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BIOMEDICAL INFORMATICS

www.bioinformation.net
Volume 16(11)

Research Article

Biomedical waste management practice in dentistry

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Received October 5, 2020; Revised October 25, 2020; Accepted October 25, 2020; Published November 30, 2020

DOI: 10.6026/97320630016958

Abstract:
Biomedical Waste Management practice in Dentistry is an important issue. Therefore, it is of interest to document awareness on such issues among clinical practitioners, academicians and students. A survey was completed using a questionnaire from 355 dentists consisting of 201 students, 39 academicians and 115 clinicians in India. Analysis of the survey data shows that majority of students, practitioners, and academicians are aware of laws binding with such issues. However, the Biomedical Waste Management practice among them is not satisfactory. Therefore, education on such issues among clinical practitioners, academicians and students is critical in this part of the globe.

Keywords: Bio dental waste; biomedical waste; green dentistry; biohazards; waste management.

Background:
Medical waste, household waste, industrial plastics, and e-waste are the primary cause of global pollution of air, water and soil, which can adversely affect the biosystem and life in our planet **[1–3]**. The effects of pollution don't stop with just befouling the surfaces, rather they go aboard with steep raise in the temperature as in global warming which leads to depletion of the protective ozone envelope. These further cause extinction of marine micro and macro flora, thawing effect on the ice resulting in the all-embracing detrimental consequence to the entire ecosystem **[4, 5]**. Bio Medical Waste (BMW) includes scrap from any procedure that deals with a living organism like preventive care involving immunization or any particulate material utilized in the diagnosis and treatment process, laboratory specimen, animal samples used in testing, and blood bank utilities **[6]**. Bio medical waste should be disposed with caution **[7]**. Many modifications had been implemented to improvise the methods of biowaste segregation and disposal **[8]**. Improper disposal of hazardous waste into the common sites lead to deleterious effects among the sanitation workers **[9]**. Several outbreaks associated with transmission of diseases like Hepatitis through syringes have been documented in the last few decades due to this menace **[10]**. Therefore, it is of interest to document

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awareness on such issues among clinical practitioners, academicians and students.

Materials and Methods:

This questionnaire-based study was cross-sectional and performed by four investigators. Existing literature sources were searched for data on biomedical waste, protocols of management, and hazards they pose to the environment. A preliminary questionnaire was constructed after discussion and resolution with all the four investigators. This comprised of three categories of dental personnel. Data for the study was collected through an online survey platform (Google Forms). Online data collection eliminated possible human errors which otherwise could occur during the transfer of paper work or any altered responses similar to those seen during personal interviews, thus overcoming bias with regard to data collection and evaluation. The survey data was collected from 355 dentists consisting of 201 students, 39 academicians, and 115 clinicians with a private dental practice.

Survey Link:

https://docs.google.com/forms/d/e/1FAIpQLScqo2lceJCc4DqY4YZ48jcLLWrXp_XJv5hhaKv65gejOMUZVA/viewform?usp=sf_link

Structure of the questionnaire:

The questionnaire consisted of few questions related to the demographics, including the geographical location of the participant. In order to avoid conflicts regarding the nature of problems, the questionnaire was divided into three sections, which included separate questions for three groups. Group A consisted of undergraduate and postgraduate students pursuing dentistry and dental specialties in various regions across the country. Group B consisted of academician working in various dentistry teaching institutions across the country. Group C consisted of clinicians (private practitioners) who manage private dental clinics.

Validation of the questionnaire:

The investigators and other dental practitioners did validation of the questionnaire and changes were made accordingly. The final validated questionnaire was shared online over various social media platforms.

Survey location:

Dental practitioners and dental students who had performed clinical dental procedures across the country were allowed to participate in the study. This would allow for a wide knowledge about students' and practitioners' understanding of the environmental hazards of healthcare waste and the precautions and guidelines with which management of waste has been taught and practiced across various states.

Analysis of the data

The contents were transferred to an excel sheet where further coding was done. The excel was analyzed by two examiners separately and the final values were crosschecked to reduce error. Data was analyzed using the SPSS (version 26.0) software.

Statistical analysis:

Frequency distribution for the study subjects was calculated based on the nature of the hierarchical work position i.e., Student, Practitioner, and Academician and also among the practitioners based on the number of years of experience. For all other survey questions, Chi-square test was performed along with the frequency distribution of individual responses. All tests were two sided and p-value of 0.05 and lesser was considered to be statistically significant and anything more than 0.05 was considered to have no statistical significance.

Results and Discussion:

The results can be categorized as areas where the dentists and the dental students were well aware, moderately aware and least aware.

There was a wide spread awareness amongst the participants about the laws & rules on bio medical waste management, color coded segregation and with the usage of hazardous symbols. According to the "Safe management of healthcare waste" rules provided by the WHO, there is a need for segregation of biomedical waste at the point of waste generation to reducee the amount of the risk faced by the sanitation workers **[11]** . The present study shows that 81.6% of the students, 88.7% of the practitioners, and 76.9% of the academicians were familiar with the laws and rules on biomedical waste management and methods of segregation before disposal. It is a well-known fact that the Dental healthcare workers are also more prone for droplet spread of the disease **[12]** and should also be immunized for Hepatitis B. In the present study, more than three-fourth of the dentists have trained their dental assistants regarding risk of handling biomedical waste and the importance of vaccination **[13, 14]**. Following the present outbreak of COVID-19, special rules have been put forth by the National Pollution Control Board along with the health ministry to prevent community spread of the disease from affected individuals, protect the soil, air, and water from being infected, and protect the community healthcare and sanitation workers from acquiring the disease during the process of handling waste disposal **[15]**. In the present study 93% of the students, 77.4% of the practitioners, and 87.2% of the academicians followed specialized waste disposal protocol. In

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segregation of wastes, anatomical waste from human tissues and animal waste are segregated in yellow colored non-chlorinated bags and disposed by deep burial in non-residential areas, incineration or plasma pyrolysis. Almost all of the dental professionals (93% students, all practitioners, and 97.4% academicians) practice disposal with separate color-coded bins. The system of symbolic representation for biomedical waste provides ease in identifying the nature of the waste **[11].** In the present study, 77.15% of the students, 89.6% of the practitioners, and 74.4% of the academicians had a knowledge of the symbols used to represent biohazardous waste. **(Table 1)**

We found a moderate level of awareness regarding the hazardous effects of the wastes generated. Although the Impression materials and gypsum-based products are non-hazardous in dry form, they become hazardous when there is water sorption and releases harmful microorganism and gases like hydrogen sulphides that has a bad odor. We found that 62.75% of the students, 54.8% of the practitioners, and 76.9% of the academicians consider impression material to be hazardous and dispose them in yellow bags. Another hazardous material in our practice is the Silver ions. These ions in the free form have properties of undesirable interactions with other components in the drainage. Fixer, Developer solution (contaminated with fixer), undeveloped X-ray film contain considerable amount of silver ions. Cleaner solution contains chromium. All these are categorized as hazardous waste **[16]**.In the current study, only 33.3% of the students, 46.1% of the practitioners, and 28.2% of the academicians were aware of the hazardous nature of the fixer solution **(Table 2**).

There was a very low level of awareness in dealing with sharp wastes, amalgam recycling, chemical waste management and incineration procedure. Ideally the waste consisting of needles used in syringes, glasses, scalpel etc. should be disinfected by autoclaving or any other chemical treatment, followed by mutilation and shredding. Less than 15% of the total respondents follow the ideal method of disposal of sharps and 28.4% of the dentists in all groups mix blood-soaked waste with sharps during disposal**.** The usage of amalgam in our practice is controversial as Mercury in blood and urine have been detected and reported. When we are disposing Amalgam restored teeth using incineration technique, it releases harmful mercury vapor. This should be avoided and disposed to amalgam recycler **[17, 18]**. In the present study, considerable usage of dental amalgam was seen whereas only 7.5% of the students, 3.5% of the practitioners, and 2.6% of the academicians dispose it after chemical disinfection in recycler. Waste management includes pharmaceutical waste, chemical waste and bio medical waste. Pharmaceutical waste consists of expired medicines or other pharmaceutical products, which can lead to the development of resistant microorganism in the area of disposal. Hence should be handed over to the concerned manufacturer in black colored bags. Chemical waste in any form may be toxic with corrosion potential, combustible, oxidizing nature, and reactive on surface. **[19]**. Solid waste can be buried in deep landfills in yellow color-coded bags and liquids can be disposed in the drainage after required preprocessing. Dentists lack awareness of this aspect of managing chemical waste or execution of proper protocol. The biomedical waste should be stored at room temperature and can lead to increase in microbial load and harmful chemical substrates by putrefaction **[11]**. Hence it should be transported within 24 hours. Almost 34.3% of the students, 46.2% of the academicians, and 5.2% of the practitioners are not sure about the temperature range. Nearly 28.4% of the students, 20.9% of the practitioners and 17.9% of the academicians are clear about retaining the waste for not more than 24 hours, if they weren't refrigerated. The wastes are also disposed using incineration and non-incineration methods. Incineration is a technique where the scrap is combusted at high temperature resulting in the formation of small particulate material. This poses disadvantage of releasing harmful gaseous materials, which attenuate the air pollution. Nearly half of the respondents in all categories incinerate the waste generated. 32.8% of the students, 98.3% of the practitioners, and 20.5% of the academicians still use chlorinated bags for disposal in their workplace, while being unaware of adverse effects. The non-incineration methods of waste disposal include thermal, chemical, irradiative, biological and mechanical process. In the present study, majority of the dentists used thermal process like autoclaving and a very few used chemical processes like use of hypochlorite **(Table 3)**

Conclusion:
Analysis of the survey data shows that majority of students, practitioners, and academicians are aware of laws binding with such issues. However, the Biomedical Waste Management practice among them is not satisfactory. Therefore, education on such issues among clinical practitioners, academicians and students is critical in this part of the globe.

Conflict of Interest:
The authors declare that they have no conflict of Interest

Financial support:
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest: None

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Author Contribution:
Dr. Aravind Kumar.Subramanian contributed in Conceptualization, Methodology, Investigation, Resources, Writing-Review and Editing, Supervision, Project administration. Dr. Nivethigaa B contributed in Methodology, Software, Investigation, Resources, and Writing Original draft, Visualization. Dr. Sri Rengalakshmi , Dr Navaneethan contributed in Software, Validation, Investigation, Data curation. Dr. Remmiya Mary Varghese and, Dr. Harish Babu contributed in Validation, Formal analysis, Investigation, Data Curation

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Edited by P Kangueane
Citation: Subramanian *et al.* Bioinformation 16(11): 958-964 (2020)

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Table 1: High level of awareness

Questions	Response	Position			Chi-Square value	p value
		Student n(%)	Practitioner n(%)	Academician n(%)		
Are you aware that the dental waste is hazardous?	May be	3(1.5)	6(5.2)	0(0)	5.24	0.07
	Yes	198 (98.5)	109(94.8)	39(100)		
	No	0(0)	0(0)	0(0)		
As per BMWM rules 2016, the biomedical waste shall be segregated at the point of generation	May be	30(14.9)	5(4.3)	7(17.9)	10.81	0.02*
	Yes	164(81.6)	102(88.7)	30(76.9)		
	No	7(3.5)	8(7.0)	2(5.1)		
How do you dispose dental waste in your work place?	Dispose in common bin	14(7.0)	0(0)	1(2.6)	9.06	0.01*
	Separately dispose in color coded bins	187(93.0)	115(100)	38(97.4)		
Are you aware of color-coding for segregation of different kind of biomedical waste?	Yes	197(98.0)	107(93.0)	37(94.9)	4.92	0.08
	No	4(2.0)	8(7.0)	2(5.1)		
Do you follow the color-coded disposal for all dental waste as suggested by the BMWM rules?	Yes	170(84.6)	109(94.8)	36(92.3)	14.77	0.01*
	No	10(5.0)	6(5.2)	0(0)		
	Sometimes	21(10.4)	0(0)	3(7.7)		
Are all dental assistants and other workers in your workplace taught about the impact of bio medical waste?	Yes	156(77.6)	112(97.4)	31(79.5)	27.96	0.001**
	No	14(7.0)	3(2.6)	0(0)		
	Not aware	31(15.4)	0(0)	8(20.5)		
Are you aware about the fact that all health care faculties dealing with the biomedical waste should be immunized for hepatitis B and tetanus?	Yes	197(98.0)	113(98.3)	39(100)	0.78	0.67
	No	4(2.0)	2(1.7)	0(0)		
When you happen to treat patients with communicable disease (like HIV, hepatitis) or during the time of active spread of any disease (like COVID 19), do you follow any special waste disposal protocol?	Yes	187(93.0)	89(77.4)	34(87.2)	16.17	0.001**
	No	14(7.0)	26(22.6)	5(12.8)		
	Not aware	12(6.0)	1(0.9)	0(0)		
Identify the universal symbol for biohazard medical waste	a	155(77.1)	103(89.6)	29(74.4)	241.51	0.001**
	b	15(7.5)	3(2.6)	4(10.3)		
	c	2(1.0)	0(0)	3(7.7)		
	d	17(8.5)	8(7.0)	3(7.7)		

* Statistically significant; **Highly Significant

Table 2: Moderate level of awareness

Questions	Response	Position			Chi-Square value	p value
		Student n(%)	Practitioner n(%)	Academician n(%)		
What procedure do you follow for the disposal of gypsum-based products?	Incineration	25(12.4)	35(30.4)	3(7.7)	108.75	0.001**
	Chemical Disinfection	45(22.4)	55(47.8)	9(23.1)		
	Autoclaved and recycled	14(7.0)	23(20.0)	2(5.1)		
	Not aware	68(33.8)	1(0.9)	13(33.3)		
Where do you dispose used impression materials in your workplace?	None	49(24.4)	1(0.9)	12(30.8)	29.09	0.001**
	Yellow bag	126(62.7)	63(54.8)	30(76.9)		
	White bag	15(7.5)	3(2.6)	2(5.1)		
	Red bag	32(15.9)	43(37.4)	4(10.3)		
	Black bag	28(13.9)	6(5.2)	3(7.7)		
According to you which among these is more hazardous to the environment?	Developer	42(20.9)	41(35.7)	12(30.8)	25.83	0.001**
	Fixer solution	67(33.3)	53(46.1)	11(28.2)		
	Not aware	92(45.8)	21(18.3)	16(41.0)		
What do you do with accidentally opened& undeveloped Xray film?	Throw into thrash	55(27.4)	31(27.0)	7(17.9)	4.14	0.38
	Labelled as biohazard and disposed	76(37.8)	39(33.9)	12(30.8)		
	Don't use X ray film	70(34.8)	45(39.1)	20(51.3)		

* Statistically significant; **Highly Significant

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Table 3: Low level of awareness

Questions	Response	Position			Chi-Square value	p value
		Student n(%)	Practitioner n(%)	Academician n(%)		
How do you dispose Sharps used/unused in your workplace?	Incinerate the needle before disposal	94(46.8)	65(56.5)	16(41.0)	5.49	0.48
	Dispose of with a label biohazard waste along with human	13(6.5)	5(4.3)	2(5.1)		
	Disinfect in 1% hypochlorite for 1hour followed by collection in blue/ white container	24(11.9)	14(12.2)	4(10.3)		
	Collect in non-openable blue/ white container	70(34.8)	31(27.0)	17(43.6)		
Can blood soaked non anatomical waste be mixed with sharps during disposal?	Yes	35(17.4)	49(42.6)	7(17.9)	32.03	0.001**
	No	146(72.6)	65(56.5)	27(69.2)		
	Not sure	20(10.0)	1(0.9)	5(12.8)		
In what color-coded bags do you dispose blood dripping biomedical waste?	Yellow	116(57.7)	57(49.6)	17(43.6)	10.05	0.12
	Red	65(32.3)	45(39.1)	19(48.7)		
	Blue	6(3.0)	0(0)	1(2.6)		
	Black	14(7.0)	13(11.3)	2(5.1)		
Do you practice restoration with amalgam in your work place?	Yes	123(61.2)	77(67.0)	12(30.8)	23.86	0.001**
	No	63(31.3)	38(33.0)	24(61.5)		
	May be	15(7.5)	0(0)	3(7.7)		
If you happen to extract a tooth with amalgam restoration, how do you indent to dispose it?	Throw it along with trash	8(4.0)	6(5.2)	1(2.6)	10.45	0.57
	Store it in a bottle of water	1(0.5)	2(1.7)	0(0)		
	Separate bin	1(0.5)	0(0)	0(0)		
	No special protocol followed	42(20.9)	29(25.2)	7(17.9)		
	Labelled as biohazard waste	77(38.3)	35(30.4)	19(48.7)		
	Discarded in yellow bags	57(28.4)	39(33.9)	11(28.2)		
	Chemical disinfection followed by recycler	15(7.5)	4(3.5)	1(2.6)		
What procedure do you follow for disposal of excess amalgam left behind during the process of restoration or during re-restoration of tooth previously filled with amalgam?	Remove individual pieces and add it to a recycler	156(77.6)	95(82.6)	30(76.9)	1.23	0.53
	Not sure	45(22.4)	20(17.4)	9(23.1)		
How do you dispose the chemicals, disinfectants and sterilizing agents used in dental practice?	Throw into the sink	1(0.5)	0(0)	0(0)	6.51	0.77
	Pre treated before making Xing with other waste water	0(0)	1(0.9)	1(2.6)		
	Disposed with biohazardous waste	65(32.3)	40(34.8)	12(30.8)		
	Disposed in separate sealed and labelled container	93(46.3)	46(40.0)	18(46.2)		
	Depends on the type of solution	1(0.5)	1(0.9)	0(0)		
	Considered non-hazardous and disposed into trash	41(20.4)	27(23.5)	8(20.5)		
In a tropical country like ours during summer, how many hours can biohazardous waste be stored in the workplace before disposal (with no refrigeration	Not sure	69(34.3)	6(5.2)	18(46.2)	101.55	0.001**
	12 hours	38(18.9)	81(70.4)	10(25.6)		
	24 hours	57(28.4)	24(20.9)	7(17.9)		
	48 hours	32(15.9)	4(3.5)	4(10.3)		
	72 hours	5(2.5)	0(0)	0(0)		
Is chlorinated plastic bags used in your workplace for waste disposal?	Yes	66(32.8)	113(98.3)	8(20.5)	151.38	0.001**
	No	54(26.9)	2(1.7)	19(48.7)		
	Not sure	81(40.3)	0(0)	12(30.8)		
Do they follow incineration method for biomedical waste disposal in your workplace?	Yes	113(56.2)	112(97.4)	18(46.2)	83.9	0.001**
	No	26(12.9)	2(1.7)	14(35.9)		
	Not sure	62(30.8)	1(0.9)	7(17.9)		
Do you follow any of these non-incineration methods for waste treatment in your workplace?	Thermal process like autoclaving	119(59.2)	82(71.3)	14(35.9)	50.62	0.001**
	Irradiative process like UV rays	6(3.0)	16(13.9)	0(0)		
	Chemical process like hypochlorite	18(9.0)	7(6.1)	4(10.3)		
	Biological process like enzyme treatment	4(2.0)	1(0.9)	1(2.6)		
	None	54(26.9)	9(7.8)	20(51.3)		

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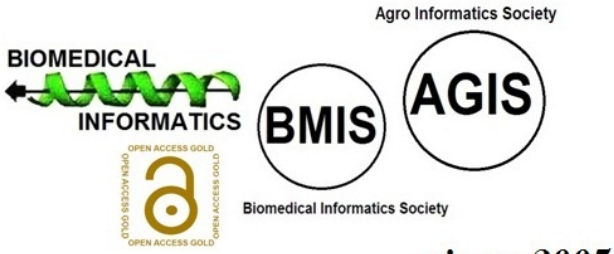

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