

## Original Article

## Occupational Exposure to Potentially Infectious Biological Material Among Physicians, Dentists, and Nurses at a University



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## ARTICLE INFO

## Article history:

Received 27 June 2018

Received in revised form

11 June 2019

Accepted 24 July 2019

Available online 2 August 2019

## Keywords:

Accidents at work

Compliance to standard precautions

Incidence

Needle stick injuries

Prevalence

## ABSTRACT

**Objective:** The objective of this study was to evaluate the prevalence and incidence of accidents with biological material, the level of knowledge, and compliance to standard precautions (SPs) among dentists, physicians, nurses, and dental and medical students.

**Methods:** A closed cohort study with a prospective and retrospective component was conducted between August 2014 and September 2015. The participants were contacted in two moments during the follow-up period, during which a structured questionnaire divided into six sections was used; the interviews were conducted during the follow-up period (Month 6) and at the end of the observation period (Month 12).

**Results:** The global prevalence of accidents in the previous 12 months was 10.2%, with a difference between professionals and students (13.0% vs. 5.1%, respectively;  $p < 0.003$ ). The incidence rate was 6.49 per 100 person/year, with difference between the groups (6.09 per 100 person/year in professionals and 7.26 per 100 person/year in students), type of specialization (hazard ratio, 3.27), and hours worked per week (hazard ratio, 2.27). The mean of compliance to SP was 31.99 ( $\pm 3.85$ ) points, with a median of 33 (30, 35) points against the expected 27.75 points. Adherence to SP was associated with the accident report ( $p < 0.020$ ).

**Conclusion:** We conclude that the proportion/incidence rate of accidents with biological material was high in relation to that in the literature, being higher in professionals and especially among physicians. The levels of knowledge and adherence to SP were good, with the best found in dentists and dental students.

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## 1. Introduction

Contact with blood and other potentially infectious biological material (BM) as a result of occupational accidents may represent a threat to the health of students and health professionals, especially in medicine, dentistry, and nursing. Accidents involving contact with blood and potentially contaminated body fluids may be associated with the transmission of 60 different pathogens, among which, hepatitis B virus (HBV), hepatitis C virus (HCV), and the virus responsible for acquired immunodeficiency syndrome (HIV) are highlighted [1].

The risk of pathogen transmission from infected persons to nonimmune persons through an injury with a sharp object has

been estimated to be between 6% and 30% for HBV; between 5% and 10% for HCV, and 0.3% for HIV [2]. It is estimated that each year, 35.7 million health workers and related professionals around the world are at risk of acquiring diseases caused by microorganisms in the blood stream via percutaneous contact [3].

Although there are ways to reduce such risks, such as a precaution standard created in 1981 by the Centers for Disease Control and Prevention initially with the name of universal precautions, such precautions are not always taken [4,5]. In addition, noncompliance may reflect high rates of incidence of occupational accidents by exposure to body fluids and sharp objects [6–8]. The purpose of this study was to evaluate the frequency of needle-stick injury (NSI) and associated factors among a group of

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professional health-care students as well as their knowledge and practices regarding the use of protective strategies against exposure to blood-borne pathogens.

## 2. Materials and methods

A closed cohort study with a prospective and retrospective component was conducted between August 2014 and September 2015, including students (dentistry and medicine) and health professionals (dentists, physicians, and nurses).

The cohort was created after a prior cross-sectional study that evaluated the level of knowledge regarding the modes of transmission of HBV, HCV, and HIV, adherence to standard precautions (SPs), and the perception of sexual and work-related risks. The study retrospectively evaluated the prevalence of reported occupational injuries with exposure to BM in the period of 12 months before the study.

The participants were contacted in two moments during the follow-up period; the interviews were conducted during the follow-up period (Month 6) and at the end of the observation period (Month 12).

The sample size was calculated using an online program, Epi Info. (versão 7.2.2.6), and it considered the maximum acceptable sampling error of 0.05 (5%), test power of 80%, and probable estimated incidence of accidents among the most exposed health professionals (surgeons) of 46.9% and the least exposed professionals (clinicians) of 18.7% [12] resulting in 628 participants.

The recruitment of individuals included in the sample was done by direct contact in the workplace or in the classroom; participants in the study were included as per the following criteria: current health professionals working in a hospital or a student enrolled in any college (medicine, nursing, or dentistry).

The structured questionnaire was divided into six sections: (1) socioeconomic and demographic information; (2) knowledge on ways of transmission and the level of risk of hepatitis B and C infection and HIV; (3) sexual habits (number of partners in the last year and use of protection); (4) compliance to SPs, including vaccination against hepatitis B; (5) risk perception; and (6) accidents with BM in the last 12 months [9].

The knowledge scale consisted of 12 questions, with a score between zero (no correct answer) and 12 (all correct answers), based on the scale used in the study conducted in Pakistan and validated in Brazil [9,10]. For the evaluation of adherence to personal protective equipment (PPE), a questionnaire survey was conducted, consisting of 11 questions.

When assessing the internal consistency using Cronbach  $\alpha$  [11] in the compliance of the scale, improvement was found by eliminating variables in relation to vaccination against hepatitis B and recapping needles because they varied less, ranging from 0.555 to 0.682. In addition, knowledge and compliance variables were classified considering the appropriate level of knowledge when the respondent achieved a result equal to or greater than 75% in the responses, as described by Sax et al. [12].

Sexual habits have changed, thus creating a new variable named sexual risk, rated 0 (no risk) and 1 (with risk). The category without risk included those who had only one sexual partner in the last year and who used barrier methods during sexual intercourse; the risk category was that they had one or more partners and unprotected sex.

The comparison between two groups of categorical variables was performed using the Chi-square test and Fisher's exact test and was made using the Student  $t$  test for dependent samples.

The incidence rate was calculated at the end of the 12-month follow-up, considering each group separately, based on the sums of months/persons at the end of the study; lost participants

contributed until Month 6, and the follow-up of the injured participants depended on the distance between the moment of cohort entry and the event date (accident).

$$\text{Incident Rate} = \frac{\text{New case in the observation year}}{\text{Persons/Time}}$$

Poisson-Tweedie regression was performed to evaluate the association among scales of knowledge, compliance to SPs, and perception of risk and other collected covariates (variables independent).

The study was approved by the Ethics Committee in Research Faculty of Medical Sciences (FCM)/Piracicaba dental school (FOP) in Brazil, and all study participants signed the informed consent.

## 3. Results

We evaluated 628 individuals with a mean [standard deviation (SD)] age of 30.26 ( $\pm 10.03$ ) years; of which, 71.49% of the participants were females; 78.8% reported having white skin color, 61.6% were single, 72.9% had no children; and 51.9% reported family income between 6 and 20 monthly minimum wage for the year 2014 (Table 1).

The mean (SD) age of the 219 students (114 medicine and 105 dentistry) was 21.68 ( $\pm 2.97$ ) years, ranging from 18 to 49 years; 73.5% were females, and 14.8% were between the 3rd and 4th period. The number of professionals included was 409, which included 107 physicians, 103 dentists, and 199 nurses (72 nurses and 127 nursing technicians). The mean (SD) age of professionals was 34.84 ( $\pm 9.44$ ) years, ranging between 20 and 62 years; 70.4% were females; 65% of professionals work in the surgical area, and 38.1% work in day shifts. The mean (SD) of hours worked per week was 48.30 ( $\pm 19.6$ ) hours, ranging between 5 and 96 hours; 63.6% reported working in one place; 47.3% have graduated from a public university.

### 3.1. Sexual risk behavior and risk perception

The number of sexual partners in the last year was an average of 1.28 ( $\pm 1.10$ ) partners, ranging from 0 to 5 partners, with differences according to the group, students having more number of sexual partners than professionals. A total of 328 (52.2%) participants did not use protection during sexual intercourse, and among those who used, 36.3% used barrier-type protection. We found that 64.6% had risky sexual behavior, with difference between professionals and students (Table 1). In relation to risk perception, we found an average point (SD) of 3.05 ( $\pm 1.1$ ) (minimum of 1 and maximum of 5), median of points, and average minimum of 4 points. The scale showed normal distribution (K-S test,  $p > 0.07$ ). We found difference among groups ( $p < 0.05$ ) and among the professionals ( $p < 0.029$ ); professionals had risk perception ( $3.15 \pm 1.11$ ) higher than students ( $2.86 \pm 1.07$ ), and dentists had lower perception ( $2.82 \pm 1.08$ ) than physicians ( $3.13 \pm 1.0$ ) and nurses ( $3.32 \pm 1.15$ ).

Among students, a difference was also found, with dental students perceiving more risk ( $3.09 \pm 1.03$ ) than medical students ( $2.64 \pm 1.08$ ).

### 3.2. Compliance to SPs

The mean (SD) of compliance to SPs was 31.99 ( $\pm 3.85$ ) points (minimum of 23 and maximum of 36), with a median of 33 points (30, 35). The expected average minimum was 27.75 points; the Cronbach  $\alpha$  was 0.682, showing nonnormal distribution (Tweedie) (K-S test;  $p > 0.000$ ).

The medians of compliance to standard precautions were high among the groups. When compared with the compliance among

**Table 1**

Comparison of sociodemographic and behavioral characteristics among students and health professionals in Brazil in 2016.

Variables	N	Students	Professionals	p
<b>Sex</b>				
Female	449	161 (25.6)	288 (45.9)	0.412
Male	179	58 (9.2)	121 (19.3)	
<b>Age</b>				
Median (percentile 25th, 75th)		21 (20.23)	32 (27.40)	
Averaged $\pm$ DP	628	21.68 $\pm$ 2.97	34.84 $\pm$ 9.44	<b>0.000*</b>
Maximum		18	20	<b>0.000†</b>
Minimum		49	62	
<b>Skin color</b>				
White (78.8%)	495	182 (83.1)	313 (76.5)	<b>0.000</b>
Black brown (15.6%)	98	21 (9.6)	<b>77 (18.8)</b>	
Yellow (4.0%)	25	<b>13 (5.9)</b>	12 (2.9)	
Indigenous, mestizo (0.5%)	3	0 (0.0)	3 (0.7)	
Do not know (1.1%)	7	3 (1.4)	4 (1.1)	
<b>Marital status</b>				
Single/divorced/separated/widower (65.9%)	414	<b>215 (98.2)</b>	199 (48.7)	<b>0.000</b>
Married/stable union (34.1%)	214	4 (1.8)	210 (51.3)	
<b>Number of children</b>				
No children (72.9%)	458	<b>216 (98.6)</b>	242 (52.2)	<b>0.000</b>
With children (27.1%)	170	3 (1.4)	<b>167 (40.8)</b>	
<b>Family income [monthly minimum wage (MMW)]</b>				
<1 MMW (0.5%)	3	2 (0.9)	1 (0.2)	0.000
1–5 MMW (27.7%)	174	42 (19.2)	<b>132 (32.3)</b>	
6–20 MMW (51.9%)	326	<b>141 (64.4)</b>	185 (45.2)	
21 or more MMW (14.3%)	90	19 (8.7)	<b>71 (17.4)</b>	
Do not know (5.6%)	35	15 (6.8)	20 (4.9)	
<b>Sexual risk behavior</b>				
Yes	406	118 (53.9)	<b>288 (70.4)</b>	0.000
No	222	101 (46.1)	121 (26.6)	
<b>Knowledge</b>				
Good	594	202 (92.2)	392 (97.3)	<b>0.004</b>
Bad	28	<b>17 (7.8)</b>	11 (2.7)	
<b>Compliance to standard precautions</b>				
Good	544	189 (90.9)	355 (88.3)	0.335
Bad	66	19 (9.1)	47 (11.7)	
<b>Risk perception</b>				
High	182	136 (33.7)	46 (22.5)	<b>0.005</b>
Low	426	268 (66.3)	158 (77.5)	
<b>Biosafety training</b>				
Yes	351	102 (49.3)	<b>249 (61.3)</b>	<b>0.004</b>
No	262	<b>105 (50.7)</b>	157 (38.7)	

\* *p*, the Chi-square test and Fisher's exact test were used for categorical variables.

† The Kruskal–Wallis test was used to compare medians.

the groups using both the scales of the data ( $p < 0.066$ ) as categorized ( $p < 0.404$ ), we found no difference between professionals and students. However, there was a significant difference when comparing compliance in dentistry with compliance in medicine and nursing ( $p < 0.000$ , Fig. 1). With regard to the permanent use of PPE, we found that 85.8% (539) wore gloves, 45.5% (286) wore masks, 59.6% (374) wore glasses, 66.6% (418) wore aprons, 34.6% (217) did not recap needles, 93.8% (589) discarded materials appropriately, and 74.7% (469) removed the lab coat to leave the hospital.

### 3.3. Knowledge

The average knowledge in both groups (students and professionals) was 11.32 ( $\pm 1.05$ ) points (minimum of 0 and maximum of 12 points), with the median of 12.00 points. The expected average minimum was 9 points; the Cronbach  $\alpha$  was 0.547, showing nonnormal distribution (Tweedie) (K–S test,  $p < 0.00$ ). There was a

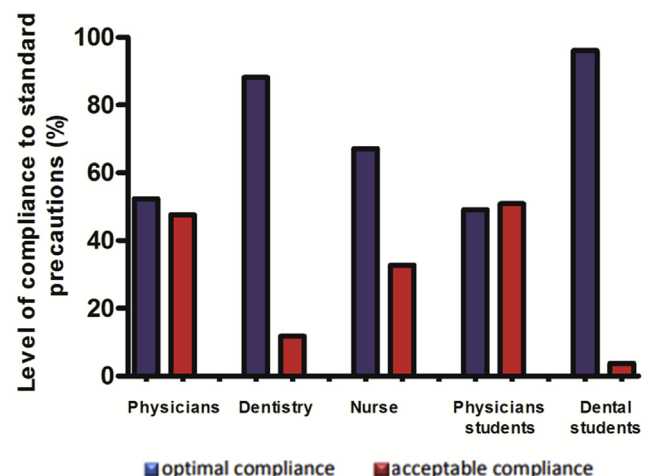


Fig. 1. Level of compliance to SP between health professionals and students.

statistically significant difference (0.000 Kruskal-Wallis (KW)) according to the group (students and professionals); professionals had an average of  $11.48 \pm 0.81$ , with a median of 12 (11, 12), whereas the students had a mean (SD) of  $11.24 \pm 1.36$ , ranging between 0 and 12 with a median of 11 (11, 12).

Training was reported by 57.39% of respondents, with significant difference among the groups ( $p < 0.004$ ); health professionals reported a higher percentage (61.3%) of training when compared with students (49.7%) (Table 1).

### 3.4. Characterization of accidents with BM

Of the 628 participants who were enrolled in the study, 64 (10.2%) participants reported having suffered a work accident with exposure to BM in the year before the study, with a difference between professionals and students (13.0% vs. 5.1%, respectively). Among those who suffered accidents, the mean (SD) number of accidents in their professional life or study time was  $1.56 (\pm 0.85)$ , ranging from 1 to 5 accidents; it was observed that 65.6% had an accident, 34.4% had more than two accidents, and 45.5% had more than three accidents (Fig. 2).

Comparing the two years (regress and follow-up), we found decrease in the proportion of accidents in the professional group and the largest decrease among nurses; in the case of students, there was an increase in both groups (medical and dental students) (Fig. 2).

Among the groups, the professionals have more accidents with BM (13%) than students (5.3%). Among students, accidents increased from 5.3% to 6.9%, and when comparing students in the program, medical students had a higher number of accidents (9.6%) than dental students (4.8%) ( $p < 0.172$ ).

Survival analysis, among the observation time to the accident by the hours worked per week at the end of follow-up, showed that 97.8% of participants who work more than 48 hours have not suffered accidents with BM (log-rank test: 3.81;  $p < 0.051$ ) (Fig. 3).

In the two moments of evaluation, the most common route of exposure was percutaneous (91.7%), and the main

perforating object that caused the accident was the needle, present in 70.3% of cases in the prior year and 62.1% in the following year.

Of the 64 injured in the preceding period, 71.8% (46) reported accidents, a figure that decreased when compared with that reported by the participants who suffered accidents in the year of follow-up (56.8%); the attitude of no accident notification log is more prevalent among professionals, both in the prior year and in the follow-up (72.2% vs. 56.25%, respectively). Regarding the use of personal protective equipment (EPI), 71.8% in the prior year and 86.5% in the year of follow-up reported to be using some items, in particular, gloves (97.4%), masks (85.9%), and glasses (21.27%) (Table 2).

## 4. Discussion

The average age of the 628 participants who were enrolled in this study is similar to that found in a study conducted in India, which was 30.32 years, mostly female secondary. This sex predominates, especially in the nursing team, but currently, there is a feminization of health professionals [13,14].

When calculating incidence rates (10.2% and 6.3%), our findings are higher than those reported in studies conducted in other countries such as Egypt [15] (4.9) and Spain [16,18] (2.6) and strongly higher than the incidence rates reported in studies conducted in Brazil [17,19].

In this study, the proportion of accidents among students of medicine and dentistry has increased from 2014 to 2015. Students in advanced periods have practice days integer and greater exposure to the BM, once they leave the laboratory and will work in the clinics, which increases the exposure and therefore accidents. In addition, the risk of accidents among students may be higher because their technical skills are being developed, and their clinical experience is still limited when compared with seasoned professionals [16,18]. On the other hand, there was a reduction in accidents among professionals, which can be explained by considering that the participants included in the study received indirect intervention when called to participate in research whose

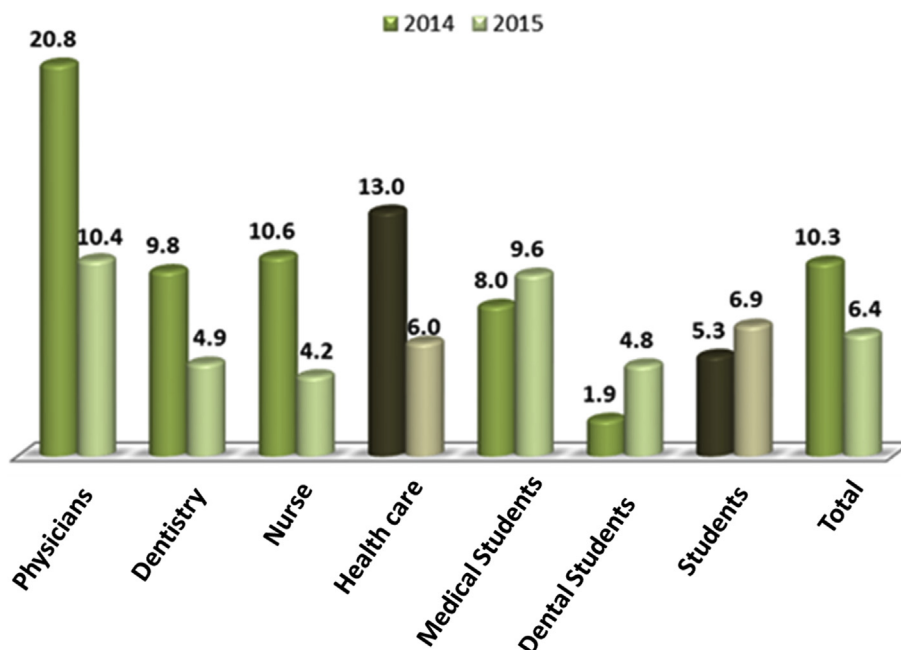


Fig. 2. Distribution of accidents with biological material.

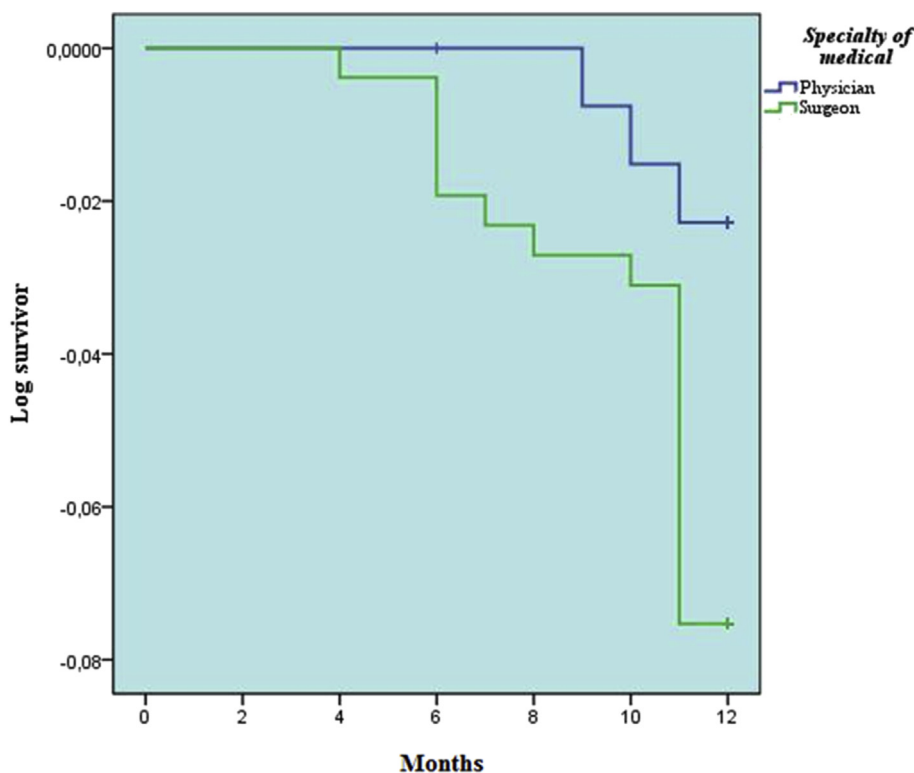


Fig. 3. Function of log survivor.

objective was clearly open, which possibly led to improvement in the perception of risk, with increased compliance and decreased accidents. This corroborates the assertion of Deming and Edwards in that evaluation is the best way to achieve changes in behavior and processes [17,19].

Among professionals and students, we find a greater number of accidents involving needles, similar to other reports in the literature [20]. The area of the body most affected was the hands, especially the fingers, similar to findings from other researchers [20–22]. Of the injured, 46 individuals reported to be using PPE, higher than that found in other studies [13].

According to a Pakistani study that used the same scale, the factors associated with the occurrence of accidents with exposure to BM are as follows: risk perception, acquiring diseases for the development of health work [13], and sexual risk behavior, the same association found in our study. We found that 52.2% of participants reported not using condoms during sex, an attitude that endangers the individual to acquire sexually transmitted diseases, a finding that has not been explored in studies involving accidents with BM. But a study in Mexico describes that adolescent workers with sexual risk behaviors have similar behavior at work, which perpetuates the risk. It is worth noting that individuals who do not have family responsibilities reduce their levels of protection against all kinds of risk. Studies report that singles are exposed more to both sexual risks and occupational injuries [13].

Neglect, carelessness, inadequate lighting, pace of work, long working hours, lack of PPE, anxiety, nervousness, and lack of training are considered decisive factors for the presence of accidents [23]. We find risk associated with the area or professional expertise. The surgical areas of workers (7.3%) had a higher prevalence of accidents when compared with those of physicians (2.2%),

an observation found in the study with 73 residents at a university hospital in Colombia [24].

By separately evaluating professionals in both times, we found hours worked per week ( $p < 0.050$ ) as a factor associated with accidents, which coincides with a study conducted in India which reported that health workers who have worked for more than 15.8 continuous hours (02–28 hours) have a higher prevalence of accidents [24].

Students and professionals often overlook injuries that do not involve blood or even minor injuries, a fact found by Doebbeling et al., who explained that underreporting ranged from 22% to 62% by health professionals in a study at several Iowa community hospitals [27]. In the present study, underreporting increased from 28.2% to 43.2% in both the prior year and the follow-up.

We still come across professionals and students recapping needles. In our study, we found 34.6% still recapping. Recapping is a practice that increases the possibility of percutaneous exposures by 2-fold and is the most common cause of accidents [13,14,21,22]. Some health professionals argue recapping can prevent unexpected injuries, both to the operator and the people around them [25]. The analysis of dental professionals in the present study indicates that they have a relatively good level of knowledge and compliance with SPs about the diseases transmitted through NSI. This was in contrast to a study conducted by Alam [26], which reported nurses and paramedical staff had lower values. This is possibly due to the use of PPE from the earliest years of clinical care, continuing education, and the greatest contact with body fluids in relation to other professions. Continuing training along with graduation is more important than occasional training to promote compliance to SPs [27,28]. In our study, the training is not regular and does not involve all staff.



**Table 2**

Comparison of the characteristics of accidents in both periods (previous year and follow-up) among students and health professionals in Brazil in 2016.

Variables	Previous year (628)	Follow-up (606)	p
<b>Accident</b>			
Yes	64 (10.2)	38 (6.3)	<b>0.011</b>
No	560 (89.2)	568 (93.7)	
<b>Work schedule</b>			
Morning	25 (39.1)	18 (47.3)	0.675
Vespertine	20 (31.2)	9 (23.7)	
Night	11 (17.2)	8 (21.1)	
Do not know	8 (12.5)	3 (7.8)	
<b>Day of the week</b>			
Monday	3 (4.7)	4 (10.5)	0.869
Tuesday	3 (4.7)	2 (5.2)	
Wednesday	3 (4.7)	1 (2.6)	
Thursday	4 (6.3)	3 (7.9)	
Friday	7 (10.9)	7 (18.4)	
Saturday or Sunday	4 (6.3)	4 (10.5)	
Do not know/do not remember	38 (59.4)	17 (44.7)	
<b>Object</b>			
Needle	45 (70.3)	23 (62.1)	0.102
Scalpel	4 (6.25)	4 (10.5)	
Others	1 (1.56)	3 (7.89)	
Wire and other	4 (6.25)	6 (15.8)	
Blood and fluids	10 (15.6)	2 (5.30)	
<b>The affected body part</b>			
Fingers	41 (64.1)	24 (63.2)	0.309
Hand	10 (15.6)	10 (26.3)	
Face	10 (15.6)	2 (5.26)	
Others	3 (4.69)	2 (5.26)	
<b>Use of PPE</b>			
Yes	46 (71.9)	32 (84.2)	0.155
No	18 (28.1)	6 (15.8)	
<b>Notification</b>			
Yes	46 (71.9)	22 (56.8)	<b>0.054</b>
No	18 (28.1)	16 (43.2)	

PPE, personal protective equipment.

p, the Chi-square test and Fisher's exact test were used for categorical variables. Bold signifies  $p < 0.05$ .

We emphasize that cross designs, with retrospective data collection through self-administered questionnaires, enable the occurrence of both recall bias, as reverse causality, and reports by other studies that there may be a failure to remember or report such accidents or simply hesitation to reveal them. However, we control these aspects with one-year follow-up and confirmation of reports on accidents in the institution's infection control departments.

#### 4.1. Conclusions

Occupational accidents with BM are more frequent in Brazil than elsewhere, and despite the existence of a regulatory standard (NR-32), these are still a major public health problem.

The increase in accidents among students was the result of longer periods of clinical practice, and this highlights the need for continuous training of biosafety protocols to have a safer work environment for health professionals and for their patients.

Compliance to SP measures was high, but the vaccination schedule was not always complete in the sample, especially among students, stressing the need for better institutional control over the immunization protocol.

#### Conflicts of interest

The authors declare that there are no conflicts of interest.

#### Acknowledgements

National Institutes of Science and Technology- CNPq/ Brasil, process: 168665/2017-4.

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