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THE EFFECTIVENESS OF INTERVENTION TO REDUCE BLOOD-BORNE PATHOGEN EXPOSURE INCIDENTS IN HEALTHCARE WORKERS IN THE LARGEST CLINICAL SETTING IN SLOVENIA

UČINKOVITOST INTERVENCIJ ZA ZMANJŠEVANJE IZPOSTAVLJENOSTI S KRVJO PRENOSLJIVH PATOGENOV PRI ZDRAVSTVENIH DELAVCIH V NAJVEČJI KLINIČNI USTANOVI V SLOVENIJI

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ABSTRACT

Aim: Aimed at evaluating the effectiveness of intensified organised training programmes introduced in 2016 and 2017 for raising awareness of the problem of blood-borne incidents (BBIs), the objective was to analyse the incidence of reported BBIs (RBBI) over a 15-year period in different groups of healthcare workers (HCWs) employed at the University Medical Centre in Ljubljana (UMCL).

Methods: All UMCL incidents that occurred and were reported from 1 January 2008 to 31 December 2022 were included in the study. The entire period was divided into two observation periods, 2008-2017 and 2017-2022. For testing a linear trend, whenever applicable a piecewise/segmented linear regression was applied, with the year 2017 as a break-point.

Results: In the 2008-2017 period, the trend of annual incidence risk was mostly on the increase. The increase was statistically significant in medical doctors (MDs) and dental medicine doctors (DMDs) ($p<0.001$) as well as in other occupational groups ($p=0.015$). In the 2017-2022 period, the decrease was statistically significant in females ($p=0.011$), in MDs and DMDs ($p=0.007$), in nurses ($p=0.021$) and in HCWs in the Surgery Division ($p=0.023$).

Conclusion: The results of the present study suggest that measures introduced in the UMCL were partially effective. The findings could serve as a basis for the development of improved programmes for better prevention, reporting and reducing the consequences of blood-borne pathogen exposure incidents among HCWs not only in Slovenia, but also worldwide.

Keywords:
Occupational incidents
Sharps
Large clinical setting

IZVLEČEK

Namen: *Z namenom ovrednotenja učinkovitosti programov organiziranega usposabljanja za ozaveščanje o problemu incidentov s krvjo prenosljivimi patogeni, izvedenih v letih 2016 in 2017, je bil cilj analizirati pojavnost prijavljenih incidentov v 15-letnem obdobju pri različnih skupinah zdravstvenih delavcev (ZD), zaposlenih v Univerzitetnem kliničnem centru Ljubljana (UKCL).*

Metode: *V študijo so bili vključeni vsi incidenti v UKCL, ki so se zgodili in bili prijavljeni od 1. januarja 2008 do 31. decembra 2022. Celotno obdobje je bilo razdeljeno na dve opazovani obdobji, in sicer 2008-2017 in 2017-2022. Za testiranje linearnega trenda je bila, kjer je to bilo možno, uporabljena segmentirana linearna regresija z letom 2017 kot mejno točko.*

Rezultati: *V obdobju 2008-2017 je trend letnega pojavnega tveganja incidentov večinoma naraščal. Povečevanje tveganja je bilo statistično značilno v skupini zdravnikov in zobozdravnikov ($p < 0,001$) in v mešani skupini zdravstvenih delavcev ($p = 0,015$). V obdobju 2017-2022 je bilo zmanjševanje trenda statistično značilno pri ženskah ($p = 0,011$), v skupini zdravnikov in zobozdravnikov ($p = 0,007$), v skupini medicinskih sester ($p = 0,021$) in pri ZD na kirurškem oddelku ($p = 0,023$).*

Zaključek: *Rezultati te študije kažejo, da so bili ukrepi, uvedeni v UKCL, v nekaterih skupinah ZD učinkoviti. Ugotovitve bi lahko služile kot osnova za razvoj izboljšanih programov za boljše preprečevanje, poročanje in zmanjševanje posledic izpostavljenosti s krvjo prenosljivim patogenom med ZD tako v UKCL kot tudi v drugih podobnih ustanovah v Sloveniji in izven nje.*

Ključne besede:
nezgode pri delu
ostri predmeti
velike zdravstvene ustanove

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1 INTRODUCTION

Healthcare workers (HCWs) are at high risk of developing infections caused by blood-borne pathogens, due to injuries with sharp medical devices (sharps), and skin and mucous membrane contacts with blood or other potentially infectious materials (1-6). Accidental occupational exposure to blood-borne pathogens, particularly to blood-borne viruses such as hepatitis B, hepatitis C and HIV, can affect an HCW's health and lead to debilitating or even fatal consequences (1, 2, 4). Additionally, the HCWs may experience significant emotional distress, fear and anxiety that may sometimes result in behavioural and occupational changes (3, 5, 7, 8). The infection is not only health damaging, but could also destroy the HCW's career and impact the hospital costs (3, 8).

Therefore, early reporting of blood-borne pathogen exposure incidents (BBIs) is crucial for immediate medical evaluation and follow-up. The beginning of immediate intervention is very important to address possible infection of the HCW and it can also help to avoid spreading blood-borne infection to others (9). Unfortunately, numerous studies show that underreporting of BBIs is considerable (10-12).

BBIs may occur in various health occupations (6, 7) as many medical procedures require the use of sharps that may penetrate the skin and cause an injury (1, 2, 6, 13). The responsible services at the University Medical Centre Ljubljana (UMCL), the largest medical centre in Slovenia, have recognized the problem and already faced it - since 1998, HCWs have been monitored and treated for incidents. However, the period 2016-2017 represents a major milestone, when intensified organised intervention - health promotion and administrative measures for reducing BBIs - was introduced.

Aimed at evaluating the effectiveness of this intervention, the objective was to analyse the incidence of reported BBIs (RBBIs) over a 15-year period in different HCW groups.

2 METHODS

2.1 Study design, time frame, observed population

A time-trend study with one year as a unit of observation was performed.

The subjects included were HCWs employed at the UMCL who reported BBIs and were treated according to the guidelines for BBIs between 1 January 2008 and 31 December 2022. This period was divided into two periods: 2008-2017 and 2017-2022. The observed HCW groups were medical doctors (MDs) and dental medicine doctors (DMDs), nurses, nurse assistants (NUAs) and others (such as laboratory workers and researchers, radiological engineers, physiotherapists and so forth).

2.2 Intervention to reduce BBIs in 2016 and 2017

Intensified educational and promotional activities included:

- information on the most common causes of BBIs;
- the importance of incident reporting;
- information on the risk of infection when exposed to infected blood;
- the protocol for the organisation and treatment of incidents in UMCL;
- preventive measures from a technical, medical and educational point of view;
- the use of safe devices;
- legislation on this issue;
- the presentation of an annual BBIs report;
- implementation of a new information system and introduction of safety discussions for deviation reporting.

The activities were first performed among health coordinators, hygienists, teaching nurses and nurses who are in charge of quality at the UMCL. They transferred the content of the trainings to other HCWs.

2.3 Data collection

The basic data were collected as extracts from the medical exposure reports, each comprising the date and time of the RBBI, date and time when the HCW reported the incident, details of the procedures being performed, including where and how the exposure occurred, and whether the exposure involved sharps or skin/mucous membrane contacts with blood or other potentially infectious materials. Following this, the incidents were first aggregated at the annual level as the annual incident number (AIN). Then the incidence risk was expressed as the incidence number in relation to the number of HCWs in each group of HCWs as a percentage - annual incidence risk (per 100 staff) (AIR). The denominator in the groups of HCWs by sex, occupation and department/division was the number of HCWs in each group, while the denominator in the types of incidents was the total number of UMCL staff. In addition, the percentage of incidents due to the individual cause (per 100 incidents) was expressed.

2.4 Statistical analysis

The distribution of AIR was statistically described by non-parametric typical values: minimum-maximum (min-max), median and interquartile range (Q1-Q3). The differences between HCW groups were tested using non-parametric tests (Mann-Whitney and Kruskal-Wallis tests).

The temporal patterns of AIR are presented as sequence plots (trend line is added where applicable). For testing the linear trend, whenever applicable, a piecewise/ segmented linear regression was applied, with the year 2017 as a break-point. P-values <0.050 were considered

statistically significant. Data were analysed by SPSS for Windows (Version 27.0. SPSS Inc. Chicago, IL, USA).

2.5 Ethical aspects

The basic data were collected from the UMCL medical exposure reports. As the reports contain personal data, access to them is strictly limited and the data is anonymised before any analysis. For the purpose of this study, individual data were further aggregated, and as such did not allow the disclosure of any identity of HCWs. The study was also approved by the Republic of Slovenia National Medical Ethics Committee (No. 0120-153/2018/7).

3 RESULTS

3.1 Basic description of the study population

In the period 2008-2022, the average annual number of HCWs employed at the UMCL was 5,644. Their structure by gender, occupation and division/department is presented in Table 1.

3.2 AIN of RBBI

The average AIN of RBBIs was 115.2, with the minimum in 2022 and the maximum in 2017 (Table 2). The AIN of RBBIs by gender, occupation and by division/department is presented in Table 2.

Table 1. Healthcare workers employed at University Medical Centre Ljubljana, Slovenia, 2008-2022, by gender, occupation and division/department.

Group	Year														
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
All	5198	5279	5257	5513	5520	5496	5596	5696	5871	5807	5921	5861	5870	5934	5837
GENDER															
Males	1092	1109	1104	1157	1159	1154	1175	1216	1274	1149	1185	1340	1163	1202	1204
Females	4106	4170	4153	4356	4361	4342	4421	4480	4597	4658	4736	4521	4707	4732	4633
OCCUPATION															
MDs/DMDs	1308	1256	1191	1211	1184	1160	1171	1206	1240	1264	1331	1482	1520	1547	1537
Nurses	3198	3232	3272	3454	3491	3509	3589	3651	3777	3793	3818	3680	3622	3642	3547
Nurse assistants	105	199	208	216	215	211	216	219	225	227	231	219	209	210	204
Other occupations	587	592	586	632	630	616	620	620	629	523	541	480	519	535	549
DIVISION/DEPARTMENT															
Internal Medicine	1014	1035	1003	1052	1074	1084	1106	1133	1178	1205	1235	1189	1076	1170	1181
Surgery	1563	1570	1588	1645	1641	1658	1674	1727	1782	1785	1781	1763	1584	1696	1693
Neurology	239	267	266	268	294	288	296	308	319	331	334	344	310	325	331
Stomatology	78	69	72	73	71	68	66	67	69	68	76	75	69	69	74
Infectology	213	217	209	245	245	253	257	266	280	270	277	268	774	298	279
Dermatovenerology	69	67	66	71	69	60	66	66	67	67	69	75	62	73	73
Otorhinolaryngology	123	118	116	128	128	127	132	137	137	141	144	151	137	132	128
Gynaecology/Obstetrics	504	492	495	498	486	459	480	477	466	481	496	482	438	472	467
Ophthalmology	149	146	147	155	152	151	152	149	154	162	171	170	156	171	173
Paediatrics	445	451	444	439	446	429	436	430	431	423	432	428	404	494	499
Other	801	847	851	939	914	919	931	936	988	874	906	916	860	1034	939

Legend: MDs=medical doctors, DMDs=dental medicine doctors

Table 2. The number of reported blood-borne pathogen exposure incidents in healthcare workers at the University Medical Centre Ljubljana, Slovenia, 2008-2022, by gender, occupation and division/department.

Group	Year														
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
All	86	106	115	103	132	135	131	134	109	159	131	116	100	99	72
GENDER															
Males	10	28	19	24	26	27	27	27	26	49	39	33	13	18	20
Females	76	78	96	79	106	108	104	107	83	110	92	83	87	81	52
OCCUPATION															
MDs/DMDs	20	25	17	21	28	29	34	32	33	41	35	32	24	28	23
Nurses	40	57	57	51	65	72	51	62	45	72	61	66	59	47	29
Nurse assistants	15	10	12	11	17	13	10	7	5	17	10	6	11	10	3
Other occupations	11	14	29	20	22	21	36	33	26	29	25	12	6	14	17
DIVISION/DEPARTMENT															
Internal Medicine	22	18	28	30	27	34	17	21	21	29	44	27	37	16	19
Surgery	21	50	45	33	55	53	61	56	42	69	38	48	36	31	18
Neurology	1	3	7	3	4	7	2	13	6	10	8	7	3	6	5
Stomatology	6	4	4	9	8	7	5	11	9	6	7	7	1	4	5
Infectology	1	0	9	8	10	4	7	1	0	6	2	1	0	3	7
Dermatovenerology	0	0	0	2	0	2	2	0	0	2	1	0	1	1	0
Otorhinolaryngology	3	6	2	5	1	4	2	2	3	1	2	2	1	3	0
Gynaecology/Obstetrics	6	9	7	3	8	6	5	8	7	9	5	9	9	7	3
Ophthalmology	4	0	2	1	4	5	7	4	6	4	5	4	3	4	3
Paediatrics	1	2	0	1	6	4	1	3	5	3	3	3	0	6	2
Other	21	14	11	8	9	9	22	15	10	20	16	8	9	18	10

Legend: MDs=medical doctors, DMDs=dental medicine doctors

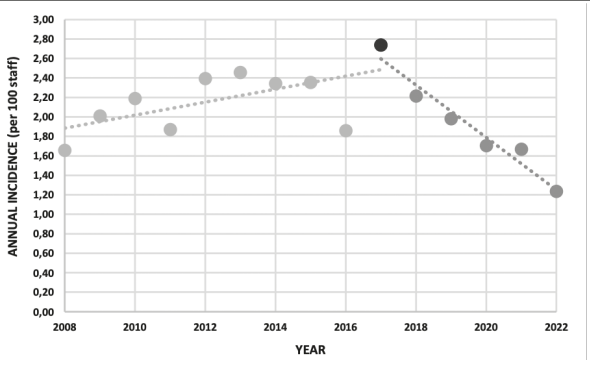
3.3 AIR of RBBIs in the entire group of HCWs

The median value of AIR of RBBIs in the entire group was 2.01 (min-max: 1.23-2.74; Q1-Q3: 1.70-2.35). It was possible to assess the linear trend in both observed periods. In the 2008-2017 period, it increased statistically marginally significantly (b=0.067; p=0.062), while in the 2017-2022 period it significantly decreased (b=-0.270; p=0.001) (Figure 1).

3.4 AIR of RBBIs in HCW groups

A statistical description of AIR of RBBIs in HCW groups is given in Table 3. There were no significant differences between genders (Figure 2), while significant differences were detected between occupations and divisions/departments (Figures 3–4).

Among occupations, the lowest values were detected among nurses and the highest among NUAs. The pairwise comparison showed some significant differences: nurses vs. NUAs (p<0.001), nurses vs. other occupations (p<0.001), and MDs/DMDs vs. NUAs (p<0.001) (Figure 3).



Legend: ● =pre-intervention period; ● =approximate point of intervention; ● =post-intervention period.

Figure 1. Annual incidence risk (per 100 staff) of reported blood-borne pathogen exposure incidents in healthcare workers at the University Medical Centre Ljubljana, Slovenia, 2008-2022.

Table 3. Statistical description of annual incidence risk of reported blood-borne pathogen exposure incidents in healthcare workers at the University Medical Centre Ljubljana, Slovenia, 2008-2022.

Group	MEDIAN	MIN-MAX	Q1-Q3	p
GENDER				
Males	2.22	0.92-4.26	1.66-2.46	0.803
Females	1.87	1.12-2.49	1.81-2.36	
OCCUPATION				
MDs/DMDs	2.16	1.43-3.24	1.58-2.65	<0.001
Nurses	1.63	0.82-2.05	1.29-1.79	
Nurse assistants	5.03	1.47-14.29	3.20-6.16	
Other occupations	3.41	1.16-5.81	2.50-4.95	
DIVISION/DEPARTMENT				
Internal Medicine	2.27	1.37-3.56	1.74-2.85	<0.001
Surgery	2.72	1.06-3.87	2.01-3.24	
Neurology	1.85	0.42-4.22	1.12-2.43	
Stomatology	8.82	1.45-16.42	5.80-11.27	
Infectology	1.01	0.00-4.31	0.37-2.72	
Dermatovenerology	0.00	0.00-3.33	0.00-2.82	
Otorhinolaryngology	1.52	0.00-5.08	0.78-2.44	
Gynaecology/Obstetrics	1.48	0.60-2.05	1.04-1.83	
Ophthalmology	2.47	0.00-4.61	1.73-2.92	
Paediatrics	0.69	0.00-1.35	0.23-0.93	

Legend: Q1-Q3=interquartile range, MDs=medical doctors, DMDs=dental medicine doctors.

Among divisions/departments, the lowest values were detected in the Paediatrics and the highest in the Stomatology Divisions. The pairwise comparison showed a significant difference between the Stomatology Division and the Paediatrics Division (p<0.001), the Dermatovenerology Department (p<0.001), the Gynaecology/Obstetrics Division (p<0.001), the Infectious Diseases Department (p<0.001), the Otorhinolaryngology Department (p=0.001) and the Neurology Division (p=0.001), as well as between the Paediatrics Division and the Ophthalmology Department (p=0.004), the Internal Medicine Division (p=0.002) and the Surgery Division (p<0.001) (Figure 4).

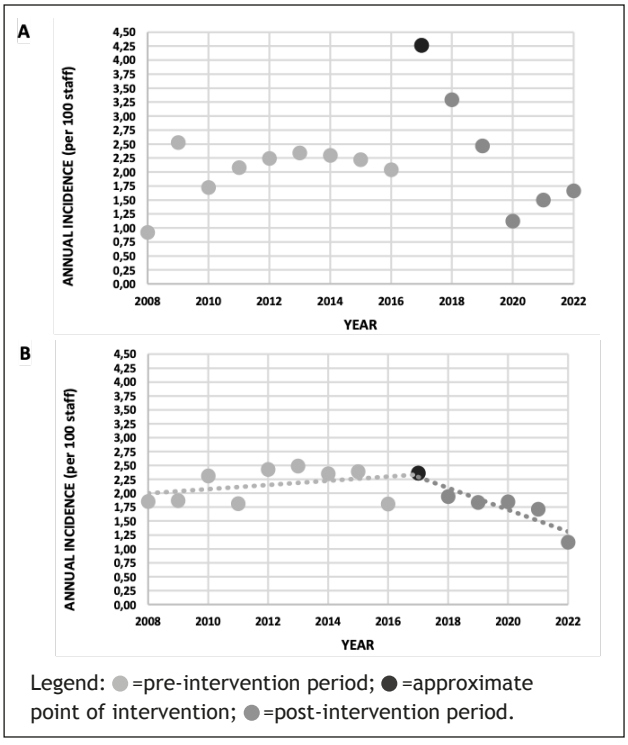


Figure 2. Annual incidence risk (per 100 staff) of reported blood-borne pathogen exposure incidents in healthcare workers at the University Medical Centre Ljubljana, Slovenia, 2008-2022, in A) males, and B) females.

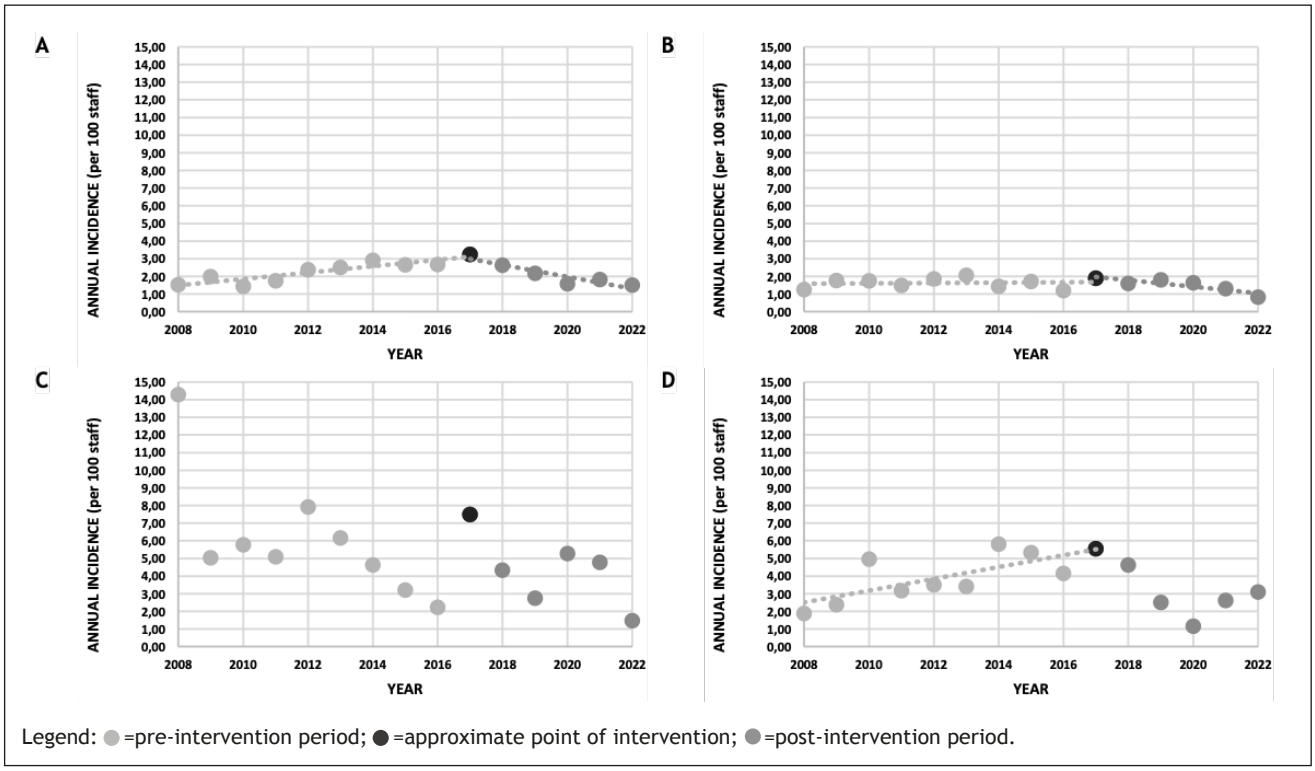


Figure 3. Annual incidence risk (per 100 staff) of reported blood-borne pathogen exposure incidents in healthcare workers at the University Medical Centre Ljubljana, Slovenia, 2008-2022, in A) medical doctors/dental medicine doctors, B) nurses, C) nurse assistants, and D) other healthcare workers.

The linear trend in both observed periods was possible to assess in the majority of HCW groups (Table 4). It mostly increased in the 2008-2017 period (it was significant in MDs/DMDs, and in other HCWs (Table 4), while in the 2017-2022 period it was mostly decreasing in all HCW groups (it was significant in females, MDs/DMDs, nurses, and in the Surgery Division (Table 4).

The decrease in incidence in the 2017-2022 period was also close to being significant in the Neurology Division and in the Ophthalmology Department (Table 4). However, it is clearly visible in Figures 4C and 4I that these two organizational units already showed the beginning of a decline in incidence before 2017. In the Neurology Division, a statistically significant downward trend started in 2015 (b=-0.305; p=0.033) and in the Ophthalmology Department in 2014 (b=-0.277; p=0.008).

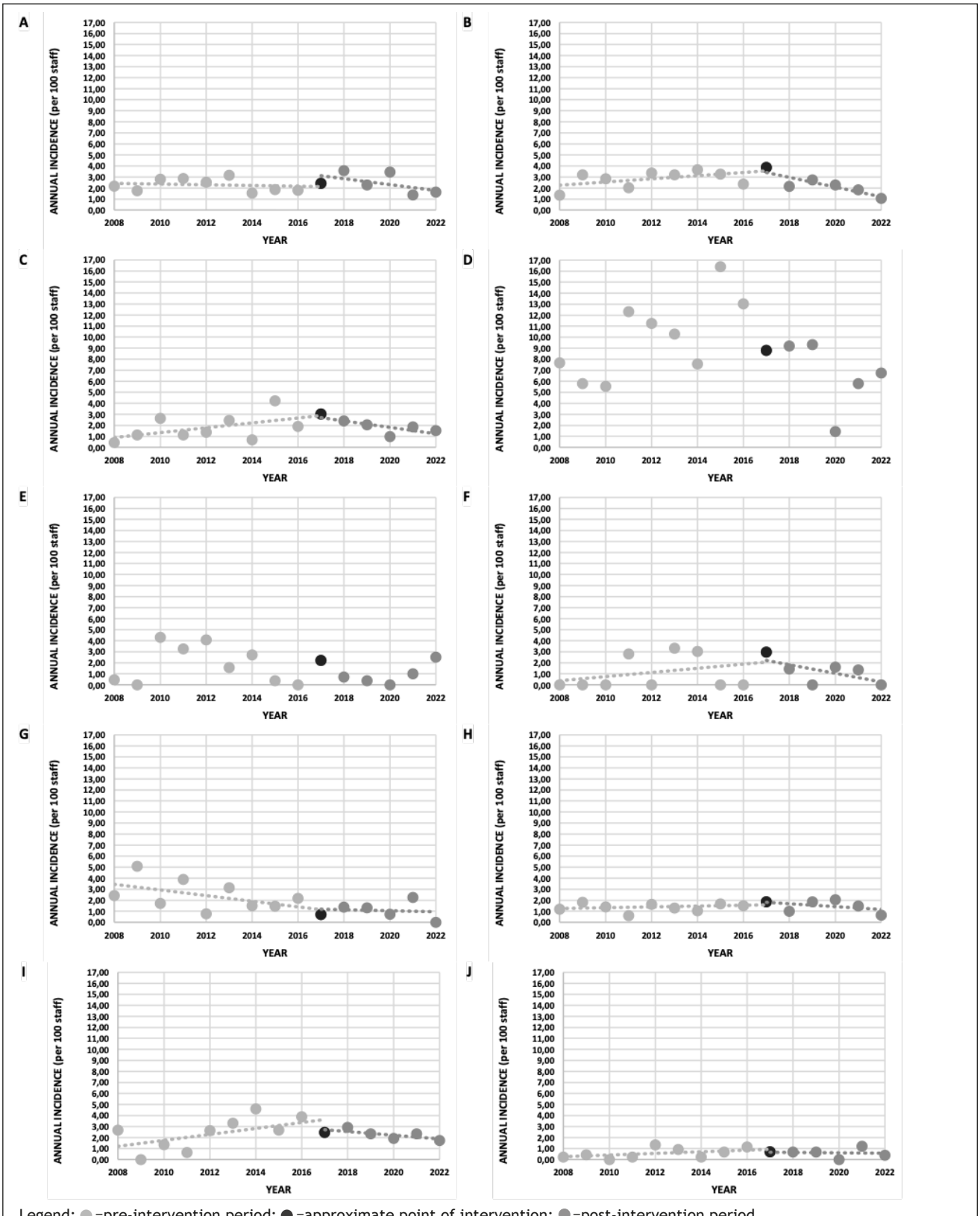


Figure 4. Annual incidence risk (per 100 staff) of reported blood-borne pathogen exposure incidents in healthcare workers at the University Medical Centre Ljubljana, Slovenia, 2008-2022, in observed departments/divisions: A=Internal Medicine, B=Surgery, C=Neurology, D=Stomatology, E=Infectology, F=Dermatovenerology, G=Otorhinolaryngology, H=Gynaecology/Obstetrics, I=Ophthalmology, J=Paediatrics.

Table 4. Trend of annual incidence risk of reported blood-borne pathogen exposure incidents in healthcare workers at the University Medical Centre Ljubljana, Slovenia, by gender, occupation and division/department in two predefined periods.

HCW GROUP	2008-2017		2017-2022	
	b	p	b	p
GENDER				
Males	NA	NA	NA	NA
Females	0.038	0.258	-0.197	0.011
OCCUPATION				
MDs/DMDs	0.181	<0.001	-0.335	0.007
Nurses	0.010	0.769	-0.185	0.021
Nurse assistants	NA	NA	NA	NA
Other occupations	0.334	0.015	NA	NA
DIVISION/DEPARTMENT				
Internal Medicine	-0.034	0.605	-0.269	0.254
Surgery	0.144	0.093	-0.440	0.023
Neurology	0.221	0.089	-0.293	0.071
Stomatology	NA	NA	NA	NA
Infectology	NA	NA	NA	NA
Dermatovenerology	0.187	0.308	-0.388	0.167
Otorhinolaryngology	-0.254	0.099	-0.043	0.845
Gynaecology/Obstetrics	0.037	0.420	-0.130	0.386
Ophthalmology	0.270	0.081	-0.168	0.089
Paediatrics	0.076	0.130	-0.020	0.862

Legend: NA=not applicable, MDs=medical doctors, DMDs=dental medicine doctors.

3.5 AIR of RBBIs due to selected causes in the total group of HCWs

Table 5 shows that the majority of RBBIs were due to contact with sharps. The median value was 88.8% (min-max: 85.5-92.2%). Other causes were rare.

Table 5. Distribution of reported blood-borne pathogen exposure incidents due to selected causes in healthcare workers at the University Medical Centre Ljubljana, Slovenia, 2008-2022.

Cause	Year														
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Sharp device	82	93	105	95	120	125	113	119	101	140	112	97	72	88	59
Splash into eye	3	8	8	3	5	6	12	8	6	9	6	5	6	8	6
Skin contact	0	3	2	4	2	3	2	1	2	3	7	3	1	0	0
Other causes	1	2	0	1	5	1	4	6	0	7	6	11	21	3	7

Also, the AIR of RBBIs due to contact with sharps was the highest (Figure 5). The median value of AIR of RBBIs due to contact with sharps over the observed period in the entire group of HCWs was 1.76 (min-max: 1.01-2.41; Q1-Q3: 1.58-2.09).

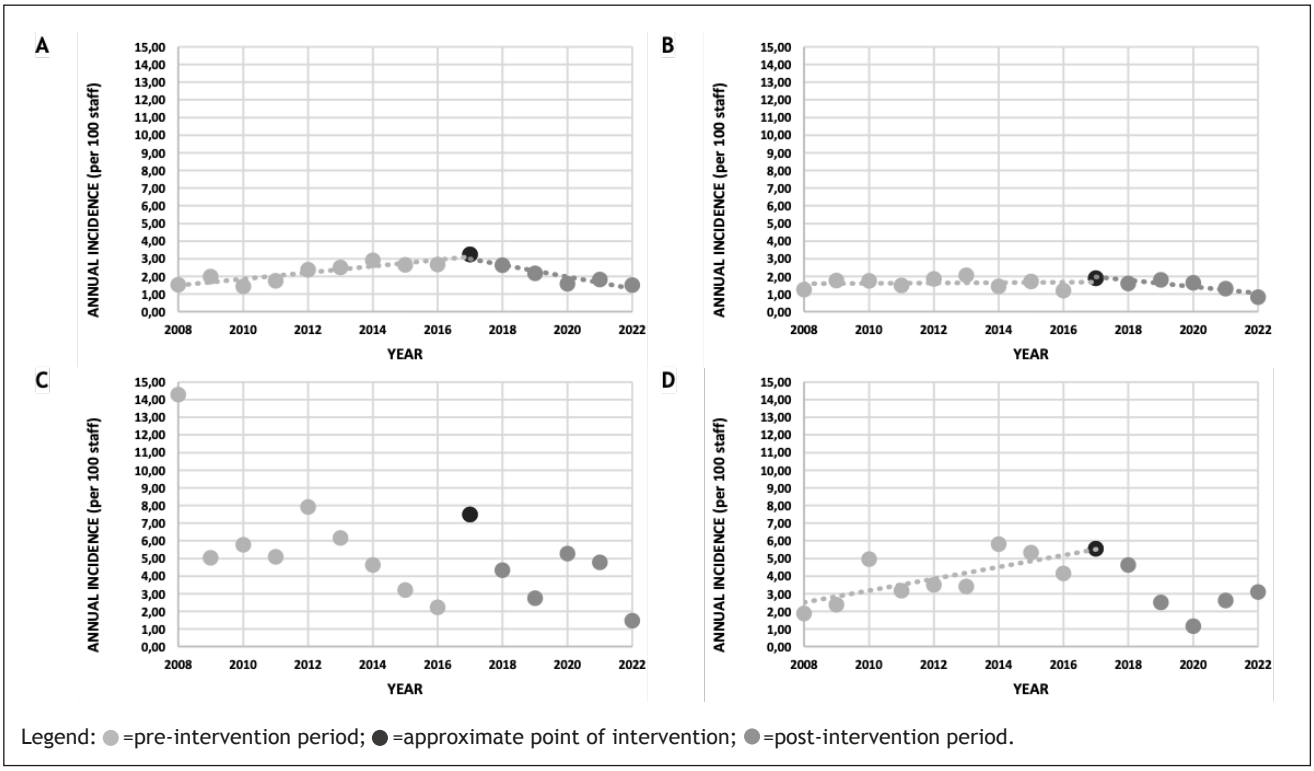


Figure 5. Annual incidence (per 100 incidents) of reported blood-borne pathogen exposure incidents in healthcare workers at the University Medical Centre Ljubljana, Slovenia, 2008-2022, due to A) sharps incidents, B) splashes into eyes, C) skin contact with potentially infectious materials, and D) other causes.

The linear trend of AIR of RBBIs due to selected causes was possible to assess in all causes in both observed periods (Table 5).

Table 6. Trend of annual incidence of reported blood-borne pathogen exposure incidents due to selected causes in healthcare workers at the University Medical Centre Ljubljana, Slovenia in two predefined periods.

Cause	2008-2017		2017-2022	
	b	p	b	p
Sharp device	0.052	0.076	-0.247	0.007
Splash into eye	0.006	0.329	-0.004	0.502
Contact of skin	0.000	0.880	-0.018	0.081
Other causes	0.008	0.133	NA	NA

The dynamics are most evident in RBBIs due to sharp devices, where the decrease in AIR in the 2017-2022 period is statistically significant (Table 6).

4 DISCUSSION

The study results showed that intervention was in general effective, as there was a statistically significant trend of decreasing AIR of RBBIs in the post-intervention period.

Unfortunately, the comparison of the results of our study with the results of similar studies was limited, since we have not found any very similar study in the literature. We were able to compare, for example, AIR of RBBIs, and the comparison showed that the incidence of RBBIs at UMCL was lower than in other studies (1, 14), which could mean underreporting, especially because even in studies with a higher incidence, underreporting is exposed as a problem (4, 11, 13, 15).

In terms of gender, the study showed that the intervention had a positive effect on female HCWs. Unfortunately, a linear trend could not be assessed in men. Interestingly, our study did not find a significant difference in BBIs between males and females, which is in contrast to some other studies, some of which reported a higher incidence in women (7, 16-18) and others in men (14).

Among the different occupational groups of HCWs, the effect of the intervention was greatest in the MD/DMD group, especially because this group recorded a significant increase of RBBIs before the intervention, and after it the strongest decline among all occupational groups. Despite the fact that the group of nurses in general has the lowest values, the intervention seems to have resulted in a further decrease of the problem. This may be due to the fact that the educational programmes on preventive measures were most intensively performed in this occupational group. On the other hand, RBBIs were most frequent in NUAs. This result is consistent with the findings of some other studies reporting a substantial risk of incidents among NUAs especially with sharps (1, 19). The reason was mostly sharps laid wrongly or placed in overfilled containers, inappropriate placing or emptying sharps containers. However, there is no evidence of effectiveness of intervention in this occupational group. It was similar in the other HCWs group.

The study also provided some important results related to divisions/departments. First, the most notable result was the high AIR of RBBIs in the Stomatology Division. However, this is consistent with some other studies which indicate that dental HCWs are at highest risk of BBIs (20, 21). On one hand percutaneous injuries prove to be a substantial risk (22), while on the other, exposure to blood and body fluids due to the nature of the occupation also represents a common problem (23). Unfortunately, the intervention did not achieve its goal in this division. Second, a significant decrease in AIR in the period 2017-2022 was recorded in the Surgery Division, where, due to the nature of the work, there is a lot of contact with sharps and, as a result, exposure to injuries is high (16, 24). This result suggests that the intervention was successful in this division. Finally, a significant decrease in AIR of RBBIs was also recorded in the Ophthalmology Department and the Neurology Division. However, this decline began before the observed intervention (in 2014 and 2015 respectively), which could be explained by the intensive trainings that took place in both units at that time.

Regarding the causes of BBIs, the intervention resulted in a significant decrease in BBIs only in sharps. However, this is actually the most important result, since this cause is by far the most common, as reported also in many other studies (1, 4, 7, 8, 25-27). It is even more important because in the pre-intervention period there was an increasing trend of BBIs with sharps. It seems that HCWs generally started to follow precautions more strictly after the intervention.

The current study has some limitations. First, only reported incidents were included, which were certainly not all. However, we believe that this gap does not represent a significant problem. Second, one can argue that participants from only one health institution were included. However, this institution is one of the largest healthcare facilities in Central Europe (28). Next, the increase in BBIs in the pre-intervention period could also be influenced to some extent by UMCL's efforts to increase the reporting of incidents, which had been going on for several years before the observed intervention. However, we believe that these activities did not have a major impact on the presented results. Next, within the post-intervention period, the Covid-19 pandemic was included, which could represent a source of bias. However, we believe that the pandemic in fact resulted in greater awareness of the importance of reporting BBIs along with a much greater consideration of precautionary measures, so the effect of the decrease shown by the results can be attributed mainly to the intervention. Finally, one might argue that the study provides no comparison with data from other hospitals in the country. However, such a comparison was out of the scope of this study, as it was a UMCL project. On the other hand, this study has an important strength - according to the available literature, it is the first to systematically investigate the data on RBBIs in a large clinical setting over a longer period of time, which also included an intervention to reduce the problem.

Despite the limitations, the study provides important implications for occupational medicine. The findings could serve in development of improved programmes for better prevention, and earlier and more accurate reporting of BBIs.

Among the promotional activities in UMCL, the most effective measures were training of HCWs, activities that promoted BBIs reporting, and preventive procedures that included proper use of safety devices. On the other hand, the protocol for reporting and treatment of BBIs proved

to be less appropriate and needs to be further upgraded. Accordingly, the findings suggest that additional health promotion and/or supervisory work-related interventions are needed. At UMCL, it will definitely be necessary to pay more attention to the education of the male section of HCWs, those HCWs who are not MD/DMDs or nurses, especially to the education of NUAs, and among the departments/divisions to the Stomatology Division, which should be supported by regular periodic surveys, as is already the case with nosocomial infections (29).

Although the findings of the current study make a significant contribution, further research is needed to elucidate the situation. First, additional data on subjects who have experienced BBIs in the UMCL, will enable more extensive statistical analysis and provide more data necessary for the development of even more reliable programmes for the management of BBIs. Next, it would be very reasonable to extend the UMCL project to at least other hospitals in Slovenia, to highlight whether the trends at UMCL are consistent with broader patterns or unique to this institution, and it would be even better if it could be extended to similar hospitals in neighbouring countries.

5 CONCLUSIONS

The results of the study showed that intervention introduced at the UMCL was partially effective; however, at the same time the study showed in which HCW groups it was less effective. The findings could serve as a basis for development of improved prevention programmes and BBIs reporting among the HCWs, not only in Slovenia, but also more widely.

CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist.

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ETHICAL APPROVAL

The study was approved by the Republic of Slovenia National Medical Ethics Committee (No. 0120-153/2018/7) and was carried out according to the Helsinki Declaration.

AVAILABILITY OF DATA AND MATERIALS

The basic data were collected from the UMCL medical exposure reports, which include personal data, therefore the data and materials are not available unless approved by the data owner.

LLM STATEMENT

During the preparation of this work the authors used no AI and AI-assisted technologies.

PREPRINTS STATEMENT

No preprint has been deposited on any preprint server.

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