Original Article

Knowledge and Awareness of Effective Recycling of Dental Materials and Waste Management among Peruvian Undergraduate Students of Dentistry: A Logistic Regression Analysis

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Objective: Biomedical waste management and recycling is a very important topic today to preserve the environment, especially at the university level where future specialists in the health sciences are trained. So, the aim of this study was to evaluate the knowledge and awareness about recycling of dental materials and waste management among Peruvian undergraduate students of dentistry.

Materials and Methods: This cross-sectional study evaluated 254 Peruvian undergraduate dentistry students from October 2019 to January 2020, at the National University of San Marcos. The associated factors evaluated were age (X1), sex (X2), year of study (X3), and marital status (X4), which were analyzed using a logit model to identify the influence of the intervening variables with a P value <0.05. Results: None of the variables studied were considered to be a factor affecting the awareness, knowledge, and management of biomedical waste in Peruvian dentistry students, with the following odds ratios (OR) being obtained: age (OR = 0.96; confidence interval [CI]: 0.85–1.08), sex (OR = 1.69; CI: 0.98–2.90), year of study (OR = 1.18; CI: 0.91–1.54), and marital status (OR = 1.84; CI: 0.14–23.68). Conclusions: The results of this study show that Peruvian Public University students have knowledge and are aware of the need for adequate management and/or recycling of biomedical waste dental care products, with none of the possible associated variables studied significantly affecting this relationship.

KEYWORDS: Awareness, dentistry, knowledge, recycling, students

INTRODUCTION

Rapid population growth leads to a continuous increase in the development and industrialization of the economy, and thus, a greater production of solid waste. This increase in waste production has a direct impact on the environment, and a lack of adequate management of recycling can become a threat to public health. Therefore, the management of biomedical waste is of great relevance, and it must be coordinated by the corresponding authorities, especially in universities and institutions in which future professionals are trained to guarantee the reduction of waste, recycling, and reuse of biomedical waste.[1-3]

One of the most important factors to take into account is the social responsibility of health-care personnel and the participation of the general population in the sustainability of any environmental conservation program.[4] The most important way to generate public interest and participation in the aforementioned

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issues is to understand and identify the knowledge and awareness about the management and recycling of these solid wastes. Therefore, the development of recycling programs is now a mainstay in most middle-to high-income countries, with health personnel being educated in the separation of waste products.

An important problem related to current biomedicine is waste management in many hospitals. However, regulation of these biological wastes is poor. Indeed, it is very alarming that most of the biomedical waste produced that does not receive adequate treatment is generally thrown into a landfill. Improper disposal of this waste has led to numerous health risks, such as puncture injuries, the development of infection, and the emergence of strains resistant to traditional antibiotics. It is therefore essential to frame and generate sustained strategists to collect, transport, discard, and recycle biomedical waste. Regulations aimed at solving this problem can preserve the environment from problems caused by deficient recycling.

Thus, the purpose of this study was to evaluate the knowledge and awareness of effective recycling of dental materials and waste management among Peruvian undergraduate students of dentistry.

MATERIALS AND METHODS

STUDY DESIGN AND PARTICIPANTS

This was an analytical and observational study that included the entire student population \((N = 254)\) of the Faculty of Dentistry at the Universidad Nacional Mayor de San Marcos (UNMSM) from October 2019 to January 2020, who performed their internship in the central hospital of the air force of Peru, Naval Medical Center, National Hospital Dos de Mayo, so it was not necessary to calculate a sample. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were applied for the preparation of this manuscript.

INCLUSION CRITERIA

1. Students of both sexes of legal age
2. Students duly registered during the 2019 academic year
3. Students who provided informed consent
4. Dentistry interns of the participating hospitals

EXCLUSION CRITERIA

1. Students with a license
2. Students who did not wish to participate

ASSOCIATED FACTORS

The factors considered to determine the level of knowledge of biomedical waste management, effective recycling, and reuse of dental materials were age \((X_1)\), sex \((X_2)\), year of study \((X_3)\), and marital status \((X_4)\).

DATA COLLECTION AND STUDY INSTRUMENT

To collect the data of students and dental interns, a validated questionnaire by Ranjan et al. with two dimensions was used. The 15 questions in the first dimension were related to the management of biomedical waste, whereas those in the second dimension (15 questions) were related to the recycling of dental materials. The answer of each question was divided into correct or incorrect. The information collected was analyzed, and a Likert scale was used to analyze awareness and knowledge regarding the two dimensions.

STATISTICAL ANALYSIS

Descriptive statistics were performed by obtaining the percentages of the categorical variables, and measures of central tendency and dispersion were used for the numerical variables. The Pearson’s chi-square test was used for bivariate analysis. The risk factors were established with the logistic regression model (logit model) using odds ratio (OR). All the analyses were carried out considering a \(P\) value <0.05 as significant. The Stata statistical software, version 15.0, was used to perform the statistical analyses.

RESULTS

Among the students, female sex was found to be the most prevalent with 60.6%, and the proportion was greatest in the third year of dentistry (29.5%). Regarding marital status, 98.4% of the undergraduate students were single, with a mean age of 22.2 ± 2.3 years [Table 1].

The results show that there was only a statistically significant association between the sex of the Peruvian undergraduate dentistry students and Q2 (Are you aware about the theoretical and practical knowledge required

| Table 1: Descriptive characteristics of the variables corresponding to Peruvian undergraduate students of dentistry |
|---------------------------------|-----------------|----------------|
| Variable                        | Categories      | \(n\) | \(\%\) |
| Sex                            | Female          | 154  | 60.6 |
|                                | Male            | 100  | 39.4 |
| Year of study                  | Second          | 57   | 22.4 |
|                                | Third           | 75   | 29.5 |
|                                | Fourth          | 66   | 25.9 |
|                                | Fifth           | 56   | 22.0 |
| Marital status                 | Single          | 250  | 98.4 |
|                                | Married         | 0    | 0    |
|                                | Cohabiting      | 4    | 1.5  |
| Age                            |                 | 22.2 | 2.3  |
to manage and/or recycle/reuse hospital waste?) and Q15 (Do you feel hospitals and other organizations are financially equipped to maintain biomedical waste management?) ($P = 0.009$ and $P = 0.007$, respectively) [Table 2].

On the contrary, the year of study of the dentistry students was found to be significantly associated ($P < 0.05$) with the following questions: Q1 (Are you aware of government regulations and legislations related to biomedical waste management in our

| Question                                                                 | Extremely aware | Very aware | Moderately aware | Slightly aware | Not at all | Sex | Year of study | Marital status |
|--------------------------------------------------------------------------|-----------------|------------|------------------|----------------|------------|-----|---------------|---------------|
| Q1. Are you aware of government regulations and legislations related to biomedical waste management in our country? | 65 (25.5)       | 74 (29.1)  | 92 (36.2)        | 20 (7.8)       | 2 (1.1)    | 0.159 | 0.039         | 0.242         |
| Q2. Are you aware about the theoretical and practical knowledge required to manage and/or recycle/reuse hospital waste? | 40 (15.7)       | 74 (29.1)  | 115 (45.2)       | 25 (9.8)       | 0 (0.0)    | 0.009 | 0.001         | 0.037         |
| Q3. Do you know how inadequate biomedical waste management contributes to environmental pollution and global warming? | 9 (3.5)         | 16 (6.3)   | 54 (21.2)        | 106 (41.7)     | 69 (27.1)  | 0.397 | 0.018         | 0.028         |
| Q4. Do you know the six effective steps of biomedical waste management? | 99 (38.9)       | 72 (28.3)  | 73 (28.7)        | 8 (3.1)        | 2 (0.7)    | 0.066 | 0.049         | 0.549         |
| Q5. Do you remember the type of incinerator that was present in the institute you studied? | 140 (55.1)      | 68 (26.7)  | 39 (15.3)        | 7 (2.7)        | 0 (0.0)    | 0.244 | 0.510         | 0.346         |
| Q6. Are you aware of methods, besides incineration and landfills, of effective waste disposal? | 92 (36.2)       | 86 (33.8)  | 58 (22.8)        | 17 (6.6)       | 1 (0.3)    | 0.100 | 0.098         | 0.766         |
| Q7. Do you see that hospital waste is being managed by professionally trained staff in our country? | 70 (27.5)       | 71 (27.9)  | 75 (29.5)        | 34 (13.3)      | 4 (1.5)    | 0.244 | 0.602         | 0.233         |
| Q8. Are you aware of the waste water treatment process? | 39 (15.3)       | 82 (32.2)  | 93 (36.6)        | 30 (11.8)      | 10 (3.9)   | 0.140 | 0.628         | 0.363         |
| Q9. Do you know lead aprons and lead collars should be disposed of by licensed recyclers? | 72 (28.3)       | 61 (24.0)  | 64 (25.2)        | 41 (16.1)      | 16 (6.3)   | 0.211 | 0.055         | 0.601         |
| Q10. Do you know that defective incineration emits greenhouse gases? | 35 (13.7)       | 60 (23.6)  | 63 (24.8)        | 61 (24.0)      | 35 (13.7)  | 0.071 | 0.253         | 0.705         |
| Q11. Are you aware of any environment-friendly technology that converts organic waste into commercially useful by-products? | 72 (28.3)       | 77 (30.3)  | 75 (29.5)        | 19 (7.4)       | 11 (4.3)   | 0.509 | 0.353         | 0.604         |
| Q12. Do you know the component of fixer solutions used in X-rays that is considered hazardous? | 76 (29.9)       | 66 (25.9)  | 73 (28.7)        | 29 (11.4)      | 10 (3.9)   | 0.082 | 0.002         | 0.565         |
| Q13. Do you feel that biomedical waste should be a practical exercise in dental colleges? | 11 (4.3)        | 29 (11.4)  | 59 (23.2)        | 66 (25.9)      | 89 (35.0)  | 0.526 | 0.007         | 0.470         |
| Q14. Are you aware that improper biomedical waste management affects the population? | 6 (2.3)         | 19 (7.4)   | 59 (23.2)        | 78 (30.7)      | 92 (36.2)  | 0.348 | 0.069         | 0.502         |
| Q15. Do you feel hospitals and other organizations are financially equipped to maintain biomedical waste management? | 22 (8.6)        | 53 (20.8)  | 98 (38.5)        | 57 (22.4)      | 24 (9.4)   | 0.007 | 0.388         | 0.922         |
country? Q2 (Are you aware about the theoretical and practical knowledge required to manage and/or recycle/reuse hospital waste?), Q3 (Do you know how inadequate biomedical waste management contributes to environmental pollution and global warming?), Q12 (Do you know the component of fixer solutions used in X-rays that is considered hazardous?), and Q13 (Do you feel that biomedical waste should be a practical exercise in dental colleges?) [Table 2].

Finally, in relation to marital status, statistically significant associations were only found between questions Q2 (Are you aware about the theoretical and practical knowledge required to manage and/or recycle/reuse hospital waste?) and Q3 (Do you know how inadequate biomedical waste management contributes to environmental pollution and global warming?) (P < 0.05) [Table 2].

Statistically significant associations were found between the sex of the students and Q16 (Are you aware of which component of dental amalgam is environmental hazard?), Q22 (Can gypsum be recycled?), Q24 (When used as a land filler can gypsum produce friendly gas?), Q25 (Do you know that gypsum can be recycled for use in more than ten other products?), Q27 (Can

| Table 3: Association of awareness of Peruvian undergraduate students on the recycling and reuse of dental materials |
| --- |
| Q16. Are you aware of which component of dental amalgam is an environmental hazard? | Extremely aware | Very aware | Moderately aware | Slightly aware | Not at all aware | Sex | Year of study | Marital status |
| n (%) | n (%) | n (%) | n (%) | n (%) | P | P | P |
| 23 (9.0) | 32 (12.6) | 60 (23.6) | 75 (29.5) | 64 (25.2) | 0.006 | 0.923 | 0.753 |
| Q17. Can silver be retrieved from dental amalgam? | 90 (35.4) | 69 (27.1) | 73 (28.7) | 16 (6.3) | 6 (2.3) | 0.082 | 0.504 | 0.782 |
| Q18. Can mercury be retrieved from dental amalgam? | 88 (34.6) | 65 (25.5) | 75 (29.5) | 21 (8.2) | 5 (1.9) | 0.265 | 0.412 | 0.323 |
| Q19. Have you seen a dental unit with an amalgam separator? | 174 (68.5) | 47 (18.5) | 28 (11.0) | 3 (1.1) | 2 (0.7) | 0.837 | 0.630 | 0.813 |
| Q20. Did you know that excess amalgam after a filling in a patient’s mouth should be disposed in a conventional spittoon attached to the dental chair? | 100 (39.3) | 59 (23.3) | 66 (25.9) | 23 (9.0) | 6 (2.3) | 0.615 | 0.072 | 0.681 |
| Q21. Are you aware that nonrecyclable materials such as syringes, needles, and intravenous (IV) sets can be recycled for other uses? | 118 (46.4) | 61 (24.0) | 47 (18.5) | 19 (7.4) | 9 (3.5) | 0.136 | 0.213 | 0.968 |
| Q22. Can gypsum be recycled? | 97 (38.1) | 63 (24.8) | 72 (28.3) | 16 (6.3) | 6 (2.3) | 0.028 | 0.273 | 0.972 |
| Q23. Can gypsum be used as a land filler material? | 87 (34.2) | 64 (25.2) | 78 (30.7) | 15 (5.9) | 10 (3.9) | 0.100 | 0.203 | 0.911 |
| Q24. When used as a land filler material, can gypsum produce friendly gas? | 108 (42.5) | 59 (23.2) | 62 (24.4) | 20 (7.8) | 5 (1.9) | 0.027 | 0.286 | 0.207 |
| Q25. Do you know that gypsum can be recycled for use in more than 10 other products? | 115 (45.2) | 70 (27.5) | 50 (19.6) | 15 (5.9) | 4 (1.5) | 0.023 | 0.085 | 0.344 |
| Q26. Are you aware that elastomeric impression materials can be recycled? | 119 (46.8) | 68 (26.7) | 54 (21.2) | 13 (5.1) | 0 (0.0) | 0.114 | 0.083 | 0.117 |
| Q27. Can thermoplastics used in dentistry be reused? | 95 (37.4) | 79 (31.1) | 62 (24.4) | 15 (5.9) | 3 (1.1) | 0.019 | 0.563 | 0.921 |
| Q28. Do you know what biodegradable plastic is? | 32 (12.6) | 34 (13.3) | 78 (30.7) | 68 (26.7) | 42 (16.5) | 0.060 | 0.346 | 0.887 |
| Q29. Apart from dental gold, can other dental alloys be recycled? | 65 (25.5) | 73 (28.7) | 72 (28.3) | 35 (13.7) | 9 (3.5) | 0.005 | 0.008 | 0.036 |
| Q30. Do you feel more studies are needed regarding the subject of recycling and reuse in dentistry? | 15 (5.9) | 17 (6.6) | 50 (19.6) | 57 (22.4) | 115 (45.2) | 0.614 | 0.566 | 0.685 |
Biomedical waste generated as a result of the clinical care of patients in all health areas is considered a public health problem when poorly disposed of. According to the World Health Organization (WHO), hazardous waste makes up around 20% of contaminants to humans and the environment. These residues can be of sharp, infectious, chemical, and pharmaceutical origin. Students and dental professionals are also exposed to an increased risk of becoming contaminated by cross infection during clinical practice as most microorganisms can be transmitted through saliva.\(^5\)[7] For this reason, this development of infections, and bacterial resistance of dental waste can cause injuries with sharp objects, not made aware of the need for this. Improper disposal of dental waste can cause injuries with sharp objects, development of infections, and bacterial resistance to certain microorganisms.\(^8\) For this reason, this study aimed to evaluate the knowledge and awareness of effective recycling of dental materials and waste management among Peruvian undergraduate students of dentistry.

In a study by D’abundo et al.,\(^{[11]}\) community health and gerontology students were interviewed before and after receiving an illustrative brochure of the Recycling Mentors project on environmental health education. Overall, the application of Recycling Mentors was a positive service learning experience in which students showed outstanding results on how to learn about recycling and the environment. In addition, it was important to motivate the development of the Recycling Mentors component in health science students. They concluded that the generation of program involving mentors and students is important to positively motivate individual change impacting the environment.

In contrast, a study by Ranjan et al.,\(^{[8]}\) assessed the awareness of medical waste management as well as recycling and the effective reuse of dental materials of undergraduate students in all the dentistry universities in India from February 2016 to April 2016. They found that 44% of the students knew nothing about the management of biomedical wastes, 22% of students were moderately aware, whereas only 5% were in the category of extremely aware. However, 61% of students were completely unaware of the aspects about recycling and reuse of dental materials. Accordingly, these authors concluded that student knowledge about the management and reuse of medical waste was insufficient, and that training programs in this respect were needed.

On the contrary, according to Saladié and Santos-Lacueva,\(^{[12]}\) awareness campaigns should be included in waste management policies to improve categorical disposal. They found that 75% of the subjects reported having improved their waste collection, and 75.4% said they knew of an awareness campaign on this issue. However, each student is required to continue to raise awareness of the influence exerted on the improvement of rates of selective waste collection. Similarly, a study by Pinto et al.,\(^{[13]}\) found that a university canteen generated high amounts of waste, which never achieved “good” standards, and suggested the need to take action. They concluded that the total waste reduced by 15%, and that the increased awareness is needed by health personnel in regard to the problem of not only

| Table 4: Multivariate logistic regression analysis of awareness of effective recycling of dental materials according to the associated factors |
|-----------------|--------|--------|--------|
| Independent variables | OR    | P      | CI 95% |
| (X1) Age          | 0.96  | 0.533  | 0.85–1.08 |
| (X2) Sex          | 1.69  | 0.055  | 0.98–2.90 |
| (X3) Year of study| 1.18  | 0.196  | 0.91–1.54 |
| (X4) Marital status| 1.84  | 0.637  | 0.14–23.68 |

OR = odds ratio, CI = confidence interval

Logit model: All the variables were entered in the statistical analysis of the multivariate model

The logit model showed that age, sex, year of study, and marital status do not significantly influence awareness, knowledge, attitude, and practices in the management of biomedical waste: a multivariate analysis of risk factors for Peruvian dental students.
According to Sood and Sood,[14] the management of waste generated during medical care is a very critical issue because it is a potential direct threat to public health and the environment. Dental waste includes gloves, gauze, developers, fixatives, mercury, and lead, and thus, health science students must be trained and educated about waste management. These results disagree with ours as Peruvian students showed an optimal level of knowledge and awareness about waste management and recycling.

Another interesting study was that conducted by Haralur et al.[15] who evaluated 80 dental technicians. The questionnaire was anonymous and was used to understand knowledge, attitudes, and guidance regarding the management of medical waste. It was pointed out that dental practice generates infectious, noninfectious toxic, and domestic waste, and that dental laboratories handle potentially infectious objects, such as plasters, dental cements, alginate, and silicone, among other products. This research concluded that there is a need to update the curriculum of students to raise awareness about the proper management of this waste. Although waste reduction is at the top of the waste hierarchy, no real decoupling between the generation and consumption of waste has been demonstrated to date.[16]

To ensure adequate waste management, greater interest in waste prevention is necessary as there is little literature related to the integration of prevention in local waste management.[17] Taking into account all of the above, our results are consistent with the results of the systematic review conducted by Kapoor et al.[18] who showed that although the level of knowledge and awareness of dental students regarding the management of dental waste is adequate, it should be increased. Further studies with dentists and other dental professionals should be carried out, as there is little literature on the level of knowledge and awareness of dentists.

Biomedical waste management is not only a social responsibility but a necessity. Care is required to protect and maintain the environment from contamination and also to ensure the safety of the workers who come into direct contact with it. In addition, it must be made mandatory for oral healthcare personnel to obtain nontechnical services and trained cleaning personnel in this field. Although students in this study showed a positive attitude toward addressing this concern, workshops and training related to adequate management of medical waste would be a step forward to achieve a healthy environment for the future.[19-21]

The main limitation of this study was the exclusion of all first-year dentistry students as the curriculum of these students in the Peruvian Public University[10,22] involves a year of general studies, and they are not yet trained in the protocols of clinical care. On the contrary, another limitation was that as a cross-sectional study, follow-up studies are needed to determine the level of knowledge and awareness regarding the recycling of dental materials of future Peruvian undergraduate students to establish possible improvement strategies, and thereby guarantee the sustainability of future projects on the management of biomedical waste.

Nonetheless, the importance of this study is that it shows the need for dental students to know how to manage and recycle dental materials and to be aware of the impact of recycling on the environment, and that well-regulated protocols on adequate management of biomedical waste are needed. This can be achieved by academic evaluation to contribute and motivate awareness with periodic training workshops aimed at students, and academic and administrative staff. Finally, we recommend constant periodic training as a part of the curriculum of undergraduate students as well as the use of effective technologies for the treatment and disposal of biomedical residues to sensitize and raise awareness among students of health sciences.

**Conclusion**

In summary, our results show that the students of the Peruvian Public University are aware and know about the management and recycling of biomedical waste from dental products. Finally, according to the logistic regression model used in this study, associated factors such as age, sex, marital status, and year of study did not significantly influence the knowledge and awareness of the Peruvian students evaluated.

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**Conflicts of interest**

None to declare.
AUTHOR CONTRIBUTIONS
Study conception (ADS, FMT), data collection (SL, RB AMD, WG), data acquisition and analysis (ADS, FMT), data interpretation (WG, AMD, FMT), manuscript writing (FMT, SL, RB).

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT
This project is exempted from ethical approval due to it was an experimental in vitro study. All the procedures have been performed as per the ethical guidelines laid down by Declaration of Helsinki.

PATIENT DECLARATION OF CONSENT
Not applicable.

DATA AVAILABILITY STATEMENT
The data that support the study results are available from the author (Dr. Frank Mayta-Tovalino, e-mail: fmaytat@ucientifica.edu.pe) on request.

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