



Assessment of Awareness About Various Dental Waste Management Practices Among Dental Students and Practicing Clinicians


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Abstract

Objective: To evaluate the knowledge of students and dental practitioners about dental and biomedical waste disposal and to impart emphasis on important aspects such as eco-friendly waste management. **Material and Methods:** This questionnaire-based study involved 186 participants which comprised of 5 domains, namely laws regarding biomedical waste, steps of waste management, categories of dental waste, general hazards of improper waste disposal and certain material/process specific questions. **Results:** Assessment of the first domain showed that only 58.4% of participants were able to correctly identify the Pollution Control Board of India as the regulatory body for the transport of medical waste. The second domain assessment revealed that 55.9% of subjects were adequately aware of the knowledge handling hospital waste. Assessment of the third domain displayed that the majority of the respondents (91.9%) knew categories of dental waste generated. Evaluation of fourth domain exhibited that 89.8% students agreed that biomedical waste management (BWM) must be made a practical exercise in dental schools to reduce “Know-Do gap” between undergraduates and postgraduates and the last domain demonstrated that only 32.3% of the participants knew the environmentally friendly technique to convert organic waste into commercially useful byproducts. **Conclusion:** It was found that postgraduates had a better awareness of the proper methods to dispose of healthcare waste when compared to students and interns. However, the overall level of awareness was less than adequate. The need for special training in BWM in the clinical set up was highlighted through this study.

Keywords: Medical Waste Disposal; Health Knowledge, Attitudes, Practice; Dentistry.

Introduction

Health-care waste includes all the waste generated by health-care establishments, research facilities, and laboratories. In addition, it also includes the waste originating from the scattered sources that are produced in the course of health care undertaken in the home, such as dialysis products, insulin injections, etc. [1]. The WHO estimates that 85% of hospital waste is non-hazardous; around 10% is infectious, while the remaining 5% is non-infectious [1]. For any successful healthcare organization to function, including dentistry, it is imperative to have awareness regarding the disposal of hazardous medical waste, which here pertains to dental waste.

Many dental graduates aspire to work independently in their own clinical setup; thus, they must be updated with the ill effects of improper waste disposal on the environment as well as healthcare workers. For this knowledge to exist, it must be taught during undergraduate clinical training as part of the dental curriculum. Improper waste disposal results in the active spread of infection, such as Hepatitis and HIV infections. It also acts as a breeding ground for vectors of transmission of various other diseases. The transmission of these diseases from healthcare waste poses a threat to the health of people as well as to their surroundings. As a part of the health care industry, it is important to stress upon the proper biomedical waste management (BWM) and emphasis should be laid on a prompt day to day practice to reduce the “know do gap” [2].

Only few studies have been conducted in the past in the areas of knowledge regarding infection control practices among health care workers [2-4] and on the waste management practices among dentists [5-10]. Most of these studies highlighted an urgent need for additional training in the BWM techniques and suggested dental materials and imaging techniques that can have minimal impact on the environment. A systematic review conducted on the knowledge and attitudes of biomedical management also highlighted inadequate knowledge, considerable variation in the BWM and the need for training programs [11].

Hence, we aimed to evaluate the knowledge of students and dental practitioners about dental and biomedical waste management. We also aimed to explore the pitfalls in the educational strategy, which fail to impart emphasis on essential aspects such as eco-friendly waste management.

Material and Methods

Study Design and institutional Characteristics

A single-center, cross-sectional, self-administered questionnaire-based study was conducted from December 2017 to March 2018 among 200 participants. The selection of participants was made by the method of convenience sampling, and the study population included interns, postgraduates, and faculty enrolled at the Manipal College of Dental Sciences, Manipal, in the year 2017-2018. Independently practicing dentists in the field practice area of our dental school were also included.

Questionnaire

Primary data was collected using a closed-ended questionnaire that comprised 25 questions from five domains viz., “legal aspects of biomedical waste”, “steps of waste management”, “categories

of dental care waste”, “general hazards of improper waste disposal” and “certain material/process specific questions”. Each had one correct/most appropriate response.

The third domain comprised nearly 1/3rd of the questionnaire due to its direct relevance in dental clinical practice. All the participants were personally approached, and the purpose of the study was explained to them. They were requested to select the most appropriate response and were assured that their anonymity would be maintained. The completed questionnaires were collected on the same day after twenty minutes.

Ethical Considerations

This study was approved by the Institutional Ethics Committee of Kasturba Hospital, Manipal (IEC no: 859/2017). Participation by the subjects was voluntary and written informed consent was sought from all the participants.

Statistical Analysis

All the statistical analysis was done using SPSS software 17 (SPSS Inc., Ill, USA). The total score of the questionnaire was calculated by giving a score of ‘1’ for the correct or appropriate responses and ‘0’ for incorrect or inappropriate responses. A comparison of this total score was made between sex, designation, and qualification of the participants using the Mann-Whitney U test. A p-value of <0.05 was considered statistically significant.

Results

A total of 186 (93%) completely filled questionnaires were selected for data analysis. Questionnaires with missing information of more than 30% of the responses were excluded (n=14). Among the participants, 74.2% were female. The majority of the respondents were interns (60%), while 31.2% were postgraduates, and 8.6% were general practitioners.

Table 1. Questions related to the legal aspects of biomedical waste management in India (Domain 1).

Questions	Response	N	%
Q1 Are you aware of biomedical waste management laws in India?	Yes	61	32.8
	No	52	28.0
	Not certain	73	39.2
Q2 According to biomedical waste laws and rules, the waste must not be stored beyond	12 hr	60	32.3
	72 hr	21	11.3
	48 hr	105	56.5
	96 hr	0	0.0
Q3 Which is the regulatory body for medical waste transport.	Pollution control board of India	108	58.4
	College administration	2	1.1
	Transport corporation of India	22	11.9
	Don't know	53	28.6
Q8 Final disposal of dental care waste is via	Corporation bin	29	15.6
	Certified collector	157	84.4

As seen in Table 1, overall, 39% of respondents were not sure regarding the existence of biomedical waste management laws in India, but 58.4% were able to correctly identify Pollution

Control Board of India as the regulatory body for the transport of medical waste. More than half of the respondents were unaware of the time for which waste can be stored prior to disposal. Only 11.3% indicated that the maximum permitted time period for storage of waste was 48 hours. The majority of the respondents (84.4%) correctly indicated that the final disposal of dental waste is carried out by a government certified collector.

Table 2. Questions related to steps of biomedical waste management (Domain 2).

Questions	Response	N	%
Q4 Are you aware of the practical and theoretical knowledge required to manage hospital waste?	Yes	104	55.9
	No	24	12.9
	Can't Say	58	31.2
Q5 In your opinion, is biomedical waste in your institution is managed by professionally trained staff?	Yes	132	71.0
	No	33	17.7
	Can't Say	21	11.3
Q6 What is the correct sequence of the six effective steps of biomedical waste management?	Segregation-Collection- Transportation- Storage-Treatment- Disposal	68	36.6
	Collection- Segregation- Storage- Transportation- Disposal	106	57.0
	Storage- Segregation- Transportation- Collection-Treatment- Disposal	9	4.8
	Transportation- Segregation- Collection- Storage-Treatment- Disposal	3	1.6

The second domain (Table 2) comprised of 3 questions about the steps of waste management. It was perceived by more than half of the respondents (55.9%) that they were adequately aware of the knowledge required to handle hospital waste. There was a general consensus among 71% of respondents that healthcare waste is managed by professionally trained staff, and they were also aware of the 6 steps of biomedical waste management. However, only 43% of the respondents were able to recapitulate the correct order of the steps.

Table 3. Questions related to steps of biomedical waste management (Domain 3).

Questions	Responses	N	%
Q 12 Are you aware that there are different categories of biomedical wastes generated in our clinic?	Yes	171	91.9
	No	9	4.8
	Can't Say	6	3.2
Q13 Which category would an extracted tooth fall into?	Infected	156	83.9
	Cytotoxic	5	2.7
	Both	21	11.3
	Don't know	4	2.2
Q14 Category of outdated medicines	Chemical waste	21	11.3
	Pharmaceutical waste	135	72.6
	Cytotoxic waste	21	11.3
	Don't know	9	4.8
Q15 Category of used impression materials and cotton	Cytotoxic	8	4.3
	Soiled	58	31.2
	Infected	112	60.2
	Don't know	8	4.3
Q16 How is excess silver amalgam stored?	Dispose into common bin	0	0.0
	Only air tight container	14	7.5
	Air tight container with water	68	36.6
	In fixer solution	104	55.9

Q17 Disposal of infected sharps like needles is carried out by.....	Disposing into a common bin	2	1.1
	Puncture proof plastic bag	115	61.8
	Break the needle and throw	15	8.1
	Incineration	54	29.0
Q18 How is developer and fixer solution disposed	Both into sewer	3	1.6
	Return to supplier and recovery of silver from fixer by a special facility respectively	37	19.9
	Diluted and led into sewer	129	69.4
	Others	17	9.1
Q19 Disposal of exposed X-ray Films	Silver reclamation companies	81	43.5
	Stored separately and disposed	96	51.6
	Buried in soil	2	1.1
	Secured landfill	7	3.8

The third domain (Table 3) assessed the knowledge of dental waste categories, which were generated in various dental specialty departments. Nearly one-third of the questions was comprised by this domain due to its striking relevance and importance in regular practice. The majority of the respondents (91.9%) claimed to be well versed with the categories of dental waste generated. It is worth noting here that a large proportion of responses pertaining to the categorization of wastes, such as extracted teeth, used impression materials, and disposal of silver amalgam-were correct responses (83.9%, 60.2%, 55.9% respectively). However, the areas that are overlooked by the dental curriculum, such as disposal of medicines, radiographic solutions, and used films, were highlighted by the respondents' lack of knowledge. More than 2/3rd of the respondents (72.6%) incorrectly categorized outdated medicines as cytotoxic waste. More than half of the respondents (51% and 63%) responded incorrectly with respect to the disposal of developer/fixer solutions and used radiographic films, respectively. More than 1/3rd of the respondents (38%) were completely sure of the correct way to handle sharps.

Table 4. General hazards of improper biomedical waste disposal (Domain 4).

Questions	Responses	N	%
Q7 All are true for hazardous waste EXCEPT	Containers to be closed except while removing and adding waste	19	10.2
	Containers must be clean on the outside	12	6.5
	Containers are to be compatible with the waste	11	5.9
	Any type of containers can be used for biomedical waste.	144	77.4
Q9 How does inadequate biomedical waste management contribute to environmental pollution as well as disease spread?	Unpleasant smell, growth and multiplication of vectors like insects, rodents and worms -transmission of diseases like typhoid, cholera, hepatitis and AIDS through injuries from contaminated syringes and needles	23	12.4
	Plague and rabies. Rag pickers in the hospital, sorting out the garbage are at a risk of getting tetanus, hepatitis and HIV infections	6	3.2
	Both	157	84.4
	Others	0	0.0
Q10 Defective incinerators emit which greenhouse gases?	Carbon dioxide, Methane, Nitrous Oxide	128	68.8
	Both	47	25.3
	Fluorine containing gases	11	5.9
	None	0	0.0
Q20 Lead aprons and lead collars are disposed by licensed recyclers	True	118	63.4
	False	12	6.5
	Don't know	56	30.1

Q22 Which component of dental amalgam is hazardous?	Silver	8	4.3
	Tin and Copper	6	3.2
	Zinc	1	0.5
	Mercury	171	91.9
Q25 Do you feel biomedical waste management should be a practical exercise in dental colleges?	Yes	167	89.8
	No	6	3.2
	Can't Say	13	7.0

The penultimate domain (Table 4) comprised of 5 general questions based on information, which is widely taught as part of the BDS curriculum with regard to the various hazards and importance of proper disposal practices. All of the questions in this domain were answered correctly, and most of the respondents (89.8%) agreed that biomedical waste management must be made a practical exercise in dental schools.

Table 5. Certain material/process specific questions in relation to biomedical waste (Domain 5).

Questions	Responses	N	%
Q11 Which of the below is an environment friendly technology that converts organic waste to commercially useful by-products?	Controlled tipping	52	28.0
	Double pot method	60	32.3
	Plasma Pyrolysis	50	26.9
	None of the above	24	12.9
Q21 Disposal of orthodontic brackets and wires	Brackets-Recyclable	91	48.9
	Wires-Similar to sharps		
	Sell to certified buyers	13	7.0
	Brackets- Incinerate	66	35.5
	Wires-Deform and dispose		
Q23 Can thermoplastics in dentistry be reused and are they biodegradable?	Others	16	8.6
	Yes	46	24.7
	No	77	41.4
	May be	63	33.9
Q24 Are you aware of the type of incinerator is present in your institute-	Yes	47	25.3
	No	94	50.5
	Can't Say	45	24.2

The final domain took into consideration certain specific questions, which would display a high, level of awareness. Table 5 showcases the following findings: Nearly 1/3rd of the respondents (32.3%) answered that plasma pyrolysis is an environmentally friendly technique to convert organic waste into commercially useful byproducts, but none were aware of what this process entails. Awareness of greenhouse gases emitted by defective incinerators was poor (68.8% incorrect responses). Half of the respondents were unaware of the type of incinerator present at their institute. More than 1/3rd of them (40%) responded correctly for aspects related to the disposal of orthodontic brackets and wires and reusability of thermoplastics.

On a detailed analysis of the collected data, one main hypothesis known as the “know-do” gap emerged regarding the knowledge in the field of dental waste management. The know-do gap is a very well-known fact observed in many fields, especially in the aspect of hospital-acquired infections (HAIs) due to improper infection control practice by doctors and nursing staff. The know-do gap defines that regardless of having sufficient knowledge, adherence to its practical application in the hospital lacks among students.

This aspect is currently lesser-known and paid attention to in the area of waste management. By addressing this survey, the students can improve their awareness and get oriented to apply their theoretical knowledge into practice. This will reduce the “know-do” gap in waste management.

The total score of the questionnaire was calculated by giving a score of “1” for the correct or accepted responses and “0” for incorrect answers. There was no significant difference in the mean values of the total score with respect to sex and qualification ($p=0.511$ and $p=0.076$), respectively, as seen in Table 6. However, the mean score was significantly higher among postgraduate students hence lowering the “know-do gap” when compared to interns ($p=0.039$). The reason given was more number of hours spent by postgraduates in the hospital (Table 6).

Table 6. Comparison of knowledge scores with characteristics of the participant.

Variables	Categories	Total Score			p-value
		N	Mean	SD	
Sex	Female	138	14.70	2.96	0.511
	Male	48	14.96	2.35	
Designation	Interns	112	14.46	2.83	0.039
	Faculty	74	15.22	2.74	
Qualification	BDS	128	14.58	2.81	0.076
	MDS	58	15.17	2.80	

Discussion

This study was undertaken in an attempt to shed light on an everyday practice by dental students during clinical hours in dental school in regard to a very important and relevant area, namely the management of dental waste. Our curriculum focuses far more on theoretical practices of solid (non-biomedical) waste disposal, rather than the disposal of used dental materials and infectious waste which is imperative and clinically relevant for us to know as independent dental health practitioners. A closed-ended questionnaire was used to collect data from the participants regarding their perception of BWM methods. The use of a closed-ended questionnaire is said to minimize recall bias and presents questions that are easy to analyze. Participants were from the same workplace, which ensured that they were all following uniform guidelines of a BWM, which also contributed to a reduced risk of bias. The questionnaire comprised five domains, each of which assessed various facets of BWM in dentistry.

BWM has gained the forefront of many issues in India, especially with the “Union Ministry of Environment and Forests” notification of BWM rules in 1998 under the provision of the Environment Protection Act in 1986 [12]. Various chemicals such as acrylic, impression materials, and components of restorative materials such as mercury have the potential of posing a threat to the environment if not disposed of properly [13,14]. There is an increased likelihood of dental professionals to acquire infections while treating patients, which is substantiated by the fact that a majority of human pathogens can be and have been isolated purely from oral secretions [8].

As shown by the results, there are few blind spots present in the awareness regarding laws pertaining to dental healthcare waste management and the level of awareness is less than adequate

which is in line with the previous reports [9-11,15]. A large number of surveys on the management of BWM in India have been conducted among general or private practitioners [7,8,16], but a limited number of studies have been carried out in dental schools [10]. There have been very few studies reported in India assessing awareness of BWM among students undergoing dental training in dental schools [17,18]. This is highly suggestive of the lack of importance given to this clinically relevant topic.

The most basic domain assessed perceptions of the various categories of waste generated in the clinical set up, and this constituted 33% of all the questions in this study. It was found that 91.9% of participants felt that they were abreast of the categories of waste management, and this was reflected by their correct responses to a majority of category-based questions. As mentioned earlier, the awareness was found to be higher when questions involved areas of dental practice which the participant deals with directly in their daily lives (e.g., Amalgam, impression materials), when compared to practices which are handled indirectly by auxiliary staff (e.g., Radiographic solutions and films, outdated medications). It can be agreed that the later mentioned activities are not carried out by dental practitioners working in a hospital set up, but the knowledge is required if they branch out and wish to run an independent practice. This is concurrent with studies conducted in many cities in North India, Chennai and Bhubaneswar where 89, 14.8, and 44%, participants were unaware of the categories of biomedical waste, respectively [19-21]. A total of 12% of participants of a study conducted in Chandigarh responded that they were unaware of the color-coding system for waste disposal [19].

When it comes to the material aspect, the main importance has been given to Mercury [22], and 53% of participants report a lack of awareness about the disposal of materials other than mercury [19]. Other studies have shown that the perceptions of amalgam disposal are inconsistent with the correct practices. As reported previously, 35.2% of the respondents in their study disposed of excess silver amalgam into the common bin, 32.8% of them stored it in an airtight container with water, and only 2% stored it under fixer solution [20]. There is a lot of reported ambiguity regarding the correct way to store/dispose of amalgam, whether under water or fixer solution [22-24], despite the guidelines given by the American Dental Association to store excess amalgam under only photographic fixer solution [25]. In other parts of the world such as Switzerland, Germany, Sweden, Denmark, etc., it has been made mandatory to have an approved amalgam separating device installed in the dental operatory [26].

The lack of knowledge regarding materials other than amalgam such as alginate impression materials, dental casting alloys, dental gypsum etc. indicates the absence of importance given to eco-friendly waste disposal aspects as part of the dental curriculum. On being asked, the respondents indicated that the above-mentioned topics were not covered by the recommended textbooks. It is, however, important to shed light on what happens to these materials post-use due to the regularity and bulk quantity in which they are used. The quantity of usage and waste generated, for example in the case of gypsum products would largely depend on the patient inflow, usage for demonstrations,

preclinical assignments etc. and it is thus a challenge to determine approximately how much waste gypsum is generated per college/practice on a daily basis. At our institute, assuming usage of 0.75-0.95 kg per student, and there being 100 students each in 5 batches, a rough estimate of product used would range between 375- 475 kg use per day. Of which about 30-40% would be waste plaster, which in most instances would be discarded in a common bin, after which it is not known to students and graduates what the fate of the materials is.

There have been reports where gypsum has been recycled as a filler and used in mixed landfills [27]. When gypsum is discarded in landfills mixed with other biodegradable waste, it leads to the liberation of hydrogen sulfide gas, which is characterized by its foul odor similar to that of rotten eggs. It is colorless, flammable, and extremely toxic to the respiratory tract and nervous system on exposure. Short-term effects of toxicity include irritation to the upper respiratory tract, eyes, breathing difficulty, particularly in asthmatics. Long-term effects include a reduction in attention span, memory, and motor function [28]. It is for this reason that the disposal of gypsum in mixed landfills was banned in 2009, a fact lesser known to people. It has thus been advised to only dispose it off in specially prepared landfills. In the UK, there has been an advent of gypsum-to-gypsum recycling, and it has been claimed that the quality of recycled gypsum is comparable and nearly matches up to virgin gypsum [29]. Similarly, a method to recycle alginate into paper received a patent [30].

Casting alloys are used commonly in all dental set ups, amounting to nearly 3-4 kg of alloy per dental college. There are nearly 300 dental colleges in India; thus about 1000 kg, is used of which half goes to waste in the form of buttons/sprues and excess material. If this amount was to be recycled, it would lead to an institutional saving of INR 13,125,000 per year, and thus resources can be reallocated towards areas requiring attention. This would not only be profitable to the institute but also to the environment by reducing the need for mining. A factor in support of this fact is that even after recasting for the 20th time, there is a negligible reduction in the mechanical properties (5-10%) [31]. Most of the curriculum about BWM deals with disposal and collection of waste with little or no mention on the concepts of recycling of materials which is of high relevance in the current era. The disposal of consumables such as rubber gloves, rubber dam sheets etc., are carried out by incineration, and this has been reported to increased release of dioxin vapors which are involved in reproductive and fetal developmental defects, cancer, hormonal imbalances and neurotoxicity [5].

These facts are not known to dentistry graduates or students as again, and it is not taught as part of the curriculum and students are left clueless about what happens to the used dental materials, as well as are unaware of the potential ways in which these can be efficiently recycled or reused.

It can be argued that awareness does not exist even at a basic level, as shown by nearly 62% of participants' responses in this study stating that sharps are disposed in a common bin after breaking the needle- which is a glaring flaw and the incorrect way to manage sharps. This is similar to other studies where 40% [21] and 58% [22] of the participants gave the same responses exhibiting a huge "know-do gap".

The next basic domain of questions assessed the awareness regarding BWM laws in India, and it was found that 58.4% were able to identify the regulatory body for BWM disposal; however, 39% of participants were uncertain regarding the legislative aspect around the law aspect. Studies conducted in Rajasthan and Delhi also concluded that the knowledge was insufficient in regard to the regulations and laws behind BWM [10,15], which are concurrent with those in Southern India where 28% of participants were unaware of the laws [20]. The results showed a slight geographical variation but arriving at a distinct conclusion warrants further studies.

From a legislative aspect, it is important to impose fines/any form of penalty for the improper disposal of dental healthcare waste and to educate dental undergraduates about this in their early years of dentistry. This is seen in other parts of the world, for example in Nigeria where it is prohibited to carry, deposit or dump any harmful wastes and anyone found guilty of this would be subjected to a penalty for the same [32]. A similar protocol by the name of Medical waste tracking act has been concurrently imposing penalties on offenders of proper waste disposal in the United States since 1988 [33]. Lesser known is the fact that there is a protocol for this even in India, pertaining to hospitals and nursing homes, regulated by the Municipal Corporation/ State Pollution Control Board with which they are registered. Their constant scrutiny ensures that no disposable plastics/ sharps are found in yellow coded bags as this can potentially cause injury to health care workers [12]. It is interesting to note that these heavy fines/penalties apply to only hospitals and that no such measure against private practitioners has been found in existing literature, even though the potential for defaulting is high in the private sector due to low awareness and not having to report to a higher authority for the same.

Studies have reported the willingness of dental practitioners/students to be a part of continuing dental education programs alongside the curriculum if they were organized to improve awareness about dental waste management [20,34]. This would then no longer render the curriculum deficient, as it is now. A practical application of this proposed solution has shown positive effects [35]. Thus it is the responsibility of each individual belonging to the healthcare sector to minimize the hazards to our environment. This can be achieved by educating students in their early years, they should be made aware of the recent advances in the waste disposal, and practical application of proper waste management must be included in the dental curriculum. Global awareness should be created regarding the correct methods of waste disposal as well as about incorporating new methods to recycle waste wherever possible.

There were few limitations in this study viz., single center study due to which only students from only one institute were recruited and non-inclusion of auxiliary staff who are the driving force in the BWM. The deficiencies in the curriculum could have reflected as a gap in the knowledge of the BWM of the participants.

Conclusion

This study was undertaken in an attempt to assess the awareness and management of dental healthcare waste, and as per the results, it has been shown that the level of knowledge regarding the

same is inadequate with respect to multiple domains. The main cause of this lies in the deficiency in the curriculum, which partly covers the biomedical waste disposal in the clinical set up but provides inadequate information regarding the ill effects of improper disposal on the environment as well as newer techniques in recycling waste. The areas warranting modifications in our curriculum have been highlighted in this article and express the need for the revisions and updates to be made such that future generations of dentists are able to lower the burden that improper health care waste disposal practices have on our environment and towards the spread of disease.

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