estimating the occupational risk of COVID-19 in HCWs. In a register-based study in Norway two outcomes, COVID-19 infection and COVID-19 hospitalization were studied during the first two COVID-19 waves in 2020 [6]. It was shown that among the occupations which involved contact with other people, nurses, physicians, and dentists had the highest odds of COVID-19 during the first wave in 2020, whereas during the second wave, bartenders, transport conductors and waiters had the highest odds of COVID-19. A Danish register-based study, in which the outcome was COVID-19 related hospitalization, covered years 2020–2021 [7]. The risk of COVID-19 hospitalization was increased in the majority of healthcare professions, including healthcare assistants, nurses, physicians and medical laboratory technicians, but not in dentists, dental assistants and dental therapists.

We conducted this register-based study aiming to assess the cumulative incidence of SARS-CoV-2 infections in a nation-wide cohort of HCWs according to the professional group from February 1, 2020 to June 30, 2021, in Finland. We wanted to explore the possible differences in the COVID-19 risk in different HCW professions and describe the severity and outcome of COVID-19 in HCWs. Furthermore, we compared the risk of COVID-19 in HCWs with the risk in general population and aimed to identify risk factors for COVID-19 among HCWs to prevent these infections by training and implementing control measures.

Methods

This retrospective register-based cohort study was conducted by combining two national registers, the Registers of Social Welfare and Healthcare Professionals (Terhikki) and the National Infectious Diseases Register (NIDR). Terhikki is a register where all HCWs are registered according to their profession after the authorisation to pursue the profession. NIDR is a register used for surveillance of infectious diseases. All registered HCWs were followed up with a linkage to NIDR from February 1, 2020 to June 30, 2021. HCWs who got their authorisation during the follow-up period were added to the cohort. The linkage was done by using national identity codes.

For each HCW we got the professional title, date of registration of profession and date of expiration from Terhikki. For the HCWs who had multiple professions registered, we had the data for each profession. COVID-19 cases were classified into professional groups based on the latest registration before the specimen positive for SARS-CoV-2. One person was counted for the denominator only once (person-year) even if they had more than one profession registered. The follow-up with the first profession ended when the second profession became valid.

The national surveillance data for COVID-19 was collected to NIDR by two notifications, a laboratory and a physician notification. Laboratory notification included the date for SARS-CoV-2 specimen, residence and national identity code, including age and sex. The physician notification included data on indication for SARS-CoV-2 test, possible COVID-19 exposure, HCW status, hospitalization, intensive care and outcome (recovered/still under care/death). COVID-19 surveillance data was routinely combined to the National Population Registry to get the data on native language, possible foreign country of birth and date of death. As Finland has three official languages (Finnish, Sami and Swedish), native language was categorized in two categories, official languages of Finland and foreign languages.

COVID-19-case was defined as a HCW with a positive SARS-CoV-2 test (PCR or antigen test) between February 1, 2020, and June 30, 2021, and who had a valid registration as HCW in Terhikki before the SARS-CoV-2 infection (date of specimen) in Finland. We excluded from the analysis HCWs who were younger than 17 years or older than 68 years. The cases who received their HCW registration after the specimen positive for SARS-CoV-2 were not counted as COVID-19-cases and they didn't contribute to the follow-up period. The HCWs who were removed from Terhikki during the follow-up period were excluded from the cohort at the day when the registration ended. Follow-up time also ended when cases got a specimen positive for SARS-CoV-2, reached the age of 68 years, or died.

We categorized professions into seven categories: dentists, dental hygienists, dental nurses, medical doctors, nurses, nursing assistants and other HCWs. Age, sex, native language, country of birth (Finland/foreign) and residence were presented for all COVID-19-cases and for the different groups of healthcare professionals. Age was analysed both as a continuous and categorized variable. The place of residence was analysed on the level of healthcare district (regional level). We analysed these variables in three different study periods (1/2/2020–30/6/2020, 1/7/2020–31/12/2020, 1/1/2021–30/6/2021). Proportions were counted for the variables from physician notification.

We calculated cumulative incidences of COVID-19-cases for the different groups of healthcare professionals and the whole Finnish population (5.5 million) by using Kaplan-Meier estimate. Smoothed hazard estimates of COVID-19 were calculated for these groups and for the whole Finnish population. We analysed the risk factors for COVID-19 in HCW in a univariate analysis using log rank test and in a multivariable modelling using Cox's regression. In the Cox's regression calendar time was the baseline. We included age as continuous variable, sex, native language, country of birth, professional group and region in the multivariable model. The study period was added as an interaction term in order to examine whether the effect of age on COVID-19 incidence among HCWs varied by the study period.

Statistical analysis was done using Stata version 17.0 (StataCorp LLC, College Station, TX, USA).

Ethical considerations

Name and personal ID number were used only in the linkage of the NIDR and Terhikki register, they were not used in data analysis or when reporting the results. The study was conducted under the Finnish Communicable Disease Act and is part of the Finnish Institute for Health and Welfare surveillance duty (https://www.finlex.fi/en/laki/kaannokset/2016/en20161227.pdf), in this case COVID-19 surveillance among healthcare workers. Therefore, the study did not require further ethical review. Ethical approval was not required for this

Table I
Characteristics of COVID-19-cases in healthcare workers (HCW) and the whole HCW cohort during February 2020—June 2021, Finland

	COVID-19-cases	Full cohort	Incidence of COVID-19 (n/N)	95% confidence interval for the incidence
	n=8,009	N=446,432	1.79%	1.75—1.83%
Sex, n (%)				
Female	6,680 (83.4%)	382,424 (85.7%)	1.75%	1.71—1.79%
Male	1,329 (16.6%)	64,008 (14.3%)	2.08%	1.97—2.19%
Age[a] (median, IQR) in years	40.9 (31.2—51.6)	44.7 (33.7—56.4)		
Age[a] categorized (y), n (%)				
17-29	1,729 (21.6%)	73,183 (16.4%)	2.36%	2.25—2.47%
30-39	2,091 (26.1%)	102,012 (22.9%)	2.05%	1.96—2.14%
40-49	1,909 (23.8%)	98,917 (22.2%)	1.93%	1.84—2.02%
50-59	1,602 (20.0%)	97,153 (21.8%)	1.65%	1.57—1.73%
60-67	678 (8.5%)	70,394 (15.8%)	0.96%	0.89—1.03%
>68	NA	4,773 (1.1%)		
Country of birth, n (%)				
Finland	6,709 (83.8%)	422,591 (94.7%)	1.59%	1.55—1.63%
Foreign	1,077 (13.5%)	19,248 (4.3%)	5.60%	5.28—5.92%
No data	223 (2.8%)	4,593 (1.0%)	4.86%	4.24—5.48%
Native language, n (%)				
Finnish, Sami or Swedish	6,641 (82.9%)	424,016 (95.0%)	1.57%	1.53—1.61%
Foreign	1,215 (15.2%)	18,989 (4.3%)	6.40%	6.05—6.75%
No data	153 (1.9%)	3,427 (0.77%)	4.46%	3.77—5.15%
Professional group, n (%)				
Dentist	75 (0.94%)	5,651 (1.3%)	1.33%	1.03—1.63%
Dental hygienist	42 (0.52%)	2,918 (0.65%)	1.44%	1.01—1.87%
Dental nurse	38 (0.47%)	4,406 (1.0%)	0.86%	0.59—1.13%
Medical doctor	359 (4.5%)	25,668 (5.8%)	1.40%	1.26—1.54%
Nurse	1,491 (18.6%)	81,945 (18.4%)	1.82%	1.73—1.91%
Nursing assistant	4,248 (53.0%)	205,369 (46.0%)	2.07%	2.01—2.13%
Other HCW	1,756 (21.9%)	118,719 (26.6%)	1.48%	1.41—1.55%
Region, n (%)				
1	20 (0.25%)	2,279 (0.51%)	0.88%	0.49—1.26%
2	250 (3.1%)	21,032 (4.7%)	1.19%	1.04—1.34%
3	35 (0.44%)	6,763 (1.5%)	0.52%	0.35—0.69%
4	31 (0.45%)	3,745 (0.84%)	0.83%	0.54—1.12%
5	4,351 (54.3%)	118,884 (26.6%)	3.66%	3.55—3.77%
6	36 (0.45%)	6,359 (1.4%)	0.57%	0.38—0.75%
7	143 (1.8%)	12,966 (2.9%)	1.10%	0.92—1.28%
8	65 (0.81%)	10,361 (2.3%)	0.63%	0.48—0.78%
9	81 (1.0%)	4,885 (1.1%)	1.66%	1.30—2.02%
10	331 (4.1%)	36,382 (8.2%)	0.91%	0.81—1.01%
11	136 (1.7%)	24,405 (5.5%)	0.56%	0.46—0.65%
12	87 (1.1%)	14,435 (3.2%)	0.60%	0.48—0.73%
13	236 (3.0%)	13,931 (3.1%)	1.69%	1.48—1.91%
14	562 (7.0%)	45,426 (10.2%)	1.24%	1.14—1.34%
15	279 (3.5%)	15,773 (3.5%)	1.77%	1.56—1.97%
16	123 (1.5%)	17,363 (3.9%)	0.71%	0.58—0.83%
17	90 (1.1%)	9,852 (2.2%)	0.91%	0.73—1.10%
18	83 (1.0%)	8,728 (1.9%)	0.95%	0.75—1.15%
19	88 (1.1%)	15,959 (3.6%)	0.55%	0.44—0.67%
20	770 (9.6%)	39,141 (8.8%)	1.97%	1.83—2.10%
21	212 (2.7%)	13,506 (3.0%)	1.57%	1.36—1.78%
Data missing		4,357 (1.0%)		

IQR Interquartile range.
[a] Age for the cases is the age on the day of COVID-19 diagnosis, for the cohort it is age in the middle of the follow-up period, 1 October 2020. The follow-up of a person ends when he/she turns 68 years.

register-based study as no identifiable data was used in the analysis nor reporting.

Results

A total of 8,009 COVID-19-cases were identified among HCWs during the study period; 6,680 (83%) were female. The median age was 40.9 years (interquartile range [IQR], 31.2–51.6 years). Of the COVID-19-cases 54% were living in the capital region. Among the different groups of healthcare professionals nursing assistants and nurses represented the majority of the COVID-19-cases, 53% and 19%, respectively (Table I). In HCWs the risk of COVID-19 was 1.79% (95%CI, 1.75–1.83%). The risk was significantly higher in males (2.08%, 95%CI, 1.97–2.19%), in the age group of 17–29 years (2.36, 95% CI, 2.25–2.47%), in HCWs with a background of a foreign country of birth (5.60%, 95%CI, 5.28–5.92%) or foreign native language (6.40%, 95%CI, 6.05–6.75%) and those living in the capital region (3.66%, 95%CI, 3.55–3.77%).

We analysed the data using the three study periods (1/2/2020–30/6/2020, 1/7/2020–31/12/2020 and 1/1/2021–30/6/2021) and found out that the risk of COVID-19 increased by time so that the risk of COVID-19 among HCWs was higher (0.95%, 95%CI, 0.92–0.98%) during the latest study period (1/1/2021–30/6/2021) compared with the risk during study periods 1 and 2, 0.32% (95%CI, 0.31–0.34%) and 0.63% (95%CI, 0.60–0.65%), respectively (Supplementary Table A1).

The cumulative incidence of COVID-19 was highest in nursing assistants and nurses (Figure 1), their risk was also higher than the risk of COVID-19 in the whole Finnish population. During the first study period hazard estimates of COVID-19 were higher for all groups of healthcare professionals compared with the hazard estimate of the whole population (Figure 2). During the two later periods the hazard remained higher than that of the whole population for nursing assistants and nurses but not for the other groups of healthcare professionals.

In the whole HCW cohort there were nine deaths within 30 days after COVID-19 (Table II). The age range for the deceased was 47–65 years. Out of 8,009 COVID-19-cases, 5,963 (74%) had both laboratory notification and physician notification, 1,896 (24%) had only laboratory notification, and 150 (2%) had only physician notification in NIDR. Thus, we had data available from the physician notification for 6,113 (76%) COVID-19-cases (Table II), for whom the median age was 40.9 years (IQR, 31.3–51.6 years) and 5,097 (83%) were female. Hypertension (7%), asthma (7%), diabetes (3%) and heart diseases (2%) were the most common underlying diseases. Obesity (9%) and smoking (3%) were the most common other risk factors. A known COVID-19 exposure was reported in family for 1,773 (29%), at work for 1,295 (21%), in healthcare for 210 (3%) and other known exposure for 720 (12%) HCWs. Of the 6,113 COVID-19-cases, 244 (4%) were hospitalized due to COVID-19.

In the Cox's regression model the risk factors for COVID-19 were male sex (HR 1.21; 95%CI, 1.14–1.29), foreign native language (HR 2.53; 95%CI, 2.23–2.87) and a foreign country of birth (HR 1.20; 95%CI, 1.06–1.36) (Table III). The effect of age to the hazard for COVID-19 was presented as a continuous variable and differed between the study periods (effect modifier). During the periods 2 and 3 but not during period 1, hazards were lower with an increasing age, HR 0.84 (95%CI, 0.81–0.86) and HR 0.81 (95%CI, 0.79–0.83) for a 10-year increase in age, respectively. Among the professional groups, the highest hazard ratios were recorded among nursing assistants (HR 1.64; 95%CI, 1.47–1.84) and nurses (HR 1.55; 95%CI, 1.38–1.74) and the lowest among HCWs in dental care. The hazard was also increased in the group of other HCWs (HR 1.26; 95%CI, 1.12–1.41), where the largest professional groups were physiotherapists, masseurs, pharmacists, laboratory personnel, psychologists, psychotherapists, midwives and

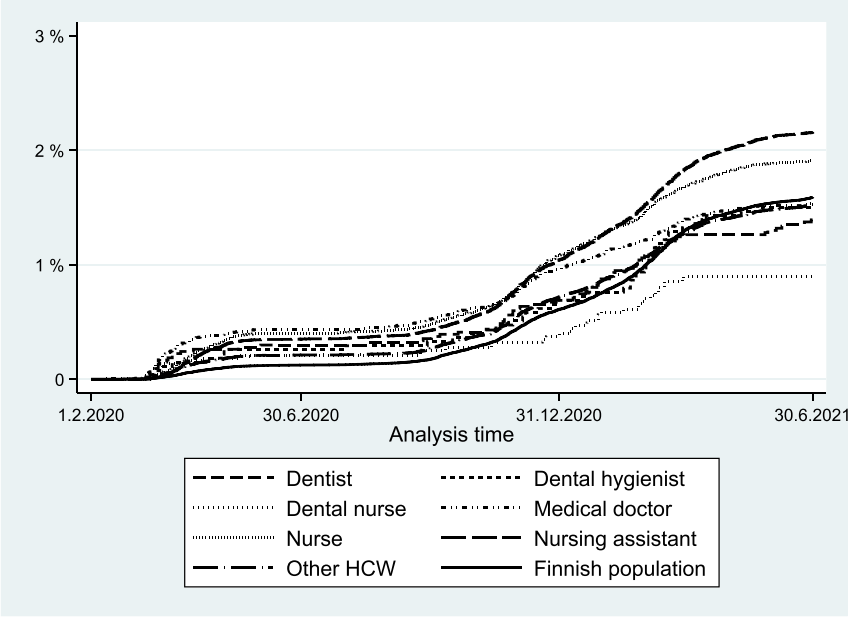

Figure 1. Kaplan-Meier estimates of cumulative COVID-19 incidence (%) in different groups of healthcare professionals and in the whole Finnish population (5.5 million) during February 2020–June 2021, Finland.

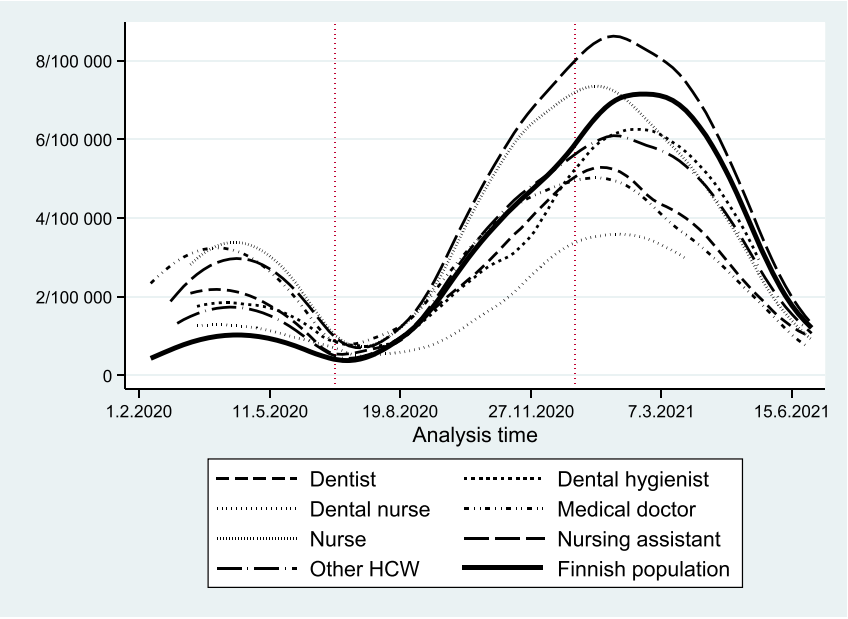

Figure 2. Smoothed hazard estimates of COVID-19 incidence (cases/100,000 population) in different groups of healthcare professionals and in the whole Finnish population (5.5 million) during February 2020—June 2021, Finland. The three study periods (1/2/2020—30/6/2020, 1/7/2020—31/12/2020 and 1/1/2021—30/6/2021) are marked with vertical lines.

radiographers. The hazard ratios were significantly lower in all other regions when compared to the capital region.

Discussion

Altogether 1.8% of registered HCWs were diagnosed with COVID-19 during the first 17 months of the COVID-19 pandemic in Finland. Among the different groups of healthcare professionals, the highest risk was in nursing assistants and nurses, and their risk was higher than that of the general population. Risk was also increased in males, in HCWs with an indicator of a foreign background, and in HCWs living in the capital region. As the pandemic evolved, younger age became a risk factor. Severe outcomes of COVID-19 in HCWs were rare.

Nursing assistants and nurses had the highest risk of COVID-19 among the different groups of healthcare professionals, which is not surprising in the light of their frequent and close patient-contacts. This is also supported by previous seroprevalence studies [8,9]. The heterogeneous group of other HCWs also had an increased risk compared to medical doctors in our study. In the Danish study in addition to healthcare assistants, nurses and physicians, an increased risk of COVID-19 hospitalization was found among medical laboratory technicians, psychological and recreational therapists within healthcare, hospital attendants, x-ray technicians as well as nurses and nursing aides in social care [7]. These occupations excluding nursing professionals in social care are included in the group of other HCWs in our study. Interestingly, we saw a risk similar to that of medical doctors for dentists, dental hygienists and dental nurses. A low rate of COVID-19 in dentists has been reported earlier, together with their good compliance to PPE [7,10], but also opposite results have been reported [6].

In Finland a remarkable number of nursing assistants work in social care, where the level of education and experience in infection control practices may differ from those in acute care hospitals. The risk of COVID-19 in HCWs has been reported to be higher with a self-reported reuse or misuse of PPE compared with an appropriate use of PPE [11]. In a Finnish study that was conducted in long-term care facilities most HCWs reported difficulties in complying with at least one COVID-19 infection prevention and control measure, especially in using PPE [12]. Knowledge on how to apply infection prevention and control measures was one of the domains influencing infection control behaviour in the qualitative part of the study. HCWs are seldom infected by known COVID-19 patients with whom PPE is used properly, but infections from undiagnosed COVID-19 patients and from colleagues take place [13], which is likely explained by a lack of PPE in these contacts. Universal masking has been shown to be effective in reducing the number of healthcare associated COVID-19 in HCWs [14].

The risk of COVID-19 was increased among those HCWs, who were not native speakers of the official languages of Finland or who had a foreign country of birth. This finding may indicate difficulties both in training, understanding, and implementing infection control guidelines. An increased work-related risk of COVID-19 in HCWs belonging to ethnic minorities is supported by earlier studies [11,15]. The finding may also reflect the trend that has been seen during the pandemic that people from ethnic minorities have an increased risk of COVID-19 [16]. In Finland a higher incidence of COVID-19 was reported in the capital region among those with a foreign native language [17].

Also, male sex increased the risk of COVID-19. Male sex has been reported to be a risk factor for a severe COVID-19 [18], and also a risk factor for infection among HCWs [19]. What makes males more prone to COVID-19 is not completely understood, but both biological and behavioural factors are possible [20]. The other significant risk factors in our study, living in the capital region and younger age, are likely reflecting the general trend of COVID-19 pandemic in Finland, as higher incidences have been associated with these factors

Table II
Characteristics of COVID-19 infections in healthcare workers (HCWs) during February 2020—June 2021, Finland

	COVID-19-cases with a physician notification	All COVID-19-cases
N (%)	6,113 (76.3%)	8,009
Age in years, median (IQR)	40.9 (31.3—51.6)	40.9 (31.2—51.6)
Female sex, n (%)	5,097 (83.4%)	6,680 (83.4%)
Marked as a HCW in physician notification, n (%)	3,657 (59.8%)	NA
Exposure to COVID-19[a], n (%)		NA
in family	1,773 (29%)	NA
at work	1,295 (21%)	NA
in healthcare	210 (3.4%)	NA
other known contact	720 (12%)	NA
no known contact	2,193 (36%)	NA
COVID-19 related hospitalization, n (%)	244 (4.0%)	NA
Care in intensive care unit, n (%)	37 (0.61%)	NA
Death		
Death[b] in NIDR, n	6	9
COVID-19 death stated in physician notification, n	4	NA
Chronical illness, n (%)		
Hypertension	415 (6.8%)	NA
Asthma	402 (6.6%)	NA
Diabetes	204 (3.3%)	NA
Heart diseases	106 (1.7%)	NA
Cancer	39 (0.64%)	NA
Chronical lung disease (other than asthma)	30 (0.49%)	NA
Liver disease	30 (0.49%)	NA
Renal disease	30 (0.49%)	NA
HIV/other immunodeficiency	13 (0.21%)	NA
Chronical muscle disease	7 (0.11%)	NA
Other chronical disease	683 (11.2%)	NA
Unknown chronical disease	17 (0.28%)	NA
Other conditions, n (%)		
Obesity (Body mass index >30)	528 (8.6%)	NA
Smoking	196 (3.2%)	NA
Pregnancy	122 (2.0%)	NA

NIDR National Infectious Diseases Register.
[a] One person can have more than one notified exposure. There were 6 cases with contact in family and at work, 3 with contact in family and in healthcare, 19 with contact in family and another known contact, 40 with contact at work and in healthcare, 10 with contact both at work and another known contact, and 3 cases with contact both in healthcare and other known contact.
[b] Out of the nine COVID-19 deaths, 8 were laboratory confirmed infections and one was notified by a physician notification.

[21]. However, age over 60 years has been described to be a protective factor against COVID-19 related sickness absence in HCWs when compared with those under 30 years [15].

There are several limitations in our study. It was not possible to identify from the register data whether these infections were related to their work in healthcare or if the transmission occurred elsewhere. We had data about the origin of the infection for part of the COVID-19-cases in the physician notifications. Of these 6,113 COVID-19 cases, 21% had a known COVID-19 contact at work, but we don't know if the work-related exposure was with a patient, a colleague or some other contact at work, which has been shown to be sources for work-related infection [4,22,23]. In contact tracing data from Finland, it was reported that in healthcare settings most COVID-19 transmission took place between colleagues (62%) or from COVID-19 patients before their identification (33%) [24]. Only in 5% of the cases transmission occurred from a known COVID-19 patient.

We did not know if the registered HCWs were still practicing the profession, and it is likely that we overestimated the number of COVID-19 in HCW. However, this also applies to the denominator. For the persons who had more than one valid registration in Terhikki, we did not have the information which one of them was the profession the person was practicing during the pandemic, thus we used the latest registered profession.

We did not analyse all professional groups separately, but we formed groups focusing on the largest HCW groups, nursing assistants, nurses and medical doctors. In addition, we wanted to examine HCWs in dental care more closely as they work in close proximity to patient's respiratory tract and were considered to be in high occupational risk when the pandemic started. In Finland separate national infection control guidelines were created for acute care hospitals, long-term care facilities and dental care, which also supported this categorization.

During the early months of the pandemic the national testing capacity was limited and the number of SARS-CoV-2 infections during that time may have underestimated the true number of infections as persons with mild symptoms were not tested. However, HCWs were advised to be tested even with milder symptoms, which can make the ratio of COVID-19 in HCWs to COVID-19 in the general population to be an overestimation for this time period. This may be partly explaining the higher hazard estimates in all HCW groups compared to the whole population during spring 2020.

We lacked the data on COVID-19 vaccination for the HCW cohort. Vaccination started in Finland on 27th December 2020 with the focus on elderly people, medical risk groups and HCWs based on their job description [25]. This can partly explain why younger age was associated with the increased risk of COVID-19 in our study, especially during the third study period. Also, as the vaccinations were prioritized first to certain HCWs, it may have affected the differences in COVID-19 risk between different groups of healthcare professionals during the third study period. By 26 October 2021, 90% of 17—69-year-old HCWs registered in Terhikki in Finland had got at least one dose of COVID-19 vaccination and 84% two doses [25].

In our data the physician notification was lacking in one fourth of the cases, and some of the physician notifications were incomplete. It is possible that there were cases whose outcome of COVID-19 was not known when the physician

Table III
Risk factors for COVID-19 in healthcare workers (HCWs) in a Cox's regression model during February 2020–June 2021, Finland. Age group, sex, native language, country of birth, professional group, region and study period (1/2/2020–30/6/2020, 1/7/2020–31/12/2020 and 1/1/2021–30/6/2021) were included in the multivariable model

	Hazard ratio	95% Confidence interval	*P* value
Sex			
female (ref.)	1.00		
male	1.21	1.14–1.29	<0.001
Age			
1st period	0.96[a]	0.92–1.00	0.08
2nd period	0.84[a]	0.81–0.86	<0.001
3rd period	0.81[a]	0.79–0.83	<0.001
Native language			
Finnish, Sami or Swedish (ref.)	1.00		
Foreign	2.53	2.23–2.87	<0.001
Data missing	2.46	2.06–2.93	<0.001
Country of birth			
Finland (ref.)	1.00		
Foreign	1.20	1.06–1.36	0.004
Data missing	1.06	0.89–1.26	0.535
Professional group			
Medical doctor (ref.)	1.00		
Dentist	0.98	0.77–1.26	0.884
Dental hygienist	1.10	0.80–1.51	0.573
Dental nurse	1.03	0.74–1.45	0.843
Nurse	1.55	1.38–1.74	<0.001
Nursing assistant	1.64	1.47–1.84	<0.001
Other HCW	1.26	1.12–1.41	<0.001
Region			
5[b](ref.)	1.00		
1	0.24	0.15–0.37	<0.001
2	0.35	0.31–0.40	<0.001
3	0.15	0.11–0.21	<0.001
4	0.26	0.18–0.37	<0.001
6	0.17	0.12–0.24	<0.001
7	0.32	0.27–0.38	<0.001
8	0.19	0.15–0.24	<0.001
9	0.51	0.41–0.63	<0.001
10	0.28	0.25–0.31	<0.001
11	0.17	0.14–0.20	<0.001
12	0.18	0.15–0.22	<0.001
13	0.47	0.41–0.53	<0.001
14	0.36	0.33–0.40	<0.001
15	0.52	0.46–0.59	<0.001
16	0.21	0.18–0.25	<0.001
17	0.27	0.22–0.34	<0.001
18	0.29	0.23–0.36	<0.001
19	0.16	0.13–0.20	<0.001
20	0.57	0.53–0.62	<0.001
21	0.47	0.41–0.53	<0.001

[a] Hazard ratio counted for 10-year increase in age.
[b] Capital region.

notification was filled in, and thus the data on hospitalization, intensive care, and death could be missing. This may cause bias when estimating the risk of severe COVID-19 in HCWs. Of the nine deaths that took place within 30 days after a specimen positive for SARS-CoV-2, we had a physician notification for six cases, and in four of them death was related to COVID-19. Thus, all deaths occurring within 30 days are not related to COVID-19. However, COVID-19-related death is not excluded to happen after 30 days. Despite this uncertainty, in our data the case fatality was very low (0.1% of the COVID-19-cases). The register-based studies from Denmark and Norway did not report COVID-related deaths. The risk of COVID-19-related hospitalization for HCWs was similar in our study compared with the Norwegian study [6].

Finally, our study showed that nursing assistants and nurses had the highest risk of COVID-19 during the first 17 months of the pandemic, and their risk was higher than the risk of COVID-19 in the general population during the whole follow-up period. Risk of COVID-19 was increased in males, in those with a foreign background, in younger age groups and in the capital region. These factors should be considered and addressed when training HCWs on infection prevention and control measures and when implementing the infection control guidelines to reduce the work-related risk and transmission of COVID-19. Enough time should be allocated for the training despite the possible heavy workload, and also for temporary HCWs [26]. When preparing the training material, language skills should be taken into account to ensure an effective training.

Authors' contributions

Sohvi Kääriäinen: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing – original draft, Visualization

Ulla Harjunmaa: Conceptualization, Writing – Review & Editing, Visualization

Tuula Hannila-Handelberg: Conceptualization, Writing – Review & Editing, Visualization

Jukka Ollgren: Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Visualization

Outi Lyytikäinen: Conceptualization, Methodology, Validation, Writing – Review & Editing, Supervision

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Conflict of interest statement

U.H. reports a relationship with Finnish Dental Society Apollonia including lecture fees. U.H. holds a position as a chairperson of the expert group instructing the oral health care on COVID-19 safety measures as part of her daily work at the Finnish Institute for Health and Welfare. Other authors declare none.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.infpip.2023.100297.

References

[1] Reuter M, Rigó M, Formazin M, Liebers F, Latza U, Castell S, et al. Occupation and SARS-CoV-2 infection risk among 108 960 workers during the first pandemic wave in Germany. Scand J Work Environ Health 2022;48:446—56.

[2] Kantele A, Lääveri T, Kareinen L, Pakkanen SH, Blomgren K, Mero S, et al. SARS-CoV-2 infections among healthcare workers at Helsinki University Hospital, Finland, spring 2020: Serosurvey, symptoms and sk factors. Travel Med Infect Dis 2021;39:101949.

[3] Piccoli L, Ferrari P, Piumatti G, Jovic S, Rodriguez BF, Mele F, et al. Risk assessment and seroprevalence of SARS-CoV-2 infection in healthcare workers of COVID-19 and non-COVID-19 hospitals in Southern Switzerland. Lancet Reg Health Eur 2021;1:100013.

[4] Paris C, Tadié E, Heslan C, Gary-Bobo P, Oumari S, Saade A, et al. Risk factors for SARS-CoV-2 infection among health care workers. Am J Infect Control 2022;50:375—82.

[5] Colaneri M, Novelli V, Cutti S, Muzzi A, Resani G, Monti MC, et al. The experience of the health care workers of a severely hit SARS-CoV-2 referral Hospital in Italy: incidence, clinical course and modifiable risk factors for COVID-19 infection. J Public Health 2021;43:26—34.

[6] Magnusson K, Nygård K, Methi F, Vold L, Telle K. Occupational risk of COVID-19 in the first versus second epidemic wave in Norway, 2020. Euro Surveill 2021;26:2001875.

[7] Bonde JPE, Sell L, Flachs EM, Coggon D, Albin M, Oude Hengel KM, et al. Occupational risk of COVID-19 related hospital admission in Denmark 2020-2021: a follow-up study. Scand J Work Environ Health 2023;49:84—94.

[8] Rudberg AS, Havervall S, Månberg A, Jernborn Falk A, Aguilera K, Ng H, et al. SARS-CoV-2 exposure, symptoms and seroprevalence in healthcare workers in Sweden. Nat Commun 2020;11:5064.

[9] Plebani M, Padoan A, Fedeli U, Schievano E, Vecchiato E, Lippi G, et al. SARS-CoV-2 serosurvey in health care workers of the Veneto Region. Clin Chem Lab Med 2020;58:2107—11.

[10] Araujo MWB, Estrich CG, Mikkelsen M, Morrissey R, Harrison B, Geisinger ML, et al. COVID-2019 among dentists in the United States: A 6-month longitudinal report of accumulative prevalence and incidence. J Am Dent Assoc 2021;152:425—33.

[11] Nguyen LH, Drew DA, Graham MS, Joshi AD, Guo CG, Ma W, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. Lancet Public Health 2020;5:e475—83.

[12] Lohiniva A, Toura S, Arifulla D, Ollgren J, Lyytikäinen O. Exploring behavioural factors influencing COVID-19-specific infection prevention and control measures in Finland: a mixed-methods study, December 2020 to March 2021. Euro Surveill 2022;27:2100915.

[13] Gómez-Ochoa SA, Franco OH, Rojas LZ, Raguindin PF, Roa-Diaz ZM, Wyssmann BM, et al. COVID-19 in Health-Care Workers: A Living Systematic Review and Meta-Analysis of Prevalence, Risk Factors, Clinical Characteristics, and Outcomes. Am J Epidemiol 2021;190:161—75.

[14] Seidelman JL, Lewis SS, Advani SD, Akinboyo IC, Epling C, Case M, et al. Universal masking is an effective strategy to flatten the severe acute respiratory coronavirus virus 2 (SARS-CoV-2) healthcare worker epidemiologic curve. Infect Control Hosp Epidemiol 2020;41:1466—7.

[15] van der Plaat DA, Madan I, Coggon D, van Tongeren M, Edge R, Muiry R, et al. Risks of COVID-19 by occupation in NHS workers in England. Occup Environ Med 2022;79:176—83.

[16] Melchior M, Desgrées du Loû A, Gosselin A, Datta GD, Carabali M, Merckx J, et al. Migrant status, ethnicity and COVID-19: more accurate European data are greatly needed. Clin Microbiol Infect 2021;27:160—2.

[17] Holmberg V, Salmi H, Kattainen S, Ollgren J, Kantele A, Pynnönen J, et al. Association between first language and SARS-CoV-2 infection rates, hospitalization, intensive care admissions and death in Finland: a population-based observational cohort study. Clin Microbiol Infect 2022;28:107—13.

[18] Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. JAMA 2020;323:2052—9.

[19] Galanis P, Vraka I, Fragkou D, Bilali A, Kaitelidou D. Seroprevalence of SARS-CoV-2 antibodies and associated factors in healthcare workers: a systematic review and meta-analysis. J Hosp Infect 2021;108:120—34.

[20] Mjaess G, Karam A, Aoun F, Albisinni S, Roumeguère T. COVID-19 and the male susceptibility: the role of ACE2, TMPRSS2 and the androgen receptor. Prog Urol 2020;30:484—7.

[21] Finnish Institute for Health and Welfare. Coronavirus cases, hospital treatment situation and deaths [webpage]. 2023. Available from: https://www.thl.fi/episeuranta/tautitapaukset/coronamap.html.

[22] Bahrs C, Kimmig A, Weis S, Ankert J, Hagel S, Maschmann J, et al. Prospective surveillance study in a 1,400-bed university hospital: COVID-19 exposure at home was the main risk factor for SARS-CoV-2 point seroprevalence among hospital staff. Transbound Emerg Dis 2022;69:720—30.

[23] Martischang R, Iten A, Arm I, Abbas M, Meyer B, Yerly S, et al. Severe acute respiratory coronavirus virus 2 (SARS-CoV-2) seroconversion and occupational exposure of employees at a Swiss university hospital: A large longitudinal cohort study. Infect Control Hosp Epidemiol 2022;43:326—33.

[24] Rannikko J, Viskari H, Sirkeoja S, Tamminen P, Kaila V, Ala-Mursula A, et al. Population-Based Assessment of Contact Tracing Operations for Coronavirus Disease 2019 in Pirkanmaa Hospital District, Finland. Open Forum Infect Dis 2022;9:ofac214.

[25] Poukka E, Baum U, Palmu AA, Lehtonen TO, Salo H, Nohynek H, et al. Cohort study of Covid-19 vaccine effectiveness among healthcare workers in Finland, December 2020 - October 2021. Vaccine 2022;40:701—5.

[26] Barker AK, Brown K, Siraj D, Ahsan M, Sengupta S, Safdar N. Barriers and facilitators to infection control at a hospital in northern India: a qualitative study. Antimicrob Resist Infect Control 2017;6:35. https://doi.org/10.1186/s13756-017-0189-9.