Abstract: The purpose of this study was to conduct a qualitative analysis of waste management practices among a group of Brazilian dental students (n=64) before and after implementing two different pedagogical methods: 1) the students attended a two-hour lecture based on World Health Organization standards; and 2) the students applied the lessons learned in an organized group setting aimed toward raising their awareness about socioenvironmental issues related to waste. All eligible students participated, and the students’ learning was evaluated through their answers to a series of essay questions, which were quantitatively measured. Afterwards, the impact of the pedagogical approaches was compared by means of qualitative categorization of wastes generated in clinical activities. Waste categorization was performed for a period of eight consecutive days, both before and thirty days after the pedagogical strategies. In the written evaluation, 80 to 90 percent of the students’ answers were correct. The qualitative assessment revealed a high frequency of incorrect waste disposal with a significant increase of incorrect disposal inside general and infectious waste containers (p<0.05). Although the students’ theoretical learning improved, it was not enough to change behaviors established by cultural values or to encourage the students to adequately segregate and package waste material.

Keywords: dental education, dental students, health care waste, dental waste, waste management, Brazil

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Health care facilities have a significant responsibility in regards to waste production or health care waste (HCW). Due to the hazard that such waste represents to health care workers, public health, natural resources, and the environment, it is necessary to have a complex management system that is planned and implemented with a focus on waste reduction while guaranteeing a safe and efficient destination for the waste. The adequate management of HCW is a biosafety practice recommended by such organizations as the World Health Organization (WHO), Brazilian Health Ministry, and U.S. Centers for Disease Control and Prevention. The correct management of waste uses standard precautions, which are part of a group of infection control measures universally adopted to minimize biological hazard aimed toward preventing the transmission of disease in clinical environments.

Health care services are subject to the creation of a health care waste management plan (HCWMP) consisting of preventive and corrective actions that must be implemented in situations of incorrect waste management or accidents. This plan must be comprised of protocols related to the separation, identification, packaging, on-site transportation, storage, collection, and off-site transportation, treatment, and final disposal of HCW. In every phase, waste management must follow certain packaging protocols to minimize the risk of injury or hazard by using various types of containers and plastic bags according to the following classification. Group A consists of infectious waste: any contaminated materials that have come into contact with blood and/or bodily fluids; e.g., gauze, cotton, disposable instruments for suction. These should be contained in white plastic bags that line waste containers with foot-operated lids. Group B consists of chemicals: any substances that are toxic to the environment, e.g., chemicals used for processing radiographs. These should be contained in white plastic bags that line waste containers with foot-operated lids. Group C consists of radioactive materials, a type of waste not produced in dentistry. It should be discarded in lead boxes. Group D consists
of general uncontaminated waste: any material that has not come into contact with blood and/or bodily fluids. These should be discarded in black plastic bags that line waste containers with foot-operated lids. Group E consists of sharps wastes: any contaminated material that punctures and/or cuts and has come into contact with blood and/or bodily fluids. Examples include scalpel blades, needles, glass vials, etc., which should be discarded in puncture-proof containers.2

In dental clinics, the initial phases of waste management include separating the HCW when it is generated and packaging it according to type. Appropriately packaging the waste into containers depends on the knowledge of the primary waste producers, that is, the professionals who work directly with the patient. After implementing the HCWMP in a dental school and incorporating the waste management protocols in the school’s biosafety protocol,8 problems were identified in the segregation and packaging phases, which are usually the responsibility of the dental students; after a period of observation, a large mixture of waste was identified due to incorrect separation. Without adequate waste segregation, all other management phases were jeopardized.9 Inadequate waste disposal may increase the risk of injury to employees in charge of cleaning and collecting waste in health care facilities. Eighty percent of accidents in educational institutions are associated with injuries caused by sharp objects left in the waste produced.10

The proposed solution for HCW management is to educate and train health professionals to separate waste appropriately11 since it is the professionals’ responsibility to ensure the health of the population.12-14 By following the HCW management guidelines, the health professional can prevent human injury as well as damage to the environment.15 Regarding health care students, Corrêa et al.16 reported that these students are exposed in academic environments to activities related to the separation, packaging, and collection of HCW; however, they do not fully understand HCW management. Therefore, these authors emphasized the need to include HCW-related issues in the pedagogical content of predoctoral courses in order to prepare professionals who are committed to socioenvironmental responsibility.

These previous studies found that, in order to correct the observed failures related to waste separation and packaging, it would be necessary to find pedagogical alternatives to improve how HCW management is taught. Nevertheless, few studies about this subject exist in the literature. For this reason, the aim of this study was to evaluate the efficacy of two different pedagogical approaches focused on conscientious waste disposal in a Brazilian undergraduate school of dentistry.

**Methodology**

This study was approved by the Ethics and Research Committee of the Faculdade São Leopoldo Mandic, Campinas, SP, Brazil (Protocol #2009/0198). Two pedagogical approaches were developed based on recommendations found in the Brazilian regulations: RDC No. 306/2004 and Conama No. 358/2005.17 Both were applied among the same group of dental students (n=64) according to the following methods.

In the first approach, lecture as a teaching method (P1), a two-hour lecture was delivered during the first bimester of classes, with the use of an overhead projector and teaching methodology based on the recommendations provided in WHO’s Teacher’s Guide: Management of Wastes from Health Care Activities.18 The lecture consisted of information related to HCW regulations, classification, hazards, and phases involved in HCW management from waste production to the final destination of the waste.

In the second approach, applied learning as a teaching method (P2), a four-hour group session was conducted during the third bimester of classes. The content was similar to P1, but it included simulation and experimenting in order to increase the students’ awareness of socioenvironmental issues related to HCW. A video “Conscientious Disposal” showing the complete sequence of management was made for the study. The video showed the risk of cross-contamination by incorrectly disposed waste, simulation of an employee injury caused by sharp waste, and the environmental contamination caused by incorrectly disposed infectious and chemical waste. To expose the students to real-life situations, the Campinas Department of Urban Sanitation organized an educational outing called the “Waste Tour,” which included a monitored and interactive visit to Delta A, the landfill in Campinas, and to the Center for Treating Infectious Waste.19

To determine the effects of the interventions, two questions were added to the integrated clinic summative evaluation to assess the knowledge regarding HCW gained by the students. The questions were as follows: 1) In the context of HCW, what is considered sharp and chemical waste, and how should they be packaged? 2) Name examples from
Group A, infectious waste, and E, sharp waste, and describe the way they should be packaged.

During the study period, the containers for waste packaging, which are routinely available to the students, were monitored. After each clinical activity, sanitation employees who were trained by the researchers collected the waste without the students’ knowledge to ensure that waste separation and packaging occurred as usual. The waste was transported in collection carts to the laboratory, where it was stored in containers until it was categorized. The collection of clinical waste produced by students was done in three blocks of eight consecutive days: before the pedagogical methods were introduced (P0); thirty days after implementation of the first pedagogical method (P1), and thirty days after implementation of the second pedagogical method (P2). The experimental design is shown in Figure 1.

The objective of the next phase was to evaluate whether the HCW had been appropriately segregated and packaged according to the methods introduced in the teaching modules based on the regulation RDC 306. The classification criteria were based on the type of waste and method of disposal (correct or incorrect). For infectious waste, the contents were materials that have come into contact with blood and/or bodily fluids, e.g., gauze, cotton, and tips; the correct receptacle is white plastic bags that line waste containers with foot-operated lids. For general waste, the contents were materials that have not come into contact with blood and/or bodily fluids, e.g., regular packaging materials; the correct receptacle is black plastic bags that line waste containers with foot-operated lids. For sharps waste, the contents were materials that puncture and/or cut and have come into contact with blood and/or bodily fluids, e.g., scalpel blades, needles, and glass vials; the correct receptacle is impermeable, puncture-proof containers.

Regarding method of disposal, the disposal was considered to be correct when the container and all of its contents belonged to the same category. For example, in the impermeable, puncture-proof box, only sharps waste was found, such as needles, endodontic files, drill bits, blades, etc. In contrast, the disposal was considered to be incorrect when the content of the container had one or more items from a different category. For example, in the impermeable, puncture-proof box, a contaminated bandage was found.

All of the data were collected according to the identification card and inserted in the inspection card. HCW handled by the employees was excluded (Group B chemicals and Group C radioactive) due to the fact that they were not produced during these clinical activities. The data were tabulated, and a

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**Figure 1. Experimental design of study**

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Discussion

HCW management consists of practices that health care professionals must employ in their daily routines to ensure that biological hazards are controlled by avoiding cross-contamination, minimizing occupational risks, protecting public health, and promoting practices that are environmentally sustainable.\textsuperscript{11} Over the past decades, legislation has been passed to regulate HCW management and reduce its impact on the population and environment.\textsuperscript{2,5,17} The most recent Brazilian law is No. 12.305, which established the National Policy for Solid Waste and the concept that waste management is a responsibility shared by the government, private companies, and the population.\textsuperscript{5} The mere presence of a law is not enough to accomplish its objective, as evidenced by the chaos that resulted from HCW management in Brazil and made it necessary to establish greater communication among scientists, relevant organizations, professionals, and the greater population to reach a solution.\textsuperscript{20} The consequence of incorrect HCW packaging and disposal is an increase of hazards inherent in the contaminated materials,\textsuperscript{21} enhancing the need for educational measures.

Table 1. Students’ correct answers about HCW

<table>
<thead>
<tr>
<th>Question</th>
<th>Median</th>
<th>Average</th>
<th>SD</th>
<th>% of Right Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>0.9</td>
<td>0.2</td>
<td>90%</td>
</tr>
<tr>
<td>2</td>
<td>0.8</td>
<td>0.8</td>
<td>0.1</td>
<td>80%</td>
</tr>
</tbody>
</table>

Table 2. Type of disposal, by container and periods of the study

<table>
<thead>
<tr>
<th>Waste</th>
<th>Time</th>
<th>Incorrect</th>
<th>Correct</th>
<th>General Total</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Infectious</td>
<td>Time 0</td>
<td>248</td>
<td>72.7%</td>
<td>93</td>
<td>27.3%</td>
</tr>
<tr>
<td></td>
<td>Time 1</td>
<td>287</td>
<td>76.7%</td>
<td>87</td>
<td>23.3%</td>
</tr>
<tr>
<td></td>
<td>Time 2</td>
<td>283</td>
<td>80.6%</td>
<td>68</td>
<td>19.4%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>818</td>
<td>76.7%</td>
<td>248</td>
<td>23.3%</td>
</tr>
<tr>
<td>II. General</td>
<td>Time 0</td>
<td>88</td>
<td>31.3%</td>
<td>193</td>
<td>68.7%</td>
</tr>
<tr>
<td></td>
<td>Time 1</td>
<td>139</td>
<td>42.2%</td>
<td>190</td>
<td>57.8%</td>
</tr>
<tr>
<td></td>
<td>Time 2</td>
<td>104</td>
<td>41.9%</td>
<td>144</td>
<td>58.1%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>331</td>
<td>38.6%</td>
<td>527</td>
<td>61.4%</td>
</tr>
<tr>
<td>III. Sharps</td>
<td>Time 0</td>
<td>57</td>
<td>79.2%</td>
<td>15</td>
<td>20.8%</td>
</tr>
<tr>
<td></td>
<td>Time 1</td>
<td>65</td>
<td>78.3%</td>
<td>18</td>
<td>21.7%</td>
</tr>
<tr>
<td></td>
<td>Time 2</td>
<td>60</td>
<td>88.2%</td>
<td>8</td>
<td>11.8%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>182</td>
<td>81.6%</td>
<td>41</td>
<td>18.4%</td>
</tr>
</tbody>
</table>
During the baseline data collection period of the HCW qualitative assessment (P0), only the biosafety protocol was used to determine the correct way to classify, segregate, and package HCW. This phase resulted in high rates of inadequate practices for segregating the HCW, an expected outcome, as these practices are common in health care facilities in Brazil,19,22,23 as well as many other countries.24,25

After the pedagogical methods were introduced, a slow and significant increase was observed in the incorrect disposal of waste in the containers for infectious waste materials and general waste materials, highlighting the continued mixing of waste materials. The use of incorrect disposal inside containers for sharps waste materials remained high, and no significant differences were found in the three periods of the study.

Research has been done on programs that focus on how to appropriately separate waste materials. Hagen et al.26 conducted a study on an HCW management education and training program for health care workers in Saudi Arabia, while Nataraj et al.27 focused on how waste materials were separated and discarded at a medical school in India. The results of both studies were more promising than ours; however, comparing these studies is difficult because the target group of the first one was hospital employees with stable jobs as opposed to dental students, who could overlook the mandatory need for these procedures. In the second study, a system for monitoring the medical students in India was implemented to identify and immediately correct improper HCW disposal, a practice not used in our study. Had there been a monitoring system in our study, more dental students may have employed the lessons learned for appropriate waste management.

According to Corrêa et al.,16 the students’ inadequate segregation and packaging of waste may be related to the lack of infrastructure for HCW management and the school’s fragmented way of teaching. They state that if the HCW management program were taught in a single unit, it could provide opportunities for reflection and self-analysis and provide the students with a greater sense of accountability. In our study, the expected behavioral change was not observed despite the pedagogical efforts, highlighting the complexity of the issue. The results of our study show that the infrastructure offered by the school and adapted to current HCW management standards as well as the new pedagogical approaches were not enough to increase the students’ awareness of appropriate waste disposal.

The data collected from the written HCW evaluation based on the theoretical learning process indicated that the students learned appropriate waste management practices and proved that in theory they understand how to correctly classify and package HCW; however, such knowledge was not applied in practice. Even though the students were aware of all of the stages involved in HCW management, the hazards associated with HCW, and current laws2,5,17 that emphasize the waste generator is responsible for the waste produced, they continued acting indifferently and with a lack of accountability for the HCW they generated. This behavior is possibly the consequence of cultural attitudes related to waste. Our society has been neglecting the “trash” produced and its impact on the environment. Few Brazilian citizens are accustomed to noticing and caring about the waste they produce and, generally, after consumption, waste is disposed in the environment without any concern for its final destination.28

Our study confirms the observations of Borges and Pinto28 that there may be limitations when HCW is treated as an isolated curriculum subject. Our society needs an educational and cultural shift in order to support the proposition that health care services should treat HCW in a multidisciplinary and systematic way to reach the organization as a whole and emphasize environmental education. University and college faculty members must be committed to HCW management, and health care courses should develop professionals who are capable of working in interdisciplinary teams, acting as health care promotion agents and responsibly providing health care services.16 Considering these results, implementing educational policies to ensure that future health care professionals are aware and committed to conscientious HCW management practices is crucial.

Conclusion

This study showed that the new pedagogical approaches improved theoretical knowledge. Nonetheless, these approaches were not sufficient to change the students’ clinical behavior or encourage them to appropriately segregate and dispose of waste in the dental clinic.

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