Incidence of SARS-CoV-2 infection among healthcare workers before and after COVID-19 vaccination in a tertiary paediatric hospital in Warsaw: a retrospective cohort study

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Abstract

A retrospective observational study was conducted among healthcare workers (HCWs) in a tertiary paediatric hospital. The study covered the period before and after implementation of the vaccination programme and evaluated the incidence of new SARS-CoV-2 infections in both periods. Risk factors of the new SARS-CoV-2 infection and COVID-19 vaccine effectiveness was also assessed in a real-world setting. The overall incidence of SARS-CoV-2 infections among HCWs in the study period was 19.4% with a high proportion of asymptomatic individuals (45.1%). The incidence before vaccination was 16.6% and nurses had a higher risk of infection, while physicians had a reduced risk (OR 1.80, 95% CI 1.29–2.52; and OR 0.45, 95% CI 0.30–0.68). Within two months of implementation, the programme achieved a high (88.9%) vaccination coverage in our cohort, although some disparities in vaccination rates were observed. In particular, older individuals, physicians, those working in clinical settings, and those previously uninfected were more likely to be vaccinated. The overall incidence of SARS-CoV-2 infection after vaccination deployment was 6.3% (40.0% in unvaccinated individuals and 3.2% in individuals vaccinated with at least one dose). The estimated vaccine efficacy was high (95.0%) in fully vaccinated HCWs and similar to those observed previously in clinical trials and real-world settings.

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Abstract:

A retrospective observational study was conducted among healthcare workers (HCWs) in a tertiary paediatric hospital. The study covered the period before and after implementation of the vaccination programme and evaluated the incidence of new SARS-CoV-2 infections in both periods. Risk factors of the new SARS-CoV-2 infection and COVID-19 vaccine effectiveness was also assessed in a real-world setting. The overall incidence of SARS-CoV-2 infections among HCWs in the study period was 19.4% with a high proportion of asymptomatic individuals (45.1%). The incidence before vaccination was 16.6% and nurses had a higher risk of infection, while physicians had a reduced risk (OR 1.80, 95% CI 1.29–2.52; and OR 0.45, 95% CI 0.30–0.68). Within two months of implementation, the programme achieved a high (88.9%) vaccination coverage in our cohort, although some disparities in vaccination rates were observed. In particular, older individuals, physicians, those working in clinical settings, and those previously uninfected were more likely to be vaccinated. The overall incidence of SARS-CoV-2 infection after vaccination deployment was 6.3% (40.0% in unvaccinated individuals and 3.2% in individuals vaccinated with at least one dose). The estimated vaccine efficacy was high (95.0%) in fully vaccinated HCWs and similar to those observed previously in clinical trials and real-world settings.

Key words:

SARS-CoV-2, healthcare workers, COVID-19 vaccine

INTRODUCTION

The ongoing pandemic of the coronavirus disease 2019 (COVID-19) caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has had significant impact worldwide. Healthcare workers (HCWs) are considered to be at high risk of exposure to SARS-CoV-2 both in the community and in the workplace and may play a critical role, especially when asymptomatic, in the transmission of the infection within the workplace (both to their patients and co-workers) as well as in the community[1].

Preventing SARS-CoV-2 infection among HCWs is critical to ensure safety for both patients and HCWs, to contain the ongoing pandemic, and to maintain a functioning healthcare system.

Many preventive measures have been implemented throughout the pandemic to contain the spread of the SARS-CoV-2 infection in healthcare settings, including universal masking, enhanced hand hygiene and personal protective equipment (PPE) training, symptom screening, and self-isolation of HCWs if symptomatic or in the case of close contact with an infected person. Notably, there has been a paradigm shift in the infection control practices against respiratory infections, which includes widespread testing of patients and HCWs, including asymptomatic individuals[2,3].

Universal testing of HCWs enabled the prompt identification of asymptomatic and presymptomatic individuals, determined the effectiveness of control measures, and helped prevent transmission to patients and co-workers[1,4,5].

Furthermore, COVID-19 vaccines were developed to overcome the pandemic.

Following the implementation of COVID-19 vaccines, HCWs were among the first prioritised for vaccination in many countries, including Poland. Data from the placebo-controlled randomized phase 3 clinical trial of the Pfizer-BioNTech BNT162b2 vaccine showed 95% efficiency in preventing symptomatic SARS-CoV-2 infection[6]. Benefits similar to those observed in clinical trials were also observed in real-world conditions[7].

There is limited data on the incidence of SARS-CoV-2 infection among HCWs beyond the second wave of the pandemic, and limited data on the incidence of infection before and after the implementation of the vaccination programme, especially for European countries[8]. So far, most studies performed in Poland were voluntary seroprevalence studies in small cohorts of HCWs, so the representativeness of the results obtained may be limited[9,10].

Knowing the factors associated with SARS-CoV-2 infection in HCWs informs preventive measures and improves the protection of HCWs and patients.

To further explore factors associated with SARS-CoV-2 infection, we retrospectively analysed the large real-world testing database obtained between October 20, 2020, and August 31, 2021, at The Children's Memorial

Health Institute (CMHI), a tertiary paediatric hospital in Warsaw. In this setting, 2,332 HCWs participated in the universal screening programme for early identification of the SARS-CoV-2 infection. The aim of the study was to analyse the incidence of new SARS-CoV-2 infections among HCWs (before and after vaccination with BNT162b2) and to explore the demographics and work-related factors associated with SARS-CoV-2 infection. We also attempted to assess the vaccine effectiveness in a real-world setting.

METHODS:

Study design, setting, and participants

This was a cohort, retrospective study with secondary data, conducted with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies[11], performed among HCWs at the CMHI in Warsaw (see **Supplementary Material**).

The CMHI is the largest tertiary paediatric hospital and research institute in Poland, with nearly 600 beds and approximately 2,430 HCWs, including employees and trainees. As previously described[12], beginning on March 9, 2020, a set of infection prevention and control measures were implemented at the CMHI to contain the spread of SARS-CoV-2 within the hospital.

The SARS-CoV-2 RT-PCR testing for symptomatic personnel, coupled with contact tracing, was implemented starting from March 17, 2020. In addition, since October 20, 2020 (the beginning of the second wave of the COVID-19 epidemic in Poland), a universal SARS-CoV-2 screening programme was deployed at the CMHI for all HCWs using a RT-PCR assay of nasopharyngeal swabs. Up to May 6, 2021 (corresponding to the end of the third pandemic wave), there were seven rounds of screening which made it possible to identify and isolate asymptomatic and presymptomatic HCWs. The HCW vaccination programme with the Pfizer-BioNTech BNT162b2 vaccine began on January 4, 2021, and up to February 28, 2021, approximately 80% of HCWs received at least one dose of the vaccine. All HCWs (clinical and non-clinical) who had at least one PCR test performed as part of the universal screening were included in the study.

Demographic, occupational, epidemiological (if applicable), and laboratory data were collected for each participant up to August 31, 2021. All data were analysed anonymously in April 2023. Details on the data sources are provided in the **Supplementary Material** .

Fig. 1 illustrates the study timeline. The study population and definition of the follow-up period for the incidence of SARS-CoV-2 infection in HCWs before vaccination (study phase 1) and after vaccination (study phase 2) are presented in **Table 1** .

Statistical analysis:

The main outcomes were the incidence of new SARS-CoV-2 infection in HCWs before and after vaccination, and the vaccine effectiveness (VE) against any SARS-CoV-2 infection. The outcomes were analysed for predefined subgroups according to age, gender, profession, workplace, and vaccination status. Data were presented as a median with interquartile range (IQR) of continuous variables and proportions of dichotomous variables. Univariable and multivariable logistic regression models were used to assess factors associated with the primary outcomes of SARS-CoV-2 infection. Details on statistical analysis including sample size calculations are presented in the **Supplementary Material** . Statistical analyses were performed using the Statistica data analysis software system (TIBCO Software Inc.), version 13. Two-side tests with a p-value of < 0.05 were considered statistically significant.

Sensitivity analysis

Sensitivity analysis was performed to examine the robustness of the results. Complete case analysis was performed (i.e. after inclusion of previously infected HCWs, those with missing vaccination status, or no follow-up data) to cover more possible events and to investigate influences of missing data on the study results (results of the sensitivity analysis are presented in the **Supplementary Material**).

RESULTS

Of the 2,332 HCWs who participated in the universal screening programme, 1,967 (84.3%) were female. The median age was 46.9 (IQR: 36.4–55.4) years. Approximately one third (32%) were nurses. One hundred and eighty-four (7.9%) HCWs worked in the COVID-19 area (**Table 2**).

Beginning on March 17, 2020 (the first case of a SARS-CoV-2 infected HCW identified at the CMHI) and up to October 19, 2020 (the start of universal screening of HCWs), we identified 86 HCWs with SARS-CoV-2 infection from the 2,332 HCWs, which corresponds to a baseline prevalence of 3.7%.

In total, 11,797 samples from 2,332 HCWs were tested as part of the universal screening programme between October 20, 2020, to May 6, 2021. After excluding 199 (1.7%) invalid test results, the median number of tests per person was 6 (IQR: 3–7). In addition, 1,298 PCR test results performed outside the screening and up to August 31, 2021, were available for 934 (40.1%) of the 2,332 HCWs (median 1 sample per person, IQR: 1–2).

Overall, 457 (19.6%) of the 2,332 HCWs had positive SARS-CoV-2 PCR test results within the study period, including 452 new infections (19.4%) and 8 (0.2%) reinfections. Almost half (45.1%) of the infections were asymptomatic and 48.6% were identified during the universal screening programme. Among 281 HCWs with laboratory confirmed SARS-CoV-2 infection, for whom data on the probable source of infection were available, the most common source of infection was the community (44.1%), followed by the household (32.7%), while the rate of infection at the workplace was only 14.2%.

Fig. 2 shows the incidence of SARS-CoV-2 infection among HCWs at the CMHI and in the general population in the Mazovian voivodeship and **Fig. S1** reports the new weekly cases of SARS-CoV-2 infection among HCWs at the CMHI by testing mode. The weekly incidence of new cases among HCWs at the CMHI fluctuated during the study period, corresponding to the dynamic of SARS-CoV-2 transmission in the community. In particular, most of the cases were identified between epidemiological (epi) week 43 and 49, 2020, which encompassed the peak of the second epidemic wave in Poland. The incidences among the HCWs decreased during the first three months of the vaccination programme and then increased again and peaked at epi week 13, 2021, which corresponded to the peak of the third wave in Poland, caused by variant Alpha (B.1.1.7; **Fig. S2**). This later peak of incidence was relatively lower among HCWs than in the community.

Study phase 1: incidence of new SARS-CoV-2 infection acquired before vaccination rollout

After exclusion of 185 HCWs with previous SARS-CoV-2 infection (n = 86) and those with the first PCR test performed after the implementation of the vaccination programme (n = 99), the study phase 1 consisted of 2,147 HCWs (**Fig. 3;** Study flow chart). During the 18-week period, 357 nurses acquired SARS-CoV-2 infection, which corresponds to a cumulative incidence of 16.6%.

More than half of the infected HCWs were asymptomatic (51%). The HCWs who tested positive for SARS-CoV-2 were similar in age and gender. The lowest percentage of SARS-CoV-2 infections was found among physicians (10%) and the highest among nurses (20%; $p < 0.001$). There was no significant difference in infection rates among HCWs working in wards involved and not involved in the treatment of COVID-19 patients or clinical and non-clinical areas, as well as across wards (**Table 3**).

Each HCW had 4 PCR tests performed as a median (IQR: 3–5 tests), with a higher number of tests performed for uninfected HCWs ($p < 0.001$).

Following adjustment for age, gender, and number of tests per person, there remained significant differences in the incidence of new SARS-CoV-2 infection across professional categories. Most notably, the odds of being infected were greater for nurses and lesser for physicians relative to the 'other without patient contact' category (OR 1.80, 95% CI 1.29–2.52, $p = 0.001$ and OR 0.45, 95% CI 0.30–0.68, $p < 0.001$, respectively; **Table S2**).

Vaccine coverage among HCWs at study phase 2

One thousand nine hundred and sixty (84.0%) HCWs of the 2,332 HCWs had known vaccination status, among them 1,743 (88.9%) HCWs had received at least one dose of the BNT162b2 vaccine by the end of February, 2021 (1,717 received two doses with a median time of 20 days between dose 1 and 2). The characteristics of the HCWs by vaccination status are presented in **Table S3** .

Unvaccinated HCWs were significantly younger than vaccinated (median age: 45.9 vs 48.2 years; $p = 0.002$). Physicians were significantly more likely to be vaccinated than other professional groups ($p < 0.001$). The HCWs in non-clinical areas were less vaccinated than those working in clinical locations (85.7% vs 90.2%, $p = 0.005$). There were differences in the vaccination status between the wards, with HCWs working on the surgical wards being the most frequently vaccinated group (92.6%, $p = 0.04$). There were no significant differences in vaccination status between HCWs working in wards involved and not involved in the treatment of COVID-19 patients. The HCWs most likely to have received at least one dose of the vaccine were previously uninfected with SARS-CoV-2 ($p < 0.001$). Before the implementation of the vaccination programme, 352 HCWs (285 vaccinated and 67 unvaccinated) had laboratory confirmed SARS-CoV-2 infection. Unvaccinated HCWs had a shorter time period from previous infections when compared with vaccinated HCWs (median 20 vs 61 days; $p < 0.001$).

Study phase 2: incidence of new SARS-CoV-2 infections after implementation of the vaccination programme

The incidence of SARS-CoV-2 infections was determined for vaccinated (partially and fully) and unvaccinated HCWs. HCWs with unknown vaccination status, previous SARS-CoV-2 infection, and/or without follow-up data were excluded from the incidence analysis (**Fig.3;** study flowchart). After applying the exclusion criteria, the incidence analysis included 1,461 HCWs with a median follow-up of 79 (IQR: 70–86) days.

In total, 93 of 1,461 (6.4%) HCWs tested positive for SARS-CoV-2 by the end of August, 2021.

There was no significant difference between infected and uninfected HCWs across demographic and occupational categories (**Table S5**). The cumulative incidence of SARS-CoV-2 infection was significantly higher among unvaccinated HCWs than in vaccinated HCWs (40.0% vs 3.2%; $p < 0.001$). When vaccination groups were considered, the cumulative incidence of new SARS-CoV-2 cases was 12.2% and 2.9% in partially and fully vaccinated HCWs, respectively (**Fig. 4**). The median interval from the first vaccine dose to SARS-CoV-2 infection was 28 (IQR: 21–31, range: 18–73) days in partially vaccinated HCWs, while in the fully vaccinated group, the median interval between the second vaccine dose and infection was 62 (IQR: 49–76, range: 25–200) days.

In a multivariate logistic regression model with confirmed SARS-CoV-2 cases as a response variable, vaccination status was the only significant predictor for SARS-CoV-2 infection after adjusting for age, gender, and number of PCR tests per HCWs (**Table S7**).

Vaccine effectiveness in preventing any SARS-CoV-2 infection was 79% (95% CI 46–92%) and 95% (95% CI 91–97%) in partially and fully vaccinated HCWs, respectively.

Vaccine effectiveness (VE) by age group and professional categories is presented in **Table 4** . VE for fully vaccinated HCWs did not vary by age (age group < 50 years: adjusted VE (aVE) = 95%, 95% CI 90–97%; 50+ years: aVE = 95%, 95% CI 87–98%) and was slightly lower for the other without direct patient contact category (aVE = 89%, 95% CI 73–96%) when compared with physicians (aVE = 96%, 95% CI 84–99%) and nurses (aVE = 98%, 95% CI 92–99%).

DISCUSSION

By using longitudinal data, our study provides robust data on the incidence of new SARS-CoV-2 infection among HCWs in a paediatric hospital during the pre- and post-vaccinations periods, encompassing the second and third wave of the COVID-19 pandemic in Poland.

During the ten months of the study period, approximately one fifth (19.4%) of the HCWs susceptible to primary infection became infected with SARS-CoV-2.

It is worth noting that almost half of the HCWs who had laboratory confirmed SARS-CoV-2 infection in our study did not report symptoms, suggesting that without the implementation of proactive universal screening a significant proportion of infection among HCWs would have remained undetected and that they would likely have continued working while unaware of their status, therefore presenting a risk of transmission to patients and co-workers. Although this study was not designed to address the issue of nosocomial transmission reduction through asymptomatic testing, we assume that the universal screening programme of HCWs applied in our hospital (as part of a bundle of intensified infection control measures) reduced the number of SARS-CoV-2 infections by early identification and isolation of SARS-CoV-2–positive individuals. There are also some issues associated with massive asymptomatic testing that must be underlined. First, it requires additional operational and testing costs and a large laboratory capacity to provide rapid turnaround for testing. Second, the results of the PCR-based screening are valid only for the day of the test, which can cause a false sense of confidence[13]. Furthermore, the resources required to identify a single asymptomatic case are substantial and may not be cost-effective during a low prevalence period[14]. Thus, testing strategies should be implemented after careful consideration of resources, infrastructure capacity, and logistical issues[15]. In addition, the testing strategy must be guided by the local epidemiology, vaccination coverage, and efficacy among HCWs and in the community.

In line with some other studies conducted after the first wave of the pandemic, the changes in the incidence rate of SARS-CoV-2 infection among HCWs in our cohort were closely followed by community infection rates[8,16,17]. Especially in the period before vaccination (study phase 1), both the dynamic and the magnitude of new SARS-CoV-2 infections were similar. On the other hand, after deployment of the HCW vaccination programme, a reduction in the weekly incidence of new cases among HCWs was observed. This downward trend initially was in parallel with the incidence decline in the community but persisted up to epi week 11, 2021, while in the general population a rapid increase in SARS-CoV-2 incidence was observed attributed to the SARS-CoV-2 Alpha variant domination (corresponding to the third pandemic wave). The incidence rate among HCWs also increased afterwards, but the observed peak was relatively lower. This finding is consistent with the anticipated protective effect of the COVID-19 vaccine.

When considering the two phases of the present study, the cumulative incidence of new SARS-CoV-2 infections decreased from 16.6% before vaccination to 6.3% after the implementation of the vaccination programme at the CMHI (study phase 2).

Due to the observational design of our study, we were unable to assess the extent to which HCW vaccination contributed to the observed reduction in the incidence of HCW SARS-CoV-2 infections. However, as the uptake of vaccination among HCWs at the CMHI was high (88.9%), we hypothesise that this impact could be significant, especially when the short-term effect is considered.

In addition, this hypothesis was supported by the high vaccine effectiveness observed in our cohort. Our findings indicate that the effectiveness of the vaccine was 95% and 79% in fully and partially vaccinated HCWs, respectively. These results are comparable to previous reports including those from clinical trials and other real-world studies[6,7,18]. In line with a previous study conducted among HCWs, we did not observe significant differences in vaccine effectiveness by age or occupational groups[7,18], although we observed slightly lower vaccine efficacy among HCWs in the 'other without direct patient contact' group. This finding could reflect lower awareness, behaviour change, and a misbelief that vaccination allows infection control measures to be relaxed.

However, despite high vaccine efficacy and high vaccination coverage, we still observed new SARS-CoV-2 infections among HCWs at a rate from 2.9% in the fully vaccinated to 39.7% in those unvaccinated.

These numbers are higher than those reported previously. In a systematic review of eighteen studies, the pooled proportion of SARS-CoV-2 infection was 1.3%, 2.3%, and 10.1% among fully vaccinated, partially vaccinated, and unvaccinated HCWs, respectively[19].

Variability in demographic and occupational factors, as well as case definitions, could explain this difference. Furthermore, the fact that we excluded HCWs with a previous SARS-CoV-2 infection from our analysis may have affected the higher infection rates observed in our cohort (the absence of the protective effect of post-infection immunity).

Although rare, these infections might diminish HCWs' belief in vaccination effectiveness, especially in those becoming infected with SARS-CoV-2 after initial vaccination. It is worth noting that, at the time of manuscript preparation, we faced a low rate (approximately 5%) of second booster dose uptake among HCWs at the CMHI. This led to concerns when considering waning vaccine immunity over time and the emergence of new variants of concern (VOC).

A systematic review by Biswas et al. revealed that vaccine acceptance varied widely between countries and ranged from 4.3% to 72%[20]. Individuals who were men, older, physicians, or well educated had a lower hesitancy to receive the COVID-19 vaccine. Other factors associated with higher vaccine acceptance were: higher income, medical risk, chronic disease history, not being infected with SARS-CoV-2 in the past, knowledge of COVID-19, and a belief that vaccines may protect friends, family, and community members[20]. Although the present study was not designed to assess the attitude to vaccination, these findings are consistent with our study. We observed that older individuals, physicians, those working in clinical settings, and those previously uninfected were more likely to be vaccinated. These observations might inform tailored communication strategies to be implemented to increase the uptake rate of COVID-19 vaccines among HCWs.

Reliable data on risk factors, SARS-CoV-2 incidence, and the proportion of HCWs who remain naïve (had no history of SARS-CoV-2 infection and/or unvaccinated) are crucial to inform infection control strategies. Previous studies reported widely varying estimates of incidence and risk factors for infection among HCW[21], and only a few studies assessed HCW infection and risk longitudinally[17].

When considering potential risk factors of SARS-CoV-2 infection among HCWs in our study, we did not find a significant difference in the infection rates among HCWs working in wards involved and not involved in the treatment of COVID-19 patients, clinical or non-clinical areas, or across different wards and these findings applied to both phases of the study. Our findings are in contrast to some previous studies, especially those studies performed during the early pandemic stage[22], which reported higher infection rates among HCWs working in COVID-19 wards with direct patient contact, but our findings are in line with the emerging literature pointing out that, except for breaches in PPE, the main risks to HCWs come from outside of work factors (in the community and household)[17,23–26]. In our cohort, before implementation of the vaccination programme (study phase 1), nurses had the highest adjusted likelihood of being infected, while physicians had a lower likelihood. Surprisingly, in the post-vaccination study period, we did not find any association between risk of SARS-CoV-2 infection and professional category. The only factor significantly associated with SARS-CoV-2 infection in the multivariate analysis was vaccination status. The increased risk of SARS-CoV-2 infection for nurses was previously reported in many observational studies[27–29]. The higher risk among nursing staff has been consistently explained by their more frequent contact with and longer contact times with COVID-19 patients when compared with physicians[28,30,31]. However, in our study we did not observe an increase in the number of cases on the wards involved in the treatment of patients with COVID-19. Furthermore, only a small percentage of HCWs (with available data on the possible source of exposure) reported exposure at work, and even fewer had high-risk contact with a COVID-19 patient. A recent case-control study from Ireland, investigating the impact of demographic and work-related factors on the risk of SARS-CoV-2 infection after in-work exposure to a confirmed case of COVID-19, revealed that male sex, Eastern European nationality, exposure location, PPE use, and vaccination status all impact the likelihood of SARS-CoV-2 infection throughout the first, second, and third pandemic waves[32]. In this study, no individual job role was determined to have a consistently higher risk of infection after documented nosocomial exposure. It is likely that the increased risk of SARS-CoV-2 infection among nurses observed in our and other studies may be an indication of the cumulative risk of certain nursing staff roles, which have an increased intensity of contact with patients and other HCWs over time, and this increases the probability of infection. In addition, nurses make up a significant proportion of the total hospital staff (approximately one-third in our cohort), thus resulting in over-representation, which may influence the interpretation of risk[32].

Together, these observations highlight the need for awareness of non-patient care exposure risk that contributes to infection in HCWs and should be considered in infection control measures (i.e. universal masking, reinforcement of hand hygiene, and distancing).

The limitations of our data should be borne in mind. First, the retrospective and observational design of the study is subject to missing and incomplete data and thus to unmeasured confounding bias. Second, although our study cohort was stratified by different occupational categories, there may still be different exposure risks within the categories. Third, we were unable to adjust our analysis for other potential confounders that may affect the risk of infection (such as comorbidities, contact time with COVID-19 cases, movement of HCWs between high- and low-risk wards, compliance with PPE, household size) due to data limitations, and therefore the results may not generalise to other settings with different characteristics. Fourth, the clinical data regarding symptoms for each HCW were retrieved from an unstandardized database generated by the ICP team for epidemiological purposes and were not consistently available. In addition, we relied on self-reported symptoms and community/household exposures. Exposures in the workplace were revealed through epidemiological investigations, including contact tracing, but are still subject to recall bias. Data on exposure was missing for almost 40% of the HCWs, therefore it was unknown whether SARS-CoV-2 PCR positive cases resulted from infections in the workplace or were acquired in the community or household. On the other hand, the exact source and direction of infection may only be inferred from epidemiological data combined with viral genomic data, otherwise assessing the source is often subjective. Fifth, the lack of detailed information on SARS-CoV-2 exposure and the use of PPE, prevented us from analysing the association of adherence to PPE over time and across different occupational categories with the risk of infection. Six, we attempted to include only new cases of SARS-CoV-2 infection, excluding HCWs with records of a positive test by PCR or anti-nucleocapsid IgG. However, as systematic testing by PCR was not performed before the study period and not all HCWs had participated in a previous serology screening programme, we cannot rule out that we included some previous positive cases in our incidence analysis. Seventh, testing in study phase 2 was less dense as the universal screening programme ended on May 6, 2021, thus HCWs with asymptomatic SARS-CoV-2 infection might be underrepresented. Eight, although our estimated vaccine effectiveness aligns with the results provided in other reports, this estimate is based on a relatively short follow-up period. Finally, our study took place prior to the emergence of the Delta variant of SARS-CoV-2, thus it might not be generalizable to an epidemic situation with a domination of another VOC (variant of concern), however, the evidence from the early period of the pandemic may inform the infection control policy in a vulnerable population with regard to other respiratory viruses.

To our knowledge, this is the only study of the SARS-CoV-2 infection among HCWs in Poland and one of the few studies based on robust data obtained mainly from proactive universal screening PCR testing. The size and diversity of the cohort (all HCWs, including nurses, physicians, and other personnel providing direct and indirect patient care, as well as non-clinical staff) together with longitudinal data collected in the period before and after vaccination implementation in HCWs, meant that it was possible to examine risk factors of the new SARS-CoV-2 infection by demographic, occupational, and vaccination status (which was determined based on vaccination records instead of self-reporting, to mitigate recall bias).

In summary, our analysis provides information on the incidence of SARS-CoV-2 infection in the pre- and post-vaccination periods. We found that after the implementation of vaccination, the risk of infection among HCWs remained relatively high despite the high coverage of vaccination and the high effectiveness of the vaccine. Although rare, breakthrough infections are challenging, as they may pose a risk to the vulnerable population. Furthermore, there are concerns about the decrease in vaccine effectiveness over time and during the emergence of new VOCs.

Thus, continued efforts to promote infection control measures and vaccination (including booster vaccine doses) and distancing remain necessary during the ongoing COVID-19 pandemic.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

FUNDING

No funds, grants, or other support was received.

AUTHOR CONTRIBUTIONS

KB, MM, and DFK were involved in study concept and design. KB, SK, and BJ were involved in acquisition of data and performing RT-PCR SARS-CoV-2 testing. KB was involved in statistical analysis and interpretation of results. BK, SK, and BJ drafted the manuscript. MM and DFK were involved in data curation and supervision of the study. All authors were involved in the critical revision of the manuscript for important intellectual content and final approval of the manuscript.

ETHICAL STATEMENT

The study was reviewed and approved by the Institutional Review Board of The Children's Memorial Health Institute in Warsaw (Ref. no. 42/KBE/2020 with later revision on March 31, 2021), and granted a waiver of consent since the data were retrospective and were deidentified prior to review and statistical analysis. Data were accessed between April 2021 and September 2022.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPLEMENTAL MATERIAL

Supplementary materials are available at the Journal of Medical Virology online.

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