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Frequency of exposure incidents in hospital workers before and during the COVID-19 pandemic based on the hospital status and the use of personal protective equipment: a descriptive study with a historical comparison group

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Abstract

Background An occupational exposure, i.e. exposure incident (EI), is contact with potentially contaminated material that may contain bloodborne pathogens and that occurs during occupational activities inside or outside a health care facility, either during direct work with a patient or during contact with a patient's body fluids and tissues. This study aimed to compare the frequency of EIs in a university hospital before and during the Coronavirus Disease 2019 (COVID-19) pandemic.

Methods This was a descriptive study with a historical comparison group conducted at the Dubrava University Hospital (DUH) in Zagreb, Croatia. We compared the frequency of EIs among healthcare and non-healthcare workers before (from March 11, 2018, to March 10, 2020) and during (from March 11, 2020, to March 11, 2022) the COVID-19 pandemic, expressed as the number of EIs per number of hospitalized patients and the total number of hospital activities. We analyzed data based on the status of the hospital (a COVID-19 hospital or not) and the use of personal protective equipment (PPE) as recommended by the World Health Organization.

Results During the total analyzed period, 241 EIs were reported in DUH. Before the pandemic, 128 EIs were reported, compared to 113 during the pandemic. Before the pandemic, 91% of EIs were recorded in healthcare workers, while during the pandemic, 96% of EIs were recorded in healthcare workers. Slightly more EIs were recorded during the period of mixed work form and de-escalation of PPE. The rate of EIs relative to the total number of hospital patients was significantly higher during the pandemic (3.9/1000) than in the pre-pandemic period (2.5/1000). The rate of EIs relative to the total number of hospital activities was significantly higher during the pandemic (0.4/1000) than in the pre-pandemic period (0.2/1000).

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Conclusion The rate of EIs relative to the total number of hospitalized patients and the total number of hospital activities in DUH was significantly higher during the pandemic, and the rate of total EIs increased among healthcare workers during the COVID-19 pandemic. The results of this study show that it is necessary to constantly and effectively work on the prevention of EI.

Keywords COVID-19, Exposure incidents, Needlestick injuries, Health personnel, Accident prevention, Work safety

Background

An occupational exposure, i.e., exposure incident (EI), involves contact by healthcare workers and other professionals with potentially contaminated material that may contain blood-borne pathogens while performing occupational activities inside or outside the healthcare facility or while working directly with the patient or contacting the patient's body fluids and tissues. The three leading causes of occupationally linked blood-borne infections among healthcare workers are hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) [1, 2].

Of the total number of EIs, percutaneous injuries are the most common (75%), and a smaller proportion are mucocutaneous injuries (25%). The risk of HBV or HCV infection is higher with percutaneous exposure than with mucocutaneous exposure [3]. Using medical instruments and needles with a safety protection mechanism is promoted as an approach to reduce the percutaneous injury rate [4].

On January 30, 2020, the World Health Organization (WHO) declared the epidemic caused by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) an international public health emergency, and on February 11, 2020, it named the disease Coronavirus Disease 2019 (COVID-19). The WHO declared COVID-19 a global pandemic on March 11, 2020 [5].

When providing medical care to patients with COVID-19, standard precautions and safe handling of sharps should be followed to avoid EIs. Despite the high risk of exposure, employees are protected from SARS-CoV-2 infection through the use of personal protective equipment (PPE) and education about its proper use [6]. During the COVID-19 pandemic, employees were required to wear PPE. In December 2020, WHO provided recommendations for optimizing the use of PPE by healthcare workers caring for patients with suspected or confirmed COVID-19, especially in countries with a major shortage of PPE [7].

It has been observed that working under complete PPE (e.g., goggles/visor, respirator mask/surgical mask, gown/protective suit, gloves) with a higher workload and prolonged wearing of PPE has adverse effects on physical health and an increased incidence of a possible adverse event, i.e. EIs [7–9].

Although the risk of infection with COVID-19 during EI is low, the risk of infection with HBV, HCV and HIV remains [10]. The first results from Croatia have shown that there was a significantly higher occurrence of needlestick and sharp injuries during the COVID-19 pandemic, compared to the period before the pandemic when normalized to the number of patient and hospital activities [8]. That analysis has covered only needlestick and sharp injuries over a two-year period, including one year before the pandemic and the first year of the pandemic. Also, that study focused only on healthcare workers [8]. We could not find additional reports in the literature about the EIs in Croatia during the COVID-19 pandemic.

This study aimed to compare the frequency of all types of EIs among healthcare workers and non-healthcare workers in a COVID-19-repurposed university hospital two years before and during the first two years of the COVID-19 pandemic.

Methods

Study design

This was a descriptive study with a historical comparison group, conducted using medical records available at the Dubrava University Hospital (DUH) in Zagreb, Croatia for the period from March 11, 2018, to March 11, 2022.

Setting

DUH is a tertiary health institution that usually treats more than 25,000 patients in its inpatient departments and provides services to more than 400,000 outpatients annually [11]. The hospital was repurposed as the COVID-19 tertiary-care center during the COVID-19 pandemic.

Participants

All exposure incidents reported by hospital workers that occurred between March 11, 2018, and March 11, 2022, were analyzed. This included data available for all healthcare workers (physicians, nurses, physiotherapists, laboratory technicians, radiological engineers) and non-healthcare workers (carers, support staff, cleaning staff) employed in DUH who filed the exposure incident report. We analyzed all reports, regardless of the potentially incomplete data. Data from adults aged ≥ 18 years were included.

Ethics

The study protocol was approved by the Ethics Committee of the DUH (reference number 2022/1403-11). Because of the study design, which involved using existing hospital data, the requirement for written informed consent was waived. All methods were carried out according to relevant guidelines and regulations.

Data collected

For the study, we used data from the hospital's standard data collection form, which contains sociodemographic data, place of work and classification of workers by work areas. It also includes data about the circumstances of the EI, including the month when the EI occurred, the time when the EI occurred, how long the worker had been working at that time, what PPE the worker used, whether any object was involved in the EI, during what activity EI occurred, what type of injury occurred, what biological material the worker came into contact with.

Based on the dates of the pandemic, we classified the date when the EI occurred into two categories, including the period before the COVID-19 pandemic (from March 11, 2018, to March 10, 2020) and the period during the pandemic (from March 11, 2020, to March 11, 2022). These dates were selected because of the World Health Organization which declared the COVID-19 pandemic on March 11, 2020 [5]. Furthermore, in the Republic of Croatia, the Ministry of Health decided to declare an epidemic of the disease COVID-19 caused by the SARS-CoV-2 virus on March 11, 2020 [12]. Consequently, we considered the "pandemic" period to start on March 11, 2020.

Furthermore, we classified the date of the EI during the COVID-19 pandemic based on the status of the hospital (a COVID-19 hospital or not). During the COVID-19 pandemic, according to the decision of the Government of the Republic of Croatia, DUH was fully repurposed into a facility for the treatment of patients with the disease COVID-19 for Northern Croatia [13]. In this respect, the date of the EI during the COVID-19 pandemic was classified into three categories. The first period started before the pandemic and included a short time during the panemic when the hospital had not yet been declared a COVID hospital (from March 11, 2018, to March 18, 2020). During the second period, the hospital was declared a COVID-19 hospital exclusively (from March 19, 2020, through June 21, 2021). During the third period, the hospital treated patients with COVID-19 as well as other patients (from May 18, 2020, to November 2, 2020, and from June 21, 2021, to March 11, 2022).

Based on the use of PPE while the hospital was declared a COVID-19 hospital, we divided the date of the EI into three categories. The first was the period with the standard PPE use (according to procedures and workplace in non-COVID departments). The second was the period with the full PPE use in departments COVID (respirator mask, goggles/visor, protective suit, gloves) to protect against transmission of SARS-CoV-2. The third was the period with the de-escalating of PPE in departments COVID (as recommended by WHO as of December 2020) to protect against transmission of SARS-CoV-2 [14].

Additionally, we collected the numbers of hospitalized patients in the entire DUH for each month in the analyzed period. The total number of active hospital activities for each month in the analyzed period was collected, which includes the sum of the following activities: number of surgical procedures, number of polyclinic activities, number of hospitalized patients, and number of examinations in the hospital's Emergency Department (ED). If some patients were in the hospital for more than one month, the data on the number of patients were taken according to the initial state, which means the number of patients found on a date in a given period.

Data about the vaccination status against HBV was collected from the hospital worker files. In the Republic of Croatia, all healthcare workers and those exposed to the risk of exposure to blood-borne viruses should be vaccinated against HBV. At the time of employment in the institution, a vaccination certificate is attached and kept in the employee's documentation. Finally, we collected results of testing the worker who suffered EI for HBV, HCV, and HIV immediately following the EI.

Statistical analysis

Descriptive statistics were performed for all variables. Categorical variables were presented as frequencies and percentages. Continuous variables were analyzed depending on the normality of the distribution. The percentage of reduction for active hospital activities during the pandemic compared with the pre-pandemic period was calculated. The calculation was made by subtracting the number during the pandemic from the number for the pre-pandemic period, dividing by the initial number, and multiplying by 100.

A comparison was made of the rate of EIs: (a) between the period before the pandemic and the period after the pandemic began, (b) by the total number of hospitalized patients (expressed as the total number of EIs per 1000 patients per month) for the period before the pandemic and the period during the pandemic, and (c) by the total number of active hospital activities (expressed as the number of EIs per 1000 activities per month).

The chi-square test was used to compare the rate of EIs in relation to the total number of patients and the total number of hospital activities. MedCalc software (Mariakerke, Belgium) was used for the statistics. The statistical significance level was set at $p<0.05$.

Results

Characteristics of the workers who suffered exposure incident

The median age of the workers who suffered EI was 31 years (range: 18–65); most were healthcare workers (93%), more often women (74%). The median length of their service was five years (range: 0–42). They mostly had secondary professional education (37%). EI was most frequently reported in internal medicine departments (20%) (Table 1).

Reported exposure incidents

A total of 241 EIs were reported during the period from March 11, 2018, to March 11, 2022. Of these, 128 EIs were reported in the pre-pandemic period (from March 11, 2018, to March 10, 2020), while 113 EIs were reported in the analyzed period during the pandemic (from March 11, 2020, to March 11, 2022). Before the pandemic, 91% of EIs were recorded in healthcare workers, whereas during the pandemic, 96% of EIs were recorded in healthcare workers (Table 1).

Circumstances of the exposure incident

EIs more frequently occurred during the first shift (from 6 AM to 2 PM), and more frequently during the winter and summer months. The objects most often involved in EIs were needles and the circumstance was most often a puncture wound sustained during the injection. PPE was not used in 7.1% of cases, and 88% of workers were wearing gloves during the incident (Table 2).

The number of hospitalized patients and the total number of active hospital activities

There were more inpatients (hospitalized patients) and more surgical procedures and examinations in the polyclinic and ED in the pre-pandemic period compared to the pandemic period. The total number of active hospital activities was higher in the pre-pandemic period (Table 3).

Comparison of the rates of exposure incidents

The rate of EIs to the total number of hospitalized patients (expressed as the total number of EIs per 1000 patients per month) was higher during the pandemic (3.9) than in the pre-pandemic period (2.5). The rate of EIs to the total number of active hospital activities (expressed as the number of EIs per 1000 activities per month) was higher during the pandemic (0.4) than in the pre-pandemic period (0.2).

Results of testing the exposed worker for HBV, HCV, and HIV during the exposure incident

Among workers who reported EI, the average value of anti-HBs titer was 412 IU/L. The majority (99%) of workers were vaccinated against HBV with all three doses. Markers for anti-HCV, anti-HIV, and HBV antigens were negative in all workers who suffered an EI. Positive

Table 1 Characteristics of respondents for the period before and during the COVID-19 pandemic

Characteristic		The results		
		The entire observed period	Before the pandemic	During the pandemic
Age in years, median (range)		31 (18–65)	32 (18–65)	29 (18–62)
Sex, N (%)	Male	62 (26)	28 (22)	34 (31)
	Woman	179 (74)	100 (78)	79 (70)
Length of service, median (range)		5 (0–42)	5 (0–40)	6 (0–42)
Qualifications, N (%)	More than 2 years of university education	75 (31)	45 (35)	30 (27)
	Up to 2 years of university education	60 (25)	31 (24)	29 (26)
	High school education	88 (37)	38 (30)	50 (44)
	Other	9 (3.7)	8 (6.3)	1 (0.9)
	Pupils/students	9 (3.7)	6 (4.7)	3 (2.7)
Division of workers by field of work, N (%)	Health workers	224 (93)	116 (91)	108 (96)
	Non-health workers	17 (8)	12 (9)	5 (4.4)
Workplace, N (%)	Department of Surgery	35 (15)	25 (20)	10 (9)
	Department of Internal Affairs	48 (20)	34 (27)	14 (12)
	Operating block	44 (18)	33 (26)	11 (10)
	Intensive treatment	18 (7)	13 (10)	5 (4.4)
	Laboratory	8 (3.3)	4 (3.1)	4 (3.5)
	Diagnostics (X-ray)	8 (3.3)	5 (3.9)	3 (2.7)
	IC (intensive care center)	20 (8)	0	20 (18)
	RC (respiratory center)	40 (17)	0	40 (35)
	The rest	20 (8)	14 (11)	6 (5.3)

Table 2 Circumstances of the exposure incident for the period before and during the COVID-19 pandemic

Characteristic		The results		
		The entire observed period	**Before the pandemic**	**During the pandemic**
Month of injury, N (%)	January	20 (8)	8 (6.3)	12 (11)
	February	18 (7)	10 (8)	8 (7.1)
	March	19 (8)	14 (11)	5 (4.4)
	April	10 (4)	4 (3.1)	6 (5.3)
	May	17 (7)	7 (5.5)	10 (9)
	June	19 (8)	17 (13)	2 (1.8)
	July	27 (11)	19 (15)	8 (7.1)
	August	12 (5)	8 (6.3)	4 (3.5)
	September	20 (8)	10 (8)	10 (9)
	October	22 (9)	6 (4.7)	16 (14)
	November	30 (12)	15 (12)	15 (13)
	December	27 (11)	10 (8)	17 (15)
What time did the exposure incident occur, N (%)	First shift (6 AM – 2 PM)	173 (72)	101 (79)	72 (64)
	Second shift (2 PM – 10 PM)	42 (17)	19 (15)	23 (20)
	Third shift (10 PM – 6 AM)	23 (10)	6 (4.7)	17 (15)
	On-call (24 h)	3 (1.2)	2 (1.6)	1 (0.9)
How long the employee was at work at the time of the exposure incident, median (range)		4 (0–18)	4 (0.5–15)	3 (0–18)
Personal protective equipment used at the time of the exposure incident, N (%)	Gloves	212 (88)	105 (82)	107 (95)
	Surgical mask	109 (45)	0	60 (53)
	Prescription glasses	32 (13)	12 (9)	20 (18)
	Goggles/visor	50 (21)	4 (3.1)	46 (41)
	Linen coat/cloak	50 (21)	26 (20)	24 (21)
	PVC coat/cloak	31 (13)	6 (4.7)	25 (22)
	Respirator mask	17 (8)	0	17 (15)
	Protective suit	9 (3.7)	0	9 (8)
	Surgical cap	8 (3.3)	3 (2.3)	5 (4.5)
	Nothing	17 (7.1)	17 (13)	0
The object with which the exposure incident occurred, N (%)	Needle	181 (75)	88 (69)	93 (82)
	Scalpel	21 (9)	13 (10)	8 (7.1)
	Tweezers	1 (0.4)	1 (0.8)	0
	The rest	38 (16)	26 (20)	12 (11)
During which activity did the exposure incident occur, N (%)	Blood extractions	47 (20)	27 (22)	20 (18)
	Giving an injection	49 (20)	15 (12)	34 (31)
	Administering an infusion	4 (1.7)	1 (0.8)	3 (2.7)
	Surgical procedure	48 (20)	37 (29)	11 (10)
	In the laboratory	6 (2.5)	4 (3.1)	2 (1.8)
	The rest	75 (31)	38 (30)	37 (33)
	Placement of peripheral cannula	12(5)	6 (4.7)	6 (5.3)
Type of injury, N (%)	Prick	199 (83)	102 (80)	97 (86)
	Tax	13 (5)	6 (4.7)	7 (6.2)
	Scratch	7 (3)	4 (3.1)	3 (2.7)
	A bite	2 (0.8)	2 (1.6)	0
	Splashing in the eyes	11 (5)	7 (5.5)	4 (3.5)
	Spray in the mouth	1 (0.4)	1 (0.8)	0
	Spray on apparently intact skin	5 (2.1)	3 (2.3)	2 (1.8)
	Spray on obviously damaged skin	3 (1.2)	3 (2.3)	0
	The rest	0	0	0

Table 2 (continued)

Characteristic		The results		
		The entire observed period	Before the pandemic	During the pandemic
Biological material with which there was contact, N (%)	Blood	187 (78)	96 (75)	91 (81)
	Serum	0	0	0
	Saliva	5 (2.1)	2 (1.6)	3 (2.7)
	Tears	0	0	0
	Stool	0	0	0
	Urine	2 (0.8)	2 (1.6)	0
	The rest	17 (8)	13 (10)	4 (3.5)
	Unknown	27 (11)	15(12)	12 (11)
	There is no data	3 (1.2)	0	3 (2.7)

Table 3 Active hospital activities for the period before and during the COVID-19 pandemic

Characteristic		The results			
		The entire observed period	Before the pandemic	During the pandemic	Percentage reduction
Number of active hospital activities, N	Number of inpatients	79,917	51,217	28,700	44%
	Number of operations	32,669	23,266	9,403	60%
	Number of polyclinic activities	750,752	537,918	211,673	61%
	Number of examinations in the central emergency department	169,820	120,395	49,425	59%
Total number of active hospital activities, N		1,033,158	732,796	299,201	59%

*Percentage of reduction in the number of hospital activities in the period during the pandemic compared to the period before the pandemic

Table 4 Results of testing for HBV, HCV, and HIV during the exposure incident

Characteristic		The results		
		The entire observed period	Before the pandemic	During the pandemic
Markers on HBV, **HCV and HIV**, n/N (%)	Vaccinated against HBV	238 (99)	126 (98)	112 (99)
	Anti-HBs positive (average)	412 IU/L	606 IU/L	300 IU/L
	Anti-HCV positive	0/241(0)	0/128 (0)	0/113 (0)
	Anti-HBc positive	4/241 (1.7)	3/128 (2.3)	1/113 (0.9)
	Anti-HIV positive	0/241 (0)	0/128 (0)	0/113 (0)
	HBsAg positive	0/241 (0)	0/128 (0)	0/113 (0)

Abbreviations: n = number of positives, N = total number

anti-HBc was detected in 4 workers who suffered an EI (Table 4).

Exposure incidents during the pandemic depending on the status of the hospital

The number of exposure events varied depending on the status of the hospital (a COVID-19 hospital or not). In the pre-pandemic period, there were 128 exposure cases, 15 cases more than during the pandemic (in COVID hospitals), where there were 113 exposure cases, of which a total of 61 exposure cases were during the period when the hospital had a mixed work form. Slightly more EIs were recorded during the period of mixed work form and de-escalation of PPE (Table 5).

The rate of exposure incidents in relation to the total number of patients and the total number of hospital activities

The rate of EIs (128 before the pandemic; 113 during the pandemic) relative to the total number of patients (51,217 before the pandemic; 28,700 during the pandemic) was significantly higher during the pandemic ($\chi2=12.5713$; $p=0.000392$). Before the pandemic, there was 1 EI on 400 patients, while during the pandemic 1 EI occurred on 253 patients. The rate of EIs in relation to the total number of hospital activities (732,796 before the pandemic; 299,201 during the pandemic) was significantly higher during the pandemic ($\chi2=37.4782$; $p<0.00001$). Before the pandemic, there was 1 EI on 5,724 hospital activities, while during the pandemic 1 EI occurred on 2,648 hospital activities (Table 6).

Discussion

The findings of this study indicate that the rate of EIs per the number of hospitalized patients and hospital activities among healthcare and non-healthcare workers had significantly increased during the COVID-19 pandemic.

EIs most frequently occurred during the first shift (from 6 AM to 2 PM), when most medical diagnostic procedures and examinations are performed in hospital

Table 5 Number of exposure incidents depending on the status of the hospital (a COVID-19 hospital or not)

Characteristic		The results		
		The entire observed period	Before the pandemic	During the pandemic
Division of work period non-COVID/COVID (pandemic), N (%)	non-COVID	128 (53)	128 (100)	0
	COVID	113 (47)	0	113 (100)
Division of work period non-COVID/COVID /mixed (hospital), N (%)	non-COVID	128 (53)	128 (100)	0
	COVID	52 (22)	0	52 (46)
	COVID mixed	61 (25)	0	61 (54)
Division of work period non-COVID/ COVID concerning the use of personal protective equipment (PPE), N (%)	Standard application PPE	173 (72)	128 (100)	45 (40)
	Complete PPE	16 (7)	0	16 (14)
	De-escalation PPE	52 (22)	0	52 (46)

Table 6 The rate of exposure incidents (EI) in relation to the total number of patients and the total number of hospital activities

Variable	Before the pandemic	During the pandemic	χ2	*p*
The rate of EI relative to the total number of patients	128 / 51,217 = 1:400	113 / 28,700 = 1:253	12.5713	0.000392
The rate of EI relative to the total number of hospital activities	128 / 732,796 = 1:5,724	113 / 299,201 = 1:2,648	37.4782	< 0.00001

practice, most commonly during blood draws, injection administration, and surgical procedures. During the pandemic COVID −19, there was a higher prevalence of EIs during the winter months. The possible cause was pronounced epidemic waves in the winter months and, consequently more hospitalizations. On the contrary, in the pre-pandemic period, EIs occurred more frequently in the summer months, where the possible cause could be a lower number of workers due to vacations traditionally taken during the summer.

The average age of workers with EI was 29 years during the COVID-19 pandemic and 32 years before the pandemic. Healthcare workers with EIs had an average of 6 years of service during the pandemic and 5 years before the pandemic. These results could be explained by the fact that procedures that expose healthcare workers to a potential exposure event are likely to be performed to a greater extent by younger workers with less experience.

Among the staff that reported EIs, the most represented were those with a secondary vocational education, and among the health workers – nurses. A similar study, conducted in Turkey, was published in 2021 by Diktas et al. A significant increase in exposure rates among nurses was noted between the pre-pandemic and pandemic periods, from 0.8 to 6.89%. The results described by Diktas et al. are consistent with the findings of this study, as they also showed that the highest number of EIs both before and during the COVID-19 pandemic occurred in nurses [15].

European Biosafety Network reported on itswebsite that COVID-19 led to an increase of 276,000 (23%) in the number of sharps injuries to healthcare workers in Europe during the year 2020. The study was conducted in March/April 2021 and surveyed 80 of the largest national hospitals in France, Germany, Italy, Spain and Poland, covering more than 300,000 healthcare workers [16].

The results of our study show that the frequency of EIs increased during the period of the COVID-19 pandemic, relative to the number of admitted patients and hospital activities. Although the total number of EIs reported in the two years before the pandemic was 128 EIs, compared to 113 EIs during the pandemic, these numbers need to be put into context. This result must be viewed differently due to a series of changes that occurred at DUH during the pandemic, including changes in the number of patients and performed hospital procedures in the analyzed two years before the pandemic and two years during the pandemic. Therefore, data were collected on the number of active hospital activities, which are indicators of the burden on the health system in the period before and during the COVID-19 pandemic. Our results showed that the number of active hospital activities was lower compared to the period before the COVID-19 pandemic. The number of inpatients in the analyzed period

before the pandemic decreased by 44% in the period during the pandemic. The number of surgical procedures decreased by 60%. The number of outpatient activities decreased by 61%. The number of examinations at the ED decreased by 59%. The total number of active hospital activities decreased during the pandemic by 59% compared to the period before the pandemic. All these changes resulted from the repurposing of the institution, which was not open anymore to all patients during the COVID-19 pandemic.

In the period of the mixed mode of operation when there were COVID-19 and non-COVID-19 wards in the hospital, more EIs were recorded. This could be explained by a greater workload in terms of the two modes of operation where care had to be taken to adequately apply PPE, which were carried out at the same time and consequently, the fatigue of health workers. Stress, anxiety, and possibly other problems with wearing PPE should be considered, as they could affect concentration and fatigue. This is supported by the results of the study carried out in Italy on a sample of 150 nurses in 117 public hospitals, which indicated that the possible causes of sharp object injuries during the COVID-19 pandemic were lack of staff, physical fatigue, work in extraordinary conditions, stress and difficulty handling sharp objects when wearing complete PPE [17]. Furthermore, our study showed an increase in EIs among healthcare workers, which was also confirmed in a similar study conducted at DUH, where one of the conclusions was that the possible cause was the complexity of using PPE [8].

In the period of PPE de-escalation that followed the recommendations of the WHO from December 2020, more EIs were reported, which could be a consequence of the heavy burden and stress of the health system because the waves of the pandemic followed one another, especially after the second wave that started at the end of October 2020. This is supported by the study conducted in 80 European hospitals in Spain, France, Germany, Poland, and Italy, which included 300,000 healthcare workers. An increase in EIs in 2020 was observed due to stress and pressure due to COVID-19, lack of PPE and lack of safety devices [17].

Almost all workers who reported EI in this study were vaccinated against HBV, which speaks in favour of mandatory vaccination against HBV. The only difference was in the level of the anti-HBs titer; the rest of the serology for HBV, HCV, and HIV was negative. A high percentage of HBV vaccination was also recorded in other European countries [17].

Given the state of the COVID-19 pandemic in 2021, it was difficult to attend educational courses [17] and other forms of educational interventions related to the prevention of EI, which likely had an impact on EI frequency. It is important to implement safe practices for daily work in health institutions to prevent EIs, which include, for example, safe disposal and handling of sharp objects [18], not putting the cap back on the needle, proper use of PPE, and the use of needle-free sutures [19].

An important problem that should be highlighted in this context is the non-reporting of EIs. Our study was based on the data about reported EIs. However, there is a possibility that some workers did not report their EIs, and thus we could not include them in this analysis. Earlier research showed that non-reporting of EIs is common. In 2022, Vieira et al. published an article analyzing the underreporting of occupational incidents associated with blood-borne risk factors among hospital employees. Their results showed that the underreporting of such incidents related to biological risk factors was high, especially regarding mucocutaneous injuries (81%). Physicians were the professional category that least reported this type of incident at work (OR=4.64; 95% CI2.20-9.78). The problem of non-reporting was particularly pronounced among male health workers in surgery. The most common reasons for non-reporting described by respondents in the study by Vieira et al. were the administrative procedure, underestimation of exposure risk, and lack of knowledge about the need to report EI [20]. Therefore, it is necessary to carry out education about vaccination, the ways of transmission of infectious diseases, and the risk of infection by needle sticks, sharp objects and other forms of EIs [21].

In this study, the most numerous group of workers that reported EIs were nurses, who have specific responsibilities and therefore, could be more exposed to the risks of EI and stress during the COVID-19 pandemic. A study conducted in Taiwan showed that nurses had the highest stress level compared to other health workers. The five biggest stressors were "rough and chapped hands due to frequent use of hand washing and disinfecting agents", "inconvenience when using the toilet at work", "restriction on eating and drinking at work", "fear of transmitting the disease to relatives and friends" and "fear of infection with COVID-19". Discomfort caused by PPE was the main stressor for participants, followed by the burden of patient care [22].

A limitation of this study is its design, which relied on the existing hospital data and did not allow a more substantive exploration of causes that led to EI, i.e. whether it was due to fatigue, stress, some urgent and unpredictable situation, lack of staff, overtime or some other reason. Data collected in only one institution were analyzed. Furthermore, the study lacked confounder control. It would be useful to compare these results with the data of other institutions that had similar organizational conditions during the COVID-19 pandemic. For a better understanding of the causes that lead to EI, it would be valuable to include more variables in future research,

such as the worker's workload (e.g. number of working hours for the past month, use of annual leave), general state of health (e.g. present stress symptoms), workforce shortage (e.g.vacation periods and staff shortages) and other factors that can lead to EIs.

Conclusion

The rate of EIs relative to the total number of hospitalized patients and the total number of hospital activities in DUH was significantly higher during the pandemic, and the rate of total EIs increased among healthcare workers during the COVID-19 pandemic. The results of this study show that it is necessary to constantly and effectively work on the prevention of EI.

Abbreviations

COVID-19	Coronavirus Disease 2019
DUH	Dubrava University Hospital
ED	Emergency Department
EI	exposure incident
HBV	hepatitis B virus
HCV	hepatitis C virus
HIV	human immunodeficiency virus
IU/L	international units per liter
PPE	personal protective equipment
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus-2
WHO	World Health Organization

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Author contributions

Study design: VK, LP; Data collection, analysis, and interpretation: VK, JS, ML, LP; Writing of the manuscript and revising the manuscript for intellectual content: VK, JS, ML, LP; Final approval of the manuscript: VK, JS, ML, LP.

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Data availability

Requests for the raw data collected within this study can be submitted to the first author Valentina Košćak (koscakvalentina7@gmail.com), who will forward data requests to the Dubrava University Hospital Ethics Committee on behalf of the requestor.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of the DUH (reference number 2022/1403-11). Because of the study design, which involved using the existing hospital data, the requirement for written informed consent was waived. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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