

# Occupational Exposure to Potentially Infectious Biological Material in a Dental Teaching Environment

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*Abstract:* The aims of this cross-sectional study were to determine the prevalence of occupational accidents with exposure to biological material among undergraduate students of dentistry and to estimate potential risk factors associated with exposure to blood. Data were collected through a self-administered questionnaire (86.4 percent return rate), which was completed by a sample of 286 undergraduate dental students (mean age 22.4 ±2.4 years). The students were enrolled in the clinical component of the curriculum, which corresponds to the final six semesters of study. Descriptive, bivariate, simple logistic regression and multiple logistic regression (Forward Stepwise Procedure) analyses were performed. The level of statistical significance was set at 5 percent. Percutaneous and mucous exposures to potentially infectious biological material were reported by 102 individuals (35.6 percent); 26.8 percent reported the occurrence of multiple episodes of exposure. The logistic regression analyses revealed that the incomplete use of individual protection equipment (OR=3.7; 95 percent CI 1.5–9.3), disciplines where surgical procedures are carried out (OR=16.3; 95 percent CI 7.1–37.2), and handling sharp instruments (OR=4.4; 95 percent CI 2.1–9.1), more specifically, hollow-bore needles (OR=6.8; 95 percent CI 2.1–19.0), were independently associated with exposure to blood. Policies of reviewing the procedures during clinical practice are recommended in order to reduce occupational exposure.

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Contact with blood and other potentially infectious biological material as a result of occupational accidents may represent a threat to the health of dental professionals. This area of work includes anatomically and functionally complex structures of difficult access and visualization. These structures have different forms and dimensions. They are rich in potentially pathogenic microorganisms and are the gateway to other organic systems. In clinical practice, dental professionals come into close contact with patients and a variety of sharp instruments. Therefore, most dental procedures performed with a high-speed handpiece use both air and water spray to cool the working tip and prevent heat. A water spray is also used to rinse the working area in order to enhance the operator's view. As soon as this water spray is emitted, it blends with the patient's saliva and any blood present, forming a potentially pathogenic aerosol. This aerosol increases the potential risk of the distribution of infectious agents in a dental environment.<sup>1</sup>

Professional experience and dexterity in using sharp instruments are important to minimize the risk of accidents as a consequence of unexpected movements on the part of patients during dental treatment. The results of a number of studies suggest that undergraduate students are particularly vulnerable to occupational exposure. Students also have variable levels of technical skill, thus making some potentially more prone to accidents than others.<sup>2-12</sup>

There is scant systematic information on occupational exposure to biological material among undergraduate students of dentistry in Brazil. The magnitude of exposure is unknown, which compromises the implementation and evaluation of preventive measures. Research is needed to determine the extent of student exposure to blood and other biological material. The findings from this research can be used to assess and potentially revise current strategies for cross-infection control.

Thus, the aims of the present study were to determine the prevalence of occupational accidents

with exposure to biological material among dental students and estimate risk factors associated with exposure to blood.

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## Methodology

Approval for the development of this study was received from the Human Research Ethics Committee of the Federal University of Minas Gerais, Brazil.

This cross-sectional study was conducted with a group of dental students at the Federal University of Minas Gerais located in the city of Belo Horizonte (southeastern Brazil). The university has an infection control policy that was officially implemented in 1989, when a biosecurity commission was established. The current curriculum consists of nine semesters. One hundred and twenty students are enrolled annually in this dental school. The target study sample population was comprised of 331 undergraduate dental students in the clinical component of the curriculum, which corresponds to the final three years of study. Student participation in the study was voluntary. Data were derived retrospectively from dental care performed by students from 2003 to 2005.

A self-administered questionnaire consisting of thirteen open-ended questions and multiple-choice items was used for data collection. The development of the questionnaire complied with all steps proposed by Streiner and Norman.<sup>13</sup> Once the purpose of the study and its conceptual basis were defined, the generation of items was accomplished by means of a broad-based review of the literature, including questions used in preexisting instruments.<sup>8,9,14</sup> Content validation was performed to determine the suitability of the theoretical content and functionality of the questionnaire. Item selection, adaptation, and new inclusions were then carried out based on the opinions of a judging commission made up of professionals from different dental institutions and specialties. The commission members were aware of the objectives and methodology of the study and were asked to express their opinions in writing.<sup>15,16</sup> Unanimity in the approval of the questionnaire was required for validation. Suggestions for changes were heeded when brought up repeatedly by different commission members. Response options were organized vertically. All survey items were constructed in the same format in order to avoid placing emphasis on any specific item. Space was included for suggestions or for the participants to express their thoughts if they did not encounter a satisfactory option.

Individual protection equipment (IPE) was considered complete when the student wore gloves, cap, mask, coat (with short or long sleeves), protection glasses, and closed shoes (which totally covered the feet).<sup>17</sup> Curriculum disciplines were combined into five groups: general dentistry, restorative dentistry and prosthodontics, pediatric dentistry and orthodontics, oral surgery, and periodontics. Occupational exposure was classified into cutaneous, percutaneous, and mucous membrane, following the definitions established by OSHA.<sup>2</sup> Considering the students' difficulties in classifying the severity of percutaneous injury on three levels, as proposed by Younai et al., a new classification with only two categories was proposed. The injury sites were considered moderate or superficial when little or no bleeding was detected, respectively. Deep injury sites were classified as those with abundant bleeding.<sup>8</sup>

A pilot study was conducted in the semester prior to data collection with a sample of twenty students enrolled in the final semester of dental school who were not part of the main sample. A final modification of the questionnaire was carried out based on the questions and suggestions that arose during the pilot study.

The questionnaire was divided into two parts. The first part was filled out by all participants and consisted of demographic characteristics, records of occupational exposure, and the use of IPE. The second part was filled out only by students who reported the occurrence of previous accidents that involved exposure to blood and other biological material. In part 2, those who reported a previous exposure were requested to provide information about the incident, including type of biological material, circumstances, source of the incident (student's assessment of which instrument caused the exposure), and characteristics of the injuries. The complete version of the questionnaire was published previously.<sup>18</sup>

Students filled out the questionnaire during lectures in the second semester of 2005. Using the test-retest model to assess answer variations by the same respondent at different times, the same questionnaire was administered a second time to thirty students, corresponding to 10 percent of the sample. Agreement between responses on the two occasions was measured using the Kappa coefficient. Kappa values ranged from 0.71 to 1.0, demonstrating a high degree of reproducibility of the answers and, consequently, a high degree of reliability.<sup>16,19</sup> Institutional patient care files were used to calculate the denominator of the rate of occupational exposure per procedure.

Results were analyzed and compared by means of frequency and statistical association tests. The chi-square test was used to test associations between the reporting of occupational exposure and the independent variables (biological material, circumstance in which accidents occurred, source of the incident, reason for failure to report, and suggestions and opinions for improving compliance with post-exposure protocol). Criteria for the selection of variables in the multivariate analysis (unconditional logistic regression) were obtained from the results of the univariate analysis (chi-square test). The forward stepwise procedure was used to include variables with statistical significance equal to or less than 10 percent into the logistic model. Variables remained in the model if they continued to be significant ( $p < 0.05$ ) and/or adjusted to the model.<sup>20</sup> Exponential transformations were then performed to obtain the odds ratio (OR). The chances of underreporting an occupational exposure to biological material were determined in the presence of the independent variables. Data were tabulated and analyzed using the Statistical Package for the Social Sciences (SPSS) 12.0.

## Results

The questionnaires were distributed to all 331 regularly enrolled students in the last six semesters of study. The return rate was 86.4 percent and the sample population consisted of 286 dental students (mean age  $22.4 \pm 2.4$  years). Table 1 displays demographic variables, distribution of frequencies related to occupational exposure to biological material, use of individual protection equipment, instruments involved in occupational exposure, and circumstances of occupational accidents.

Exposure to biological material was reported by 167 students (58.4 percent), the majority of whom were female (66.8 percent). Exposure was classified as cutaneous (34.3 percent), percutaneous (29.0 percent), and mucous membrane (6.6 percent). Multiple episodes of exposure were reported by 27.2 percent of the interviewees, and 5.9 percent reported four or more previous episodes of exposure. These results correspond to a rate of 1.78 occupational episodes of exposure per student affected. The rate of reporting percutaneous occupational exposure was 9/10,000 procedures performed on patients.

When asked about the use of IPE, the majority (87.4 percent) of the students reported correct use. The most frequently used protection equipment in-

cluded gloves, closed shoes, and masks, which were mentioned by 98.3 percent, 96.2 percent and 95.1 percent, respectively.

**Table 1. Distribution of demographic variables and frequencies related to the sample of 286 undergraduate dental students**

	n	%
Gender		
Female	191	66.8
Male	95	33.2
Age*		
$\leq 22$ years	175	61.2
$> 22$ years	108	37.8
Prevalence of accident		
Yes	167	58.4
No	119	41.6
Type of accident†		
Cutaneous exposure	98	34.3
Mucous membrane exposure	19	6.6
Percutaneous exposure	83	29.0
Biological material*		
Blood	71	24.8
Saliva	102	35.7
Frequency of accidents*		
One	89	31.1
Two	42	14.7
Three	19	6.6
Four or more	17	5.9
Severity of percutaneous injury*		
Superficial/moderate	73	88.0
Deep	10	12.0
Individual protection equipment (IPE)†		
Complete	250	87.4
Incomplete	36	12.6
Long-sleeve coat	194	67.8
Gloves	281	98.3
Mask	272	95.1
Glasses	256	89.5
Cap	261	91.3
Closed shoes	275	96.2
Source of incident*		
Hollow-bore needle	29	10.1
Suture needle	8	2.8
Probe	24	8.4
Excavator	33	11.5
Drill	15	5.2
Others	27	9.2
Circumstances of accident*		
When recapping the needle	10	3.5
Spray of biological material	20	7.0
Rubbish management	4	1.4
Management of sharp instruments	71	24.8
Procedure of cleaning instruments	43	15.0

\*Only positive answers (yes) were computed.

†Answers are not mutually exclusive.

A significant proportion of accidents occurred during the handling of sharp instruments (24.8 percent) and during instrument cleaning procedures (15.0 percent). Overall, 3.5 percent of students reported that recapping needles was the source (cause) of exposure. Students identified hollow-bore and suture needles (12.9 percent) and excavators (11.5 percent) as frequently involved in occupational exposure. IPE, disciplines, source of incident, and the circumstances of the accidents were statistically significantly associated with exposure to blood (Table 2). There was no statistically significant association between occupational exposure to blood and age or gender ( $p>0.05$ ).

The bivariate analysis revealed a statistically significant association between occupational accidents with exposure to blood and the use of IPE ( $p=0.005$ ). Almost 44 percent of the students who reported an incomplete use of IPE in daily practice suffered accidents with exposure to blood. The odds ratios were higher for those who did not wear a long-sleeved coat (OR=2.9, 95 percent CI 1.7–5.1), mask (OR=3.3; 95 percent CI 1.1–9.6), or protective glasses (OR=2.2; 95 percent CI 1.0–4.9).

There were statistically significant associations between cutaneous exposure and exposure to saliva (OR=18.4; 95 percent CI 10.0–34.0), as well as between exposure to blood and students who were enrolled in the final year of the course (OR=3.1; 95 percent CI 1.7–5.9)

In the multiple logistic regression analysis, the variables that remained independently associated with occupational exposure were incomplete use of IPE (OR=3.7; 95 percent CI 1.5–9.3), handling of sharp instruments (OR=4.4; 95 percent CI 2.1–9.1), most specifically hollow-bore needles (OR=6.8; 95 percent CI 2.4–19.0), and providing patient care in clinics where surgical procedures were carried out (oral surgery and periodontics) (OR=16.3; 95 percent CI 7.1–37.2) (Table 3).

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## Discussion

Despite being permitted to mark more than one option in the case of multiple episodes of exposure, a number of participants did not respond to some of the questions. It should be pointed out that memory bias is a potential limitation associated with retrospective data collection; findings need to be analyzed in light of usual precautions when considering self-reports by subjects without other means of verification of their

description of exposure incidents. The limitations of retrospective self-reporting highlight the need for further research using different study designs.<sup>11,21</sup>

The substantial number of students who reported multiple episodes of exposure in the present study indicates that dental students are at risk when they work in the clinical environment.<sup>12,13,22</sup> The rate of 1.78 occupational episodes of exposure per student approximates the figure reported by Kotelchuck et al.<sup>9</sup> According to these researchers, students with limited technical skill and/or limited emotional and managerial skills for dealing with patients may characterize a high-risk group for occupational exposure. This conclusion is reinforced by our finding that the majority of multiple episodes of exposure occurred among students who were in the initial phases of the clinical curriculum and therefore relatively inexperienced in providing patient care (73.9 percent).

The 35.6 percent of percutaneous and mucosa episodes of exposure is close to the percentage reported by Kotelchuck et al.<sup>9</sup> It has been reported that percutaneous exposure is the most efficient mechanism of occupational infection.<sup>8</sup> Health care professionals working with HBV-infected blood and the presence of HBeAG antigens run a risk of hepatitis B transmission ranging from 22.0 percent to 31.0 percent. The HBeAG antigen is found in serum during acute and chronic HBV infection. Its presence indicates that the virus is replicating and serves as a marker of increased infectivity.<sup>23</sup> Health care professionals run a 1.8 percent risk of hepatitis C, whereas the risks of HIV in percutaneous lesions and mucosa are 0.3 percent and 0.1 percent, respectively. Post-exposure risk involving injured skin is not precisely quantified, but it has been estimated that it is lower than the risk of mucosa episodes of exposure.<sup>17</sup> In dentistry, the majority of injuries are caused by accidents with small-bore needles and instruments. Therefore, dental professionals are exposed to a lower volume of blood, thus representing lower risk.<sup>23-25</sup> The risk for HIV transmission ranges between 0 and 0.08 percent, while the risks for HBV and HCV (hepatitis C) are 9.0 percent and 1.4 percent, respectively.<sup>26-28</sup>

The 34.3 percent prevalence of cutaneous exposure, which was statistically significantly associated with exposure to saliva, may be attributed to inherent aspects of the profession, such as the production of aerosol as a result of the use of instruments such as high-speed handpieces and ultrasound dental scalers.<sup>29,30</sup> The prevalence of superficial/moderate (88.0 percent) or deep injury sites (12.0 percent) is similar to that reported by other studies in the literature.<sup>8</sup>

**Table 2. Simple logistic regression: occupational exposure to blood and independent variables**

	YES		NO		p value OR (95% CI)
	n	%	n	%	
Age					
≤22 years	41	23.4	134	76.6	>0.10
>22 years	30	27.8	78	72.2	
Gender					
Male	21	22.1	74	77.9	>0.10
Female	50	26.2	141	73.8	
IPE					
Complete	55	22.0	195	78.0	0.005 2.8 (1.3-5.8)
Incomplete	16	44.4	20	55.6	
Long-sleeve coat					
Yes	35	18.0	159	82.0	<0.001 2.9 (1.7-5.1)
No	36	39.1	56	60.9	
Mask					
Yes	64	23.5	208	76.5	0.033 3.3 (1.1-9.6)
No	7	50.0	7	50.0	
Glasses					
Yes	59	23.0	197	77.0	0.046 2.2 (1.0-4.9)
No	12	40.0	18	60.0	
Final-year students					
Yes	47	20.3	185	79.7	<0.001 3.1 (1.7-5.9)
No	24	44.4	30	55.6	
General dentistry					
No	36	19.1	152	80.9	0.002 2.3 (1.4-4.1)
Yes	35	35.7	63	64.3	
Surgery and periodontics					
No	36	15.1	202	84.9	<0.001 15.1 (7.3-31.3)
Yes	35	72.9	13	27.1	
Accident with hollow-bore needle					
No	51	19.8	206	80.2	<0.001 9.0 (3.9-20.9)
Yes	20	69.0	9	31.0	
Accident with suture needle					
No	64	23	214	77	0.003 23.4 (2.8-193.8)
Yes	7	87.5	1	12.5	
Accident with excavator					
No	47	18.6	206	81.4	<0.001 11.7 (5.1-26.8)
Yes	24	72.7	9	27.3	
Accident when recapping needles					
No	64	23.2	212	76.8	0.004 7.7 (1.9-30.8)
Yes	7	70.0	3	30.0	
Sharp instrument management					
No	33	15.3	182	84.7	<0.001 6.4 (3.5-11.5)
Yes	38	53.5	33	46.5	
Procedure of cleaning instruments					
No	49	20.2	194	79.8	<0.001 4.1 (2.1-8.1)
Yes	22	51.2	21	48.8	
Prevention—not to recap needles					
Yes	5	71.4	2	28.6	0.014 8.1 (1.5-42.6)
No	66	23.7	213	76.3	

Accidental exposure was more frequently reported by female students. Despite the absence of a statistically significant association between gender and occupational exposure to blood, similar results have been previously reported.<sup>8,31,32</sup> Wood et al. found

that female undergraduate students not only had a higher level of risk, but were also more concerned for themselves and their patients regarding exposure to potentially infectious material.<sup>12</sup> However, it is still unclear whether women experience a greater number

**Table 3. Adjusted multiple logistic regression: occupational exposure to blood**

	OR adjusted (95% CI)	p value
IPE		
Complete	1.00	
Incomplete	3.7 (1.5–9.3)	0.006
Surgery and periodontics		
No	1.00	
Yes	16.3 (7.1–37.2)	<0.001
Accident with hollow-bore needle		
No	1.00	
Yes	6.8 (2.4–19.0)	<0.001
Sharp instrument management		
No	1.00	
Yes	4.4 (2.1–9.1)	<0.001

of occupational episodes of exposure or whether they are more prone to report them (or both). This is an area for further research.

The use of incomplete IPE was independently associated with exposure to blood. Despite the consensus that the use of IPE per se does not ensure a reduction in the acquisition of pathogenic microorganisms from blood and other body fluids, this finding supports an association between adherence to measures of individual protection and a reduction in the risk of occupational exposure.<sup>21,33,34</sup> Furthermore, the routine use of gloves (reported by 98.3 percent) does not avoid the occurrence of percutaneous injury, but reduces the amount of inoculated bacteriological material and, consequently, the risk of infection.<sup>35</sup> Students who did not wear long-sleeved coats, as recommended by the institution, had a greater chance of being exposed to blood. It has been reported that arms are the most likely sites for injury due to their proximity to the operational site, thus reinforcing the need for protection.<sup>29,30</sup>

A higher proportion of occupational exposure accidents has been reported among students who are in the early phases of clinical education.<sup>8,11</sup> In our study, however, a statistically significant association between exposure to blood and final-year students was found, which is in agreement with findings from other studies.<sup>9,12,32</sup> The aspects of occupational exposure reported among students in different phases in the dental clinical context should be explored in further research.

In the oral surgery and periodontics clinics, where surgical procedures are carried out, students exhibited a greater chance of exposure to blood. The great number of accidents could be explained by the

use of sharp instruments that are required due to the invasive nature of the procedures. The logistic regression analysis revealed that the use of sharp instruments, primarily hollow-bore needles, was independently associated with exposure to blood. The work of dental surgeons frequently requires the use of hollow-bore needles for administering local anesthetics. In our study, the higher prevalence of accidents involving hollow-bore and suture needles was statistically significantly associated with exposure to blood, which is in agreement with other studies.<sup>4,8,25,31,36</sup> It is important to stress that accidents involving hollow-bore needles represent a higher risk of infection when compared to those involving compact needles. This is due to the presence of blood within the hollow-bore needles.<sup>4,8,11,25,31</sup>

A surprising result of our study was the relatively high rate of exposure to blood (70 percent) in the procedure of recapping needles; this has been reported as an etiological factor for occupational exposure, despite institutional efforts to reduce such exposure. In agreement with Ramos-Gomez et al., a number of students reported that accidents could have been prevented if they had followed the recommendation of not recapping needles.<sup>4</sup> Other items involved in occupational accidents, such as excavators, drills, and probes, have also been identified with different frequencies in other studies. For excavators and drills, the proportions range from 7.1 percent to 12.5 percent and 4.9 percent to 18.2 percent, respectively. In relation to probes, the figures found in other studies range between 7.0 percent and 14.3 percent.<sup>4,8,11,12,24</sup> Occupational exposure to blood was statistically significantly associated with instrument cleaning before sterilization. This is a high-risk activity when

performed manually, as it involves several stages and repeated handling of the instruments. Preventive measures and equipments are recommended to minimize this unnecessary risk, in addition to the use of individual protective equipment.<sup>4,8</sup>

In this context, some reflections are important. Although the term “occupational accident” suggests an unpredictable or unplanned event, risk factors for occupational exposure are consistently present in the work situation. Therefore, they are both predictable and preventable. The findings of this study indicate that there is an urgent need for dental schools to assess and potentially revise procedures designed to prevent occupational exposure. Updated protocols should reinforce adequate procedures, but also go beyond the conventional teaching of universal procedures for cross-infection control in order to minimize the risk associated with the learning process. Infection control in oral health care as a discipline has been incorporated into the formal curriculum at a large number of dental schools. Nevertheless, the findings reported here indicate that a theoretical approach may not be sufficient in providing practitioners with the necessary skills for working with patients. Thus, teaching standard precaution measures as an abstract theoretical body of concepts does not achieve the desired impact on individual students, as their unique roles as participants are not taken into consideration.

This has implications for dental education. Dental schools might offer opportunities for students to analyze their own experiences in the dental clinic from the perspective of infection control. Following Ardenghi et al., we suggest a complementary approach to teaching standard precautions that might involve pairs of students working together with patients. In this collaborative working experience, one student could be doing the dental treatment while his or her colleague observes and takes field notes on infection control and prevention measures adopted during the treatment.<sup>37</sup> Analysis and discussion could take place in small group meetings afterwards. Experience obtained in dental practice combined with ongoing seminars engages dental students in discussing infection control recommendations of their present and future work. This approach also takes advantage of the opportunity to engage students in self-reflection—discussing and reflecting on their own actions—which could foster a change of behavior. As this analysis would involve the students’ own work, this would be more meaningful than judging the practices of others, as in case-based learning or

any teaching approach that analyzes cases involving other practitioners. Providing the opportunity to share experiences in order to address problems of a practical nature promotes changes in behavior and in the student’s sense of responsibility, thereby preparing him or her for professional life. Favoring empowerment, as expressed in positive autonomy—seen in the light of self-actualization—signifies acquiring the ability to act effectively on the determinants of occupational risks in favor of prevention for an improved quality of life.<sup>18</sup>

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## Conclusions

A high prevalence of occupational exposure to blood among undergraduate dental students was observed in this study. The incomplete use of IPE, the disciplines in which surgical procedures were carried out, and the manipulation of sharp instruments such as hollow-bore needles were associated with students’ exposure to blood.

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