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Original Article

Exposure incidents among medical students in a high-prevalence HIV setting

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Abstract

Introduction: Occupational injuries in medical students are concerning, especially in countries with a high prevalence of bloodborne infections. With more HIV-infected patients on antiretroviral treatment, appropriate post-exposure prophylaxis (PEP) depends on knowledge of source patients' infection status and treatment response. This study determined the number and type of exposure incidents, reporting practices, and PEP use among medical students at the University of Pretoria, South Africa.

Methodology: Data were collected from an anonymous voluntary questionnaire completed by medical students from years 1 to 6 of study as well as from incident records archived at the Department of Family Medicine. Data were described and tests of association performed in Stata 11.

Results: Thirteen percent of students overall and 21% of senior students reported an incident in the preceding year. The majority of incidents occurred during phlebotomy, with fatigue and work pressure found to be major contributing factors. Underreporting was common and many students displayed a lack of risk awareness and a preference for managing the incident privately. Although 59% knew the HIV-status of the source patient, less than a third knew the viral load and only 16.9% the regimen. Side-effects on antiretroviral treatment used for PEP were common and only about three-quarters of the students completed the course.

Conclusions: We recommend targeted training, especially in the senior years, together with improving the work environment through attention to working hours, sharps disposal and ready availability of safety devices, improved reporting systems, individualised PEP, and possibly the implementation of an occupational injury support line.

Key words: exposure incidents; needle stick injuries; unsafe practices

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Introduction

Occupational injuries among healthcare workers represent a serious challenge with an estimated 3 million healthcare workers worldwide sustaining a needle stick injury from a contaminated sharp each year [1]. Concern has been expressed at the absence of formal surveys to determine the causes of the high number of injuries and many have called for 'more protection and training' [2]. Medical students are especially vulnerable to exposure incidents due to both their particular work environment and developing skills level [3-5]. They often work long hours, frequently in places with inadequate facilities for sharps disposal, and may not have mastered the skills required to effectively undertake appropriate venesection practices and invasive procedures. Percutaneous and mucosal incidents also expose students to infectious pathogens, especially viruses such as the human immunodeficiency virus (HIV) and hepatitis B and C viruses [6]. For instance, patients with HIV-related diseases occupied more than half of the hospital beds in sub-Saharan Africa in 2006 and in South Africa, even in the era of widely available antiretroviral treatment (ART), at least 44% of medical admissions are for HIV-infected patients [7]. Given the high prevalence of these pathogens in sub-Saharan Africa, it is important to perform context-specific research into the frequencies and settings of such incidents in order to inform policy and best practice.

Exposure to HIV-infected blood requires decisive and accurate management in terms of counseling, support and provision of appropriate ART for post-exposure prophylaxis (PEP). This is only possible when incidents are reported timeously and detailed information about the source patient is available. Appropriate reporting is also essential to effectively

monitor the incidence of occupational exposure, as well as to identify areas of high exposure risk so that appropriate preventive measures can be implemented. Many studies, which have investigated the incidence and factors associated with exposure incidents, both nationally and internationally, have highlighted the problem of underreporting [8-15]. Few studies have, however, assessed the reasons for underreporting and non-adherence to protocols.

Management of HIV-related exposure incidents increasingly entails individualized PEP, with knowledge of the source patient's ART regimen and HIV viral load (VL) informing regimen choice [16,17]. This is especially important where recommended regimens for PEP and HIV treatment overlap, since the presence of HIV-associated drug resistance in the source patient may negatively affect the outcome of PEP [18]. To our knowledge, however, no studies have assessed how information about patients' infection status and treatment influences the management of exposure incidents and ART prescribing practices. The present study therefore set out to build on the current literature by exploring the number and types of exposure incidents, reporting practices, and PEP use among medical students at the University of Pretoria, as a basis on which to formulate recommendations on how such incidents could be minimized and better managed.

Methodology

After giving informed consent, medical students between year one and six of study in 2012 completed an anonymous voluntary questionnaire, adapted from Mendelson [4]. In addition, details about exposure incidents were sourced from incident records archived in the Department of Family Medicine at the University of Pretoria, which is tasked with the management of exposure incidents. Data were entered into Excel (Microsoft Office 2011), cleaned and then transferred to Stata (StataCorp. 2009. *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.) version 11 for analysis. Categorical variables were described according to proportions and continuous variables as the median and inter-quartile range, since assumptions of normality were not satisfied. Statistical differences between categorical variables were tested using the Chi-squared test; Fisher's exact test was used when expected counts were less than 5 per cell. Statistical significance was set at 0.05. Missing data points were excluded from the analysis. The study was conducted in accordance with the Declaration of Helsinki (October 2013) and the Research Ethics Committee, Faculty of Health Sciences, University of Pretoria, approved the study protocol (68/2013).

Results

Number and types of exposure incidents

The study included records from 809 students: 384 (47.5%) were in their junior years (years 1 to 4) and 425 (52.5%) were senior students (years 5 and 6). One hundred and five students (13%) reported having had an exposure incident during 2012 and of these, 15 (14.3%) were junior and 90 (85.7%) senior students. The incidence of exposure injuries in senior students was 21.2%. Eighteen of the 105 students (17.1%) had experienced more than one incident in 2012 and 77 students reported having had previous exposure injuries. Three-quarters of the students reported percutaneous incidents, 20% had experienced mucocutaneous incidents and 5% a combination of the two.

Approximately one third (35.8%) of students reported regular use of vacutainers during phlebotomy, but only 10.3% used these exclusively. Only 13.8% used safety needles and a mere 4.4% used these exclusively. The remainder used either a conventional syringe and needle or a butterfly needle. Even more worrisome is the finding that more than three-quarters (76.5%) transfer blood or body fluids to specimen tubes by holding all the tubes in one hand and piercing each tube in turn; the remaining 23.5% use vacutainers. In addition, only two-thirds (66.1%) reported using gloves all the time, while 23% used gloves more than 50% of the time, 9.5% less than 50% of the time and 1.4% never used gloves.

Interestingly, just under half (45.4%) of the students reported changing practices involving invasive procedures when they knew that a patient was HIV-infected: 28% elected for double-gloving, 11.2% used a vacutainer, 9.3% asked a senior colleague to assist and 3.7% avoided performing the procedure.

Regarding their most recent incident, 43.2% of the students had been injured during phlebotomy, 23.9% while performing other invasive procedures such as inserting intravenous lines, giving injections or performing lumbar punctures, 15.3% while assisting with surgery and 14.2% during suturing. A very small number (5.1%) of injuries occurred during non-invasive procedures such as restraining patients or delivering babies. Almost a quarter (24.8%) sustained the injury while obtaining a specimen, 16.3% while handling or transferring the specimen, and a few while recapping a needle, disposing of sharps and cleaning up (5.6%, 8.4% and 8.9% respectively). The remaining 36%

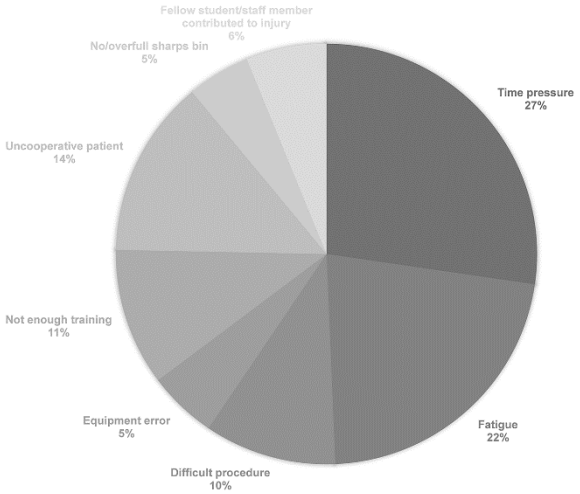
reported diverse scenarios, mostly related to surgery or suturing procedures.

Circumstances surrounding incidents

Just over 80% (82.4%) of injuries occurred in four disciplines: Obstetrics and Gynaecology (35.2%), Family Medicine (24.5%), Surgery (12%) and Emergency Medicine (10.7%). Most students felt that many factors had contributed to the incident, but pressure of work and being fatigued were the most common factors listed, followed by an uncooperative patient, insufficient training and the difficulty of the procedure (Figure 1).

As can be seen from Table 1, senior students were significantly more likely to have experienced an exposure incident, frequently more than one, most likely due to their higher exposure to invasive procedures. Incident types were comparable, with the majority in both groups experiencing percutaneous injuries. Senior students were more likely to transfer blood and other bodily fluid to specimen containers unsafely and less likely to wear gloves more than 50% of the time. They were, however, more likely to change their practice if they knew a patient was HIV-infected. Even though there was no difference in the likelihood of reporting exposure incidents between junior and senior students, the former were more likely to do so within 24 hours.

Figure 1. Factors contributing to the exposure incident.



The majority of students found the incident to be very stressful with a median stress level estimated to be 8 out of a possible 10 (interquartile range (IQR) 5-9) while a fifth (21.2%) rated it as the most stressful event possible. The following factors contributed to the stress students experienced: 23.2% felt they had received no support from the clinical staff at the time of the incident, while 17.6% experienced the department through which

Table 1. Associations between study variables.

Outcome variable	Exposure variable	p-value
Year of study (1-4 vs. 5-6)	Occurrence of exposure incident during 2012	**<0.001***
	Number of incidents	**<0.001**
	Type of incidents	0.350
	Method used to transfer blood and other bodily fluids	**<0.001**
	Frequency of wearing gloves (<50 vs. >50% of the time)	**<0.001**
	Reporting of incidents	0.776
	Time taken to report incident (<24 vs. >24 hours)	**0.039**
	Need for more training	**0.015**
	Format of training	0.145
	Changing practice when patient HIV+	**0.001**
ART regimen	Knowledge of HIV status of patient	0.603
	Knowledge of patient's HIV viral load	0.120
	Knowledge of whether patient is on ART	0.482
	Side effects on ART	0.493
Completed ART course	Knowledge of HIV status of patient	0.728
	Knowledge of patient's HIV viral load	0.052
	Knowledge of whether patient is on ART	0.093
	ART regimen	0.446
	AZT-based vs. TDF-based	0.506
	RAL-based vs. LPV-based	0.726
	Side-effects on ART	0.189

*Numbers in bold denote statistically significant results ($p<0.05$); HIV = human immunodeficiency virus; ART = antiretroviral therapy; AZT = zidovudine; TDF = tenofovir; RAL = raltegravir; LPV = lopinavir.

they had been rotating as unsupportive. In contrast, almost all students felt supported by family and friends (99.3%) or others in whom they could confide (94.4%). A sizeable proportion of students had felt generally stressed at the time of the incident, because of either other personal issues (29.6%), or academic stress (40.9%) and 31% believed the incident had worsened their anxiety and depression. More than half admitted worrying about their own HIV status (52.1%) and ART side effects (51.4%).

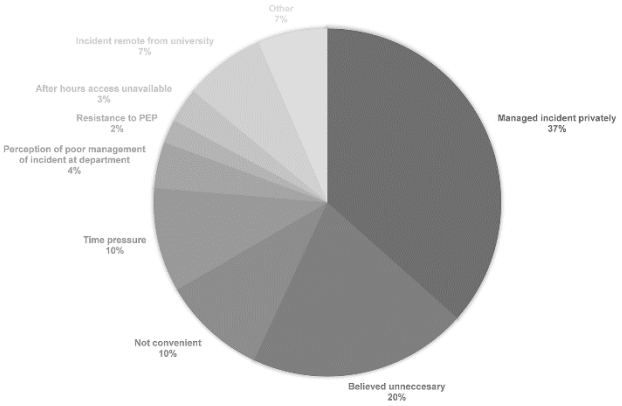
Management of exposure incidents

Ninety-one percent of students had washed the wound under a tap and 37.4% had used a disinfectant. Although advised not to do so, 17.8% had squeezed the wound to make it bleed. Just over half (53.7%) had reported the incident to the Department of Family Medicine as prescribed by university policy and, of these, 32.7%, 31.7% and 35.6% were reported immediately, within 24 hours, or only after one day respectively. Reasons for not reporting the incident are shown in Figure 2. The most common reasons were a preference for managing it privately (37%), believing it was not necessary (20%), and experiencing the reporting procedure as inconvenient or not having the time to report (10% each).

Just over three quarters (78.9%) of the students with injuries had been prescribed PEP for HIV. Of those not accessing ART, 60% stated they believed the risk was negligible and another 20% based this decision on the negative HIV result of the patient. Almost 60% (59.3%) of students reported awareness of the patient's HIV infection status at the time of the incident. Of these patients, a total of 34% was HIV-infected. Only 27.1% of the students, however, knew the patient's VL result, and, while roughly half (50.6%) knew whether the patient was taking ART, only 16.9% knew the regimen. Almost half of the students (46.7%) did not know their own hepatitis B immunity status, but of those tested, 95% showed sufficient immunity. A large proportion of students was also unaware of the hepatitis B and C infection status of their patient (78.7% and 80% respectively).

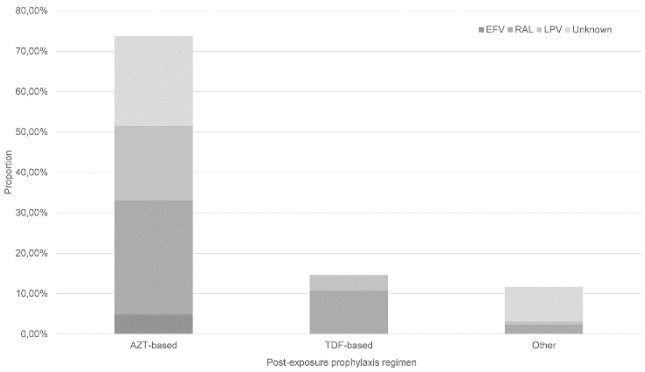
For students who had been prescribed PEP after the incident, 18.3% could not recall what they had taken. For the remainder, the most common regimens are shown in Figure 3. Even though the majority had started ART immediately (70.5%) or within 2 hours (20.9%), 8.5% only started more than 24 hours after the incident. Almost three quarters (73.3%) completed the ART course, with the median number of days of ART being 28 (IQR 7-28). Of the students who did not complete

Figure 2. Reasons for not reporting incidents.



PEP = post-exposure prophylaxis.

Figure 3. Breakdown of antiretroviral regimens used for post-exposure prophylaxis.



AZT = zidovudine; TDF = tenofovir; LPV = lopinavir; RAL = raltegravir; EFV = efavirenz.

the course, 66.7% reported that this was due to side-effects, while the remainder said that the patient had tested HIV-negative. A very large number of students (82.2%) experienced side-effects and most had a combination of these, with the most common being gastro-intestinal (nausea (80.8%), vomiting (27.3%), diarrhoea (21.2%), hepatitis (3%)), neuropsychiatric (headache (14.1%), mood swings or depression (11.1%), dizziness (8.1%)) or of a general nature (fatigue (31.3%)). Alarmingly, only 1 student completed 6 months of follow-up after the exposure incident.

ART regimen choice was not influenced by knowledge of patients' HIV status, VL, and whether they were on ART (Table 1). There was no association between the different ART regimens and whether students experienced side-effects. Completion of the regimen was also not associated with knowledge of the

patients' HIV status, VL, whether patients were on ART, and whether the students had experienced side-effects.

Training experiences and needs

Thirty-two percent of students felt they needed more training on prevention of injuries. Almost half (49%) preferred practical sessions, 41% favoured conventional methods, such as lectures (23.5%), cards or booklets (9.8%), and reinforcement of practice (7.8%), and 5.9% asked for audiovisual material such as videos, slideshows and iPhone applications (5.9%). In addition, 64.7% thought the working or training environment should be modified to help prevent injuries, most notably by providing and maintaining sharps bins (38.8%), giving access to safety needles and other safety equipment (29.6%), and ensuring that all sizes of gloves (22.5%) and vacutainers (20.4%) were readily available. Some felt that more staff, shorter working hours (8.3%) and behaviour change (7.1%) were needed.

Discussion

In this study, exposure incidents were frequent with 13% of students overall and 21% of senior students reporting an incident in the preceding year. This is in keeping with national and international studies that report injury rates in senior medical students of between 11% and 41% per year with an increasing incidence in the senior years [9], [19-22] and rates as high as 55% to 69% in interns [10,23]. The majority of incidents had occurred during phlebotomy, most likely due to the frequency with which students perform this procedure [10,19]. Unexpected patient movement during phlebotomy has been shown to be an important underlying cause and awareness of this potential risk should be incorporated into training [5,10]. Even though uncommon in our study, others have shown that being injured by a third party, for instance by a fellow student or a more senior colleague while performing a procedure or assisting in theatre, is a significant risk [5,10,19]. Training should therefore specifically address this risk and involve instructing all the categories of staff of the operating team in safe instrument transfer techniques [5].

Predictably, fatigue and time pressure were major contributors to incidents. A study at Tygerberg Hospital, South Africa, similarly showed that exposure incidents tended to occur on call or at night and that more than half of the students had had less than 6 hours, or even no sleep, in the preceding 24 hours [24]. Others have also found that inattention, stress or haste were major contributors to exposure injuries [5]. Departments that record disproportionately high incident rates are known for 'longer hours, demanding and often chaotic conditions, and high stress', resulting in students being fatigued [19,24]. In addition, incidents tended to occur more often in the beginning of the year and at the start of a rotation, possibly due to inexperience and uncertainty about the organization of the ward, resulting in being rushed or flustered [10,24]. It is important that all departments assess these contributing factors and that students receive additional training in relevant procedures in the beginning of the rotation, be declared competent before being allowed to perform these procedures in patients, and be well orientated in each ward.

Underreporting was common in keeping with other studies, which have also shown that only 46% to 64% of incidents are reported [8-15]. The most common reasons for not reporting the incident were preferring to manage it privately, or thinking that it was not necessary to do so. The latter reason was also reported by others, consistent with a lack of risk awareness, which should be addressed in training [5,12]. In addition, we found that lack of time and a perception that the reporting procedure was inconvenient also contributed to underreporting. Others echo these contentions and also mention ignorance of the reporting system, trivialization by superiors and shame as contributing factors [5,14,15]. Of note is that a large percentage of students (37%) preferred to manage the incident privately, suggesting that there may be unexplored issues regarding students' trust in the reporting system. One way in which to build trust is by ensuring privacy and confidentiality. The current practice in our institution is that students' results are available on the national laboratory database, implying that anyone with access to the system (i.e. fellow students and lecturers) can access their results. It is vital that such potential barriers to reporting practices be revisited and addressed on a contextual and institutional level.

In keeping with other studies, only about three-quarters of the students completed the ART course despite a high rate of HIV-infection in the source patients [19]. Side-effects were the most common reason for non-completion, a finding confirmed in many international studies which have reported substantial, subjective adverse effects in almost every series evaluating health care workers taking PEP [25-28]. Even though side-effects did not necessarily result in PEP discontinuation in this study, it seems prudent that PEP counselors be instructed in the timely

identification and appropriate management of side-effects. It may also be necessary to consider new ART regimen options, especially when considering the increasing number of patients failing treatment due to resistance to 1st line, and some even to 2nd and 3rd line regimens.

In this context, it is alarming to note that only about a quarter of students had knowledge of their patient's VL result, and, while half knew whether an HIV-infected patient was on ART, less than a fifth knew the regimen. Knowledge of hepatitis infection status in patients was even worse, with 80% of students completely unaware of this information. Local and international guidelines stress the importance of knowing a patient's ART history in order to inform PEP regimen choice. A recent unsuppressed VL in the source patient can alert the PEP counselor of the need to adjust PEP with the aid of expert consultation, preferably performing a genotypic drug resistance test if at all feasible [1,16-18].

It can be foreseen that training and up-skilling of the staff who are managing incidents will be needed. Countries may also consider following the example of the Centers for Disease Control and Prevention in the USA in instituting a PEPline where trained counselors can assist in assessing the risk of the exposure, selecting appropriate PEP regimens, managing side-effects and providing ongoing counseling and support for an emotionally traumatic event [29]. This could be based at a national disease surveillance centre or academic institution with existing infrastructure and serve as a national resource. Post-incident support is especially important since many students were already stressed before experiencing this traumatic event. Other studies have reported that some students felt that an exposure incident impacted on their career decisions and even made them question the viability of practising medicine in countries such as South Africa; issues that should be addressed by means of proper counseling [24].

Many of the students expressed the need for more formal training in universal precautions and exposure incident prevention. The best strategy seems to involve a practical component with reinforcement of appropriate practices as students enter their senior years. Educational programmes, especially procedural training, have been shown to decrease the number of exposure incidents [5,30,31]. Training should be comprehensive and practical, specifically aimed at helping students identify high-risk settings and taking the necessary precautions, including getting assistance, or even delaying the procedure [24]. Training should also emphasize the need to know a patient's infection status, VL and ART regimen. Training alone, however, cannot prevent all incidents and it is imperative that the widespread introduction of safety devices, as called for by the WHO [32], be given priority. Studies have shown that safe instruments can reduce needle-stick injuries by 50% [5]. It is, however, vital that students are not only instructed in the appropriate use of these devices, but are also monitored for the correct use of the safety mechanisms.

University and hospital authorities have a responsibility to ensure the safety of students during their training, and, for this reason, every effort should be made to ensure that the work environment does not contribute to exposure injuries. A workplace audit in

Table 2. Table of recommendations for prevention and management of exposure incidents.

Prevention	Training	• Practical sessions • Inclusion of novel technology in training • Emphasis on importance of knowing a patient's infection status, VL and ART regimen • Reinforcement of good practice in senior students
	Safety equipment	• Routinely available • Students responsible for carrying own equipment, at minimum gloves, vacutainers, and safety needles
	Departmental rotations	• Ward orientation • Specific instruction in relevant procedures • Competency testing before patient contact
	Work environment	• Working hours • Sharps disposal bins easily accessible and readily available
Management	PEP	• Individualise PEP based on patient's VL and ART • PEP helpline as a national resource • 24-hour availability
	Minimising underreporting	• Ensure privacy of student blood results • Simplify reporting procedures • Explore the option of electronic reporting for students doing rotations away from the university

PEP = post-exposure prophylaxis; VL = HIV viral load; ART = antiretroviral regimen.

the Free State, South Africa, found infection control measures in all three public hospitals evaluated to be unsatisfactory, specifically the unavailability of, or overflowing sharps containers. In addition, over a quarter (28.5%) of staff washed their gloves after use and a fifth did not always wash their hands with soap and water between patients, likely due to the absence of gloves and soap in the wards [33]. At minimum, safety equipment and gloves should be universally available and sharps containers positioned and maintained to allow for easy and safe disposal of sharps. However, the availability of safety equipment during rotations, especially in rural settings, is a concern [4]. Students therefore also need to embrace a culture of safety and should be empowered to have their own safety equipment and to take responsibility to carry this equipment with them.

This study has some limitations. The voluntary, retrospective and cross-sectional design of the study is open to reporting and recall bias and restricts analysis to tests of association and not causality. The data also originate from a single institution and may therefore not be representative of the situation in other institutions. This research does, however, have significant strengths, such as the large number of participants that allows for adequate statistical power to detect differences between junior and senior students; the inclusion of a wide variety of settings to which students are exposed; the novel aspects not previously explored in this field, such as the reasons for underreporting and non-adherence to protocols; and a focus on recommendations for preventing and managing such incidents. In addition, this study uniquely demonstrates the importance of patient information, such as the treatment regimen and treatment response, in the management of exposure incidents, and provides data that supports implementation of strategies that improve the work environment of students through adequate sharps disposal and safety devices.

We recommend that exposure incidents be tackled with a multi-faceted approach, ranging from prevention of exposure injuries to appropriate management (Table 2). Prevention strategies should consider training, the availability of safety equipment, appropriate ward orientation of students and new staff, and the safety of the work environment. Management should focus on best practices for PEP, including consideration of a PEPline, and improved reporting systems that ensure the privacy and confidentiality of results.

Conclusion

The problem of exposure injuries in healthcare workers is both common and longstanding, affecting at least a fifth of senior medical students and a large number of qualified healthcare workers annually. Underreporting of incidents is widespread and training institutions should ensure that identification of barriers to reporting are prioritised and addressed on an institutional level. With increasing numbers of HIV-infected patients on ART, it has become imperative for students to establish the VL and ART regimen of the source patient as a matter of urgency after an exposure incident in order to assess the need to individualise PEP. We recommend targeted incident prevention training, especially in the senior years, improving the work environment through attention to working hours, ready availability of both safety devices and sharps disposal containers, individualized PEP and possibly the implementation of a PEP support line.

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Authors' contributions

All three authors designed the study, assisted in refining the manuscript and read and approved the final version. MvR distributed the questionnaires to the students and managed the incident reporting; TR wrote the first draft.

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