Sustainable waste management practices: An empirical investigation of healthcare

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Abstract

Purpose: Literature lacks the empirical studies targeting on capturing the perception about healthcare waste management (HCWM) practices of various organizations, which are involved in generating, handling and disposing of the healthcare waste (HCW). Due to population burden and poor handling of infectious wastes, sustainable HCWM is becoming the challenging issue for the developing countries. To cope up with the situation, the studies must be conducted for analyzing the various issues involved in managing infectious HCW. Taken together, these issues are critical to tackling in order to establish a robust and efficient HCWM system. This research intends to provide the empirical insights on various issues like:importance of establishing sustainable HCWM system; objectives of setting up sustainable HCWM system; and barriers and enablers of implementing sustainable HCWM system in India.

Methodology: A structured questionnaire has been developed and tested to collect the opinion from various organizations involved in HCWM process. The respondents are taken from the healthcare facilities, medical institutions, waste treatment facilities and Government officials involved in regulating the HCWM processes. The present study has laid down four hypotheses related to concerned issues on HCWM, which have been analyzed in two stages: preliminary analysis and statistical analysis using statistical tools.

Results: The results indicate that employees from healthcare facilities (HCFs) are having a different perception from those of waste treatment facilities and Government regulatory bodies on various issues related to HCWM system. HCFs' employees are more focused on delivering healthcare services, rather than on the byproduct they are producing during the process. The

conflicting perceptions of the HCFs' employees have been the major challenge to the proper disposal of HCW.

Practical Implications: The survey revealed following important objectives for hospitals' administration for implementing sustainable HCWM system: quality services to patients, protect people from infectious waste, proper segregation system, develop sustainable practices of handling waste, develop a holistic mechanism for handling waste, and training to waste handling workers. The study highlighted some of the key enablers of implementing sustainable HCWM system like: knowledge and training aids to waste handling team, adoption of the latest technology for treating HCW, segregation of HCW. Questionnaire survey also focused on the main barriers obstructing the implementation of sustainable HCWM system like: lack of infrastructure and convenience, insufficient budget allocation, no awareness among waste handling workers, poor transportation of bio-medical waste from hospitals to treatment facilities.

Originality: The present study tries to touch the ground reality behind the poor management of HCW. Empirical results presented various implications to hospital administration, waste treatment facilities and Government by highlighting the major issues and factors for implementing efficient and effective HCWM system.

Keywords: Healthcare waste; medical waste; waste management; sustainable; empirical study; questionnaire survey.

1. Introduction

Healthcare waste management (HCWM) has been neglected area due to lack of resources and huge population burden in the developing countries (Thakur and Ramesh, 2015a). The infectious waste from various healthcare facilities (HCFs) is mixed with the general waste and disposed of in a very regular fashion without any chemical disinfection treatment (Thakur and Ramesh, 2015a; Abor and Bouwer, 2008). This can lead to serious harm to hospital staff, waste handling workers, public and environment. As per WHO (2005), a robust HCWM system based on legislation and planning, dedicated operational resources, trained staff should be developed for the environment protection. As research in HCWM is at a nascent stage, therefore, proper plans and policies should be laid down for controlling the infectious waste disposal process.

Various empirical studies have been conducted to analyze the HCWM practices in different countries (Patil and Pokhrel, 2005; DaSilva *et al.*, 2005; Taru and Kuvarega, 2005; Askarian *et al.*, 2004), but literature lacks the studies related to assessing the perception and attitude of the employees and organizations involved in generation and handling of medical waste (MW) (Thakur and Ramesh, 2015b). Tudor *et al.* (2007a) analyzed the gaps between the intended behavior and actions, and stressed on overcoming the limitations in the execution part, in order to achieve sustainable waste management. Some researchers (Tudor *et al.*, 2007b; Almuneef and Memish, 2003) argued that healthcare waste (HCW) quantity can be reduced by implementing better management practices. Hence, the present study has been conducted to understand the perception of practitioners involved in the waste disposal process on various issues related to implementing sustainable HCWM system in India. The employees from the healthcare facilities (HCFs), Common Biomedical Waste Treatment Facilities (CBWTFs) and Government Regulatory Authorities were targeted to get an opinion about: the importance of implementing sustainable HCWM system; the objectives of implementing sustainable HCWM system; and the enablers and barriers of implementing sustainable HCWM system in India.

2. Overview of Healthcare Waste Management in India

In India, National Environmental Policy, 2006 has defined various controlling measures for protecting the environment and collecting and treating the infectious wastes. The waste management policies are governed by the subordinate legislation and Ministry of Environment, Forest and Climate Change (MoEF). The Central Government of India in conjunct with State

Pollution Control Boards (SPCB) administers the gamut of waste management regulations. The overview of the current HCWM process is shown in Figure 1. As per BMW (Management & Handling) Rules, 1998 all the persons and organizations who deal with generation, collection, storage, transportation, treatment and disposal of biomedical waste (BMW) come under these rules (Thakur and Ramesh, 2015b). The enforcement of BMW (Handling & Management) Rules, 1998 by Indian Government has directed the HCFs to manage their waste under defined waste disposal process. However, in countries like India and China, where there is huge population burden and also the resources are limited, the HCWM system is full of challenges and threats.

Figure 1: Overview of current HCWM system in India

3. Hypothesis Development

To analyze the various issues related to HCWM, the present study has developed four hypotheses:

3.1 Importance of implementing sustainable HCWM system

Implementing proper HCWM system is important for the society and failure of which will lead to infection and harm to the public and environment (Muduli and Barve, 2012). Manga *et al.* (2011) stressed defining the more clear roles and responsibilities of the personnel involved in the waste management process. Therefore, it is crucial to analyze the perception of various organizations involved in the process of handling BMW (like HCFs, CBWTFs and Pollution Control Boards), about the importance of implementing HCWM system with respect to their core business. This led to the formulation of the hypothesis H1 as follows:

H1: *There is a significant difference in the perception regarding the importance of implementing sustainable HCWM system with respect to the core business among the five groups under consideration.*

3.2 Objectives of implementing sustainable HCWM system

Hazardous MW is threatening the environment and it needs special treatment before final disposal (Hassan *et al.*, 2008). The inappropriate HCW disposal methods in the developing countries are leading to environmental and human health hazards (Hossain *et al.*, 2011). Although, policies and guidelines have been provided by the World Health Organization (WHO), but, still

efforts have been unsuccessful in most of the Nations (Muduli and Barve, 2012). Insa *et al.* (2010) stressed that for proper implementation of HCWM system, its scope must be defined clearly and specifically. With this reference, the second hypothesis (H2) has been framed.

H2: *There is a significant difference in the perceptions of five groups regarding principle objectives of implementing sustainable HCWM system among five groups of respondents.*

3.3 Enablers for implementing HCWM system

In order to build up a strong HCWM system, it is important to identify and focus on key issues like: training programs (El-Salam, 2010; Farzadkia *et al.*, 2009; Bendjoudi *et al.*, 2009; Oweis *et al.*, 2005), waste minimization through reuse, recycling and reduction (Jang *et al.*, 2006), organizational structure and infrastructure (Ojha, 2014; Tudor *et al.*, 2005), written policies and protocols (Soliman and Ahmed, 2007), education to waste handling workers (Gupta and Boojh, 2006), coordination among different departments (Bendjoudi *et al.*, 2009) etc. The enablers for implementing effective and efficient HCWM system may vary from one Nation to Nation and from one region to another. Hence, the present hypothesis focuses on finding the key enablers for implementing HCWM system in India.

H3: *There is a significant difference in the perception of the level of importance in addressing the issues for effective implementation of HCWM practices.*

3.4 Barriers of HCWM system

Although, there are well-defined policies and guidelines for handling infectious waste, but still HCWM system is full of inadequacies, which are acting as barriers, like: absence of use of coded and colored bags, no proper wastes' bagage tracking techniques (Oweis *et al.*, 2005), ineffective segregation at sources (Farzadkia *et al.*, 2009; Stanković *et al.*, 2008; Tsakona *et al.*, 2007), inappropriate collection methods, unsafe storage of waste, insufficient financial and human resources for proper management, and poor control on waste treatment and disposal process (Thakur and Ramesh, 2016; El-Salam, 2010; Alagoz and Kocasoy, 2008; Jang *et al.*, 2006). Birpinar *et al*. (2009) in their case study done in Istanbul, observed that 25% of the hospitals used inappropriate containers for waste collection and 77% of the HCFs provided inadequate equipment to the waste handling team. Hence, the last hypothesis analyzes the perception of respondents about barriers of implementing HCWM system in India.

H4: *There is a significant difference in the perception of respondents, regarding barriers of implementing HCWM system in India.*

4. Methodology and data collection

4.1 Questionnaire design

The data have been collected through a structured interview and questionnaire survey. The questionnaire was designed with the help of literature review and field survey and in the end, it was finalized in the brainstorming sessions with the experts and Government officials in the related field. The questionnaire has been shown in Appendix A.

Cronbach's alpha (α) has been calculated to check the internal consistency of the questionnaire. The Cronbach's coefficient (Cronbach, 1951) represents the percentage of variance that can be explained by the observed scale in hypothetical true scale. In the developed questionnaire, 'α' value for question 2.2 is 0.890 for 9 items and 126 cases. Similarly, 'α' for question 2.3 is 0.908 (9 items and 126 cases) and for question 2.4 is 0.922 (10 items and 126 cases). Since, all reliability values are greater than 0.7, which testify that the items are retained on an adequate scale (Nunally and Bernstein, 1978). Hence, all scales are internally consistent.

4.2 Sample design

Initially, the questionnaire was sent to 300 respondents, from hospitals, CBWTFs and PCBs. But, after so many reminders, the survey could get only 23 questionnaires filled. Then the data was collected personally, by conducting face-to-face interviews by adopting convenience sampling, which resulted in another 103 filled questionnaires. Finally, 126 questionnaires were used for further statistical analysis.

5. Data analysis and results

The data have been analyzed in two ways: i) preliminary analysis ii) statistical analysis. Statistical tests have been performed to test above stated hypothesis for all the groups using Statistical Package for Social Sciences (SPSS). The opinions collected from different groups have been compared over various issues related to HCWM. Total received responses from the five groups have been shown in Table 1.

Table 1: Frequency distribution of respondents

5.1 Importance of HCWM system

5.1.1 Preliminary analysis of hypothesis 1

Here, respondents rated their perception about the importance of implementing HCWM system, on the scale ranging from 1 (Not important) to 5 (Critical). From the responses collected, it was possible to ascertain the importance given to HCWM system by each group. Table 2 clearly reflects that group G5 ('Government Regulatory Authority') has assigned highest weight (4.444) to HCWM, followed by G3 ('Hospital & CBWTF Managers'), (4.467). Group G4 ('MD Students & Practitioners') has given least importance to HCWM system with respect to their profession. Groups G1 ('Doctors'), (3.0) and G2 ('Professors and Doctors'), (3.368) have also given less importance to HCWM system in comparison to their core business. The results clearly indicate that the generators of HCW have shown less interest to HCWM as compared to waste handlers, which has been come out as the basic hurdle for properly handling the HCW.

Table 2: Group-wise weighted average score on the importance of HCWM system

5.1.2 Statistical analysis of hypothesis 1

To test the significance of difference among the opinions of five groups, one way ANOVA analysis has been conducted. The results clearly reflect that there is a significant difference in the perception of the five groups as shown in Table 3.

Table 3: ANOVA for hypothesis 1

Furthermore, to analyze the differentiating groups, the post hoc analysis has been done using Tukey test for all the groups. Tukey test has been applied using simple harmonic means of samples due to unequal sizes of all the five groups. In Table 4, post hoc analysis shows that hospital administration and waste treatment facilities' managers and Government regulatory board are more concerned about the implementation of HCWM system than doctors, professors, and MD students. Doctors think that their main concern is to provide better healthcare services to the public and not to implement the HCWM system. Hence, doctors gave less importance on their part to implement the HCWM system.

Table 4: Homogeneous subsets for hypothesis 1

5.2 Objectives of HCWM system

5.2.1 Preliminary analysis of hypothesis 2

Here, the respondents were asked to give their preferences over various listed objectives of implementing HCWM system. The average score for each objective has been depicted in Figure 2. Figure 2 clearly shows that, group G1has given highest importance (with mean value 4.784) to objective 2 (Protecting people from the infectious waste) and least importance to (mean value 3.059) objective 4 (To reduce infectious waste). Hence, as per doctors, the main objective to implement the HCWM system is to protect people from infection in the hospital premises and reducing and recycling the HCW, is not their area of concern. Similarly, professors have given highest importance to objective 1 (Providing better hospital premises) with a mean value of 4.474 and objective 2 (Protecting people from infectious waste) with a mean of 4.474 and rated objective 4 (Reducing infectious waste) with a value of 2.368lowest. Hospital administration and treatment facilities' managers have given highest priority to objective 4 (Reducing infectious waste) with a mean value of 4.733 and lowest to objective 7 (Providing convenience to waste handling workers) with a mean of 3.0. Medical students have rated objective 2 (To protect people from infectious waste) highest with a mean value of 4.696 and objective 4 (To reduce infectious waste) with the least score (2.739). Government regulatory bodies have given highest weight (4.833) to objective 9 (Training & skills enhancement) and lowest (2.611) to objective 5 (Reduce cost of disposing of HCW).

Figure 2: Weighted average scores for objectives within each group

5.2.2 Statistical analysis of hypothesis 2

The results of the statistical analysis are shown in Table 5, which reflect that all groups have not given the same importance to each objective. Generally, the healthcare services providers are having different opinions than that of HCW handling and management teams. Here, the test results are significant for some objectives, which represent that groups are having different perceptions.

Table 5: ANOVA results for hypothesis 2

The Post-HOC analysis results for each objective have been discussed below:

For objective 1 (To provide better hospital premises and quality services to the patients), all the groups except CBWTF's managers have rated very high. They think that the main objective of implementing HCWM system is to provide the better hospital premises to the visiting people and patients. But, the CBWTF's managers have given it comparatively less importance, as they are not only concerned about the hospital premises, but the whole environment affected by infectious waste. For objective 2 (To protect patients, staff, and public from infectious waste), all the groups other than CBWTFs' managers have given high weight. Since, for CBWTFs' managers, this objective is not important, as they are not directly concerned about the hospital staff and patients. Objective 3 (To implement proper segregation system), has been strongly agreed upon by all the respondents' groups. This might be due to the fact that, in all waste handling and disposing processes, segregation is the most important step. Poor segregation of HCW at the source, will make whole waste quantity as hazardous waste. The ANOVA-test reveals that there is no significant difference between different groups' responses over the importance of the segregation process. For objective 4 (To reduce the infectious waste), groups doctors, professors, and medical students have disagreed, while CBWTFs' administration and Government regulatory bodies think that waste minimization should be the aim of any sound HCWM system. But, as per doctors and professionals, their main aim is to provide better healthcare services to people and in that process, it may sometimes lead to an extra amount of waste. So, as per their perception, the waste amount cannot be controlled, but waste management can be done effectively.

Objective 5 (To reduce the cost of disposing of HCW), has been rated moderately by all groups except the regulatory board members. As per Government regulatory board members, the hospital administration and CBWTF should invest more in developing advanced technologies of treating the waste and ensure proper disposal of HCW. While the hospital administration and doctors think that this is not their main business and hence, cost should be cut by outsourcing the process. Objective 6 (To develop sustainable waste handling practices), has been strongly recommended by all the groups. The test results reveal that there is no significant difference between the respondents' opinions about the importance of objective 6 in the HCWM system.

For objective 7 (To provide convenience to waste handling workers), there is no significant difference among the respondents' ratings of all the groups. Respondents have not given high importance to this issue for implementing the HCWM system. Objective 8 (To develop a holistic mechanism to deal with biomedical waste), has been rated very important by all the respondent groups. As per respondents, a holistic mechanism for dealing with infectious waste should be developed, which starts from the point of generation of HCW and ends with the final disposal of residual ash coming out from the incinerators after treatment. The homogeneous subsets for objective 9 (Providing training and enhancing skills), has also been very highly rated by all the respondents. Hence, providing training and education to waste handling workers about the infectious nature of MW and its proper handling techniques, is an important element for any HCWM system.

5.3 Issues related to HCWM in India

5.3.1 Preliminary analysis of hypothesis 3

Here, the respondents have rated various enablers of implementing HCWM system on a scale ranging from 1 to 5 and the summary of the weighted average score for each enabler has been depicted in Figure 3. Figure 3 clearly shows that doctors have given highest importance (mean score = 4.255) to issue 7 (Latest technology adoption) and 8 (Segregation and collection of HCW) (mean score = 4.255) and least importance (mean score = 2.235) to enabler 3 (Infrastructure and convenience) while implementing HCWM system. Academicians have rated enabler 8 (Segregation and collection of HCW) highest (mean score = 4.526) and enabler 6 (Budget allocation) lowest (mean score = 2.158). Hospital administration and CBWTF' managers have given highest score (mean score = 4.867) to enabler 8 (Segregation and collection of HCW) and rated enabler 9 (Frequent transportation of HCW) least important (mean score = 2.733). Medical students have assigned highest weightage (mean score = 4.522) to enabler 7 (Latest technology adoption) and comparatively less weightage (mean score = 2.0) to enabler 6 (Budget allocation). Government regulatory board members have rated enabler 8 (Segregation and collection of HCW) as the most important (mean score = 4.556) and enabler 9 (Frequent transportation of HCW) least important (mean score = 2.833).

Figure 3 here

5.3.2 Statistical analysis of hypothesis 3

The results of statistical analysis shown in Table 6 reflects significant results for some of the enablers, which means that groups are having different perception over these following enablers: 3 (Infrastructure and convenience), 6 (Budget allocation in HCWM), and 9 (Frequent transportation of HCW).

Table 6: ANOVA results for hypothesis 3

The results of Post-HOC analysis and various homogeneous subsets for each enabler are:

All groups have strongly agreed on enabler 1 (Knowledge and training aids to waste handling workers and staff) and there is no statistical difference among the ratings given by different groups. Hence, all groups have given high importance to education of the workers and staff; those are handling and disposing the infectious waste. Similarly, there is no difference in the perception among the respondents regarding enabler 2 (Appreciation and motivation), but it has been rated a little lower side. The recognition of waste handling team is important to motivate them and implement HCWM system more efficiently and effectively.

Post-HOC analysis for enabler 3 (Infrastructure and convenience) divides all the groups into different homogeneous sets. The results show that the healthcare services providers have given less importance to build infrastructure, as they think that HCFs should outsource these waste handling activities and should focus only on primary business. Providing extra infrastructure will add more cost to the healthcare establishments. For enabler 4 (Collaboration and integration among HCFs and CBWTFs), the respondents have given the average score. They think that collaboration and integration among the HCFs and CBWTFs is not very important, as the whole process is very much specific and not much flexibility is required. Once, the HCWD process is outsourced, thereafter it becomes the sole responsibility of CBWTF to collect the waste daily and process it as per predefined rules.

The respondents have same opinions about the importance of enabler 5 (Development of the performances matrices). Their perception is that there should be standard evaluation criteria for evaluating CBWTFs in order to ensure the proper functioning of HCWM system. Post-HOC analysis has divided the five groups into two subsets on enabler 6 (Budget allocation in HCWM).

Healthcare service providers don't want to spend much budget to implement the HCWM system and consider this as the sole responsibility of waste treatment facilities. Hence, as per their viewpoint, CBWTFs should allocate an optimum budget for the implementing string HCWM system.

Enabler 7 (Adoption of the latest technology in treating the waste) has been rated highly by all the groups. The updated technology will help to reduce the pollution emission to the environment while treating infectious MW. Also, for enabler 8 (Segregation and collection of HCW), the respondents have given very high importance in implementing HCWM system. Segregation has been considered as main activity in comparison to all other activities involved in the HCWM system. All groups have been placed on the same subset regarding the importance of segregation in managing infectious waste. The enabler 9 (Frequent transportation of HCW) has been rated very low by the respondents. The strong logistics capabilities have been given little importance in case of managing the HCW.

5.4 Barriers of implementing HCWM system in India

5.4.1 Preliminary analysis of hypothesis 4

Here, the respondents were asked to give their weightage for various barriers of implementing HCWM system and the weighted average score for each barrier has been shown in Figure 4. From Figure 4, it is clear that doctors have given highest importance (mean score = 4.392) to barrier 3 (Budget problems) and least importance (mean score = 1.725) to barrier 1 (Lack of hospital administration' and doctors' commitment) in obstructing the implementation of effective HCWM system. Academicians have rated barrier 9 (No frequent transportation of waste) very important (mean score = 4.316) element to tackle and barrier 4 (Lack of perception of self-harm) comparatively less important (mean score = 1.684). Hospitals' administration and CBWTFs' managers have given highest weightage (mean score = 4.80) to barrier 1 (Lack of administration and doctors commitment) and lowest weightage (mean score = 1.913) to barrier 6 (Lack of benchmarks in India). Medical students have considered that barrier 1 (Lack of administration and doctors commitment) as strongest (mean score = 4.87) obstacle and barrier 4 (Lack of perception of self-harm) as less important (mean score = 1.696) comparatively. Government regulatory board members have rated barrier 1 (Lack of administration and doctors

commitment) as the most important (mean score = 4.611) hurdle and barrier 6 (Lack of benchmark in India) as the least important (mean score = 2.333) in implementing HCWM system.

Figure 4 here

5.4.2 Statistical analysis of hypothesis 4

The statistical results are shown in Table 7, clearly reflect that all groups have not given the same importance to each barrier. Different groups have different perception about the barriers of implementing HCWM system. Table 7 shows that statistical test results are significant for the following barriers: 1 (Lack of hospital administration and doctors' commitment) and 4 (Lack of perception of self-harm).

Table 7: ANOVA results for hypothesis 4

Post-HOC test classifies the groups into different sub-sets over barrier 1 and 4 and for rest of the barriers, the perception of all the groups is same. The test results for Post-HOC analysis are discussed below:

Hospitals employees have given very less importance to barrier 1 (Lack of hospital administration and doctors commitment). The respondents' groups (doctors, professors and medical students) have rated barrier 1 moderately, while the groups (CBWTFs' managers and Government regulatory board members) have given very high importance to hospitals administration and doctors' commitment in implementing the HCWM system. Barrier 2 (Lack of infrastructure and convenience) has been rated highly by all the respondents' groups and stressed that strong infrastructure plays very crucial role in facilitating the HCWM practices. The convenience provided to waste handling workers, will help them to handle infectious waste more easily and safely.

The barrier 3 (Budget problems), has been rated very important for implementing HCWM system in India. As HCWM is not the primary concern for HCFs, so they want to minimize the cost of handling waste on their side. Hence, very less budget is allocated to install the updated technology to manage waste, which has become the big threat for implementing HCWM system.

Barrier 4 (Lack of perception of self-harm) has been rated on the lower side by all the groups. Although, Government regulatory bodies have also observed that waste handling workers are not

aware about the harm that can be caused by infectious waste and they handle it without following any instructions. Hence, workers need to be trained and educated to make the waste handling process safer.

The barrier 5 (Lack of monitoring) has been rated moderately by all the five respondents' groups. Respondents have agreed on the fact that there has been very less monitoring of waste handling activities and disposal methods at the treatment facility. As per respondents, there should be a tracking system to monitor the movement of each bag of infectious waste, till the final disposal is over.

The respondents have given very less importance to barrier 6 (Lack of benchmark in India) as they think that the whole procedure is well defined in the Biomedical Waste Management and Handling Rules, 1998. Although, Pollution Control Board employees have given high ratings comparatively and they argued that we need to standardize the whole waste management process. Lack of awareness among waste handling staff and workers, has been rated as important barrier for implementing HCWM system.

Barrier 8 (No maintenance staff at treatment facility) has been rated moderately by all the respondents' groups. As per respondents, lack of maintenance at waste treatment facilities, obstructs the disposal process and stressed that there should be at least one maintenance engineer at each treatment facility. Barrier 9 (No frequent transportation of bio-medical waste from HCF to CBWTF) has been rated important by all respondents' groups. As per the hospitals' employees, sometimes waste remains in the hospital premises for more than 4-5 days, that can be very harmful for the hospital environment. As per waste handling rules also, HCW should be transported to the treatment facility within 48 hours. Hence, poor logistic infrastructure leads to improper HCWM system. Barrier 10 (Non-aligned operational objectives among HCFs & CBWTFs) has been assigned average importance, while implementing HCWM system. All groups have agreed on the importance of collaboration among hospitals and treatment facilities and stressed that it is the shared responsibility of both the HCFs and CBWTFs to ensure proper disposal of HCW.

6. Discussion and implications of the study

The robust HCWM system is now the matter of concern for healthcare establishments, waste treatment facilities, central pollution control board and state pollution control boards. Therefore, hospitals and treatment facilities have to work collaboratively, to implement efficient and effective

HCWM system. The present study has identified some enablers and barriers, which should be anticipated and emphasized in order to achieve the objectives of implementing proper HCWM system.

6.1 Implication from hypothesis 1

Hypothesis 1 reveals that all respondents' groups have given importance to HCWM system, but employees from hospitals have rated less in comparison to the employees from waste treatment facilities and Government Regulatory Boards. Since, doctors are involved in HCW generation process, hence, they have to be more responsible in order to protect the hospital premises from infectious waste. Doctors' participation is very important to train and educate waste handling workers and lay down policies and procedures. HCWM process starts from hospitals, therefore, doctors have to ensure their active participation in the whole process.

6.2 Implications from hypothesis 2

The respondents' have rated the following issues as highly important: 'to protect people in hospitals', 'training and skills enhancement', 'provide better hospital premises', 'sustainable waste handling practices', 'proper segregation' and 'to develop holistic mechanism to deal with HCW'. Hence, policies should be framed targeting these elements on priority.

6.3 Implications from hypothesis 3

Healthcare facilities, treatment facilities and Pollution Control Boards should focus primarily on the identified enablers of implementing effective and efficient HCWM system. List of various enablers and the corresponding action plan to implement the HCWM system, are given in Table 8.

Table 8: Recommendations to enhance the enablers of implementing sustainable HCWM system

6.4 Implications from hypothesis 4

Hospital administration and CBWTFs' managers should anticipate and address the barriers effectively. The list of various barriers and the corresponding action plan to overcome these barriers, have been given in Table 9.

Table 9: Recommendations to overcome barriers of implementing HCWM system

7. Conclusion

Almost, all the studied healthcare establishments are lacking in one part or the other in implementing HCWM system in their premises. Therefore, everyone related to healthcare industry is feeling the need to implementing strong HCWM system, which can effectively and efficiently meet the environmental expectations. So, there is a great scope for further improvement in the existing system. Studies in the current field, were missing the analysis of the opinions of various teams and organization involved in HCWM process. Hence, the present study, conducted the survey to test the perception of experts and practitioners in the field on various issues related to: importance of implementing HCWM system, objectives of HCWM system, barriers and enablers of implementing the HCWM system in India.

Survey has resulted into the main objectives of implementing HCWM as: quality services to patients, protect people from infectious waste, proper segregation system, develop sustainable practices of handling waste, develop holistic mechanism for handling waste, and training to waste handling workers. The survey has come out with some strong issues for implementing HCWM system, which hospital administration and CBWTFs' managers should focus in order to establish robust system for dealing with infectious waste. The present study highlighted the major enablers of implementing HCWM system as: knowledge and training aids to waste handling team, adoption of latest technology for treating HCW, segregation of HCW. The questionnaire survey has also revealed some barriers, which obstruct the implementation of HCWM system as: lack of infrastructure and convenience, insufficient budget allocation, no awareness among waste handling workers, poor transportation of bio-medical waste from hospitals to treatment facilities. Hence, hospital administration, treatment facilities and Government regulatory boards should collaboratively focus on implementing the enablers and overcoming the barriers of HCWM system.

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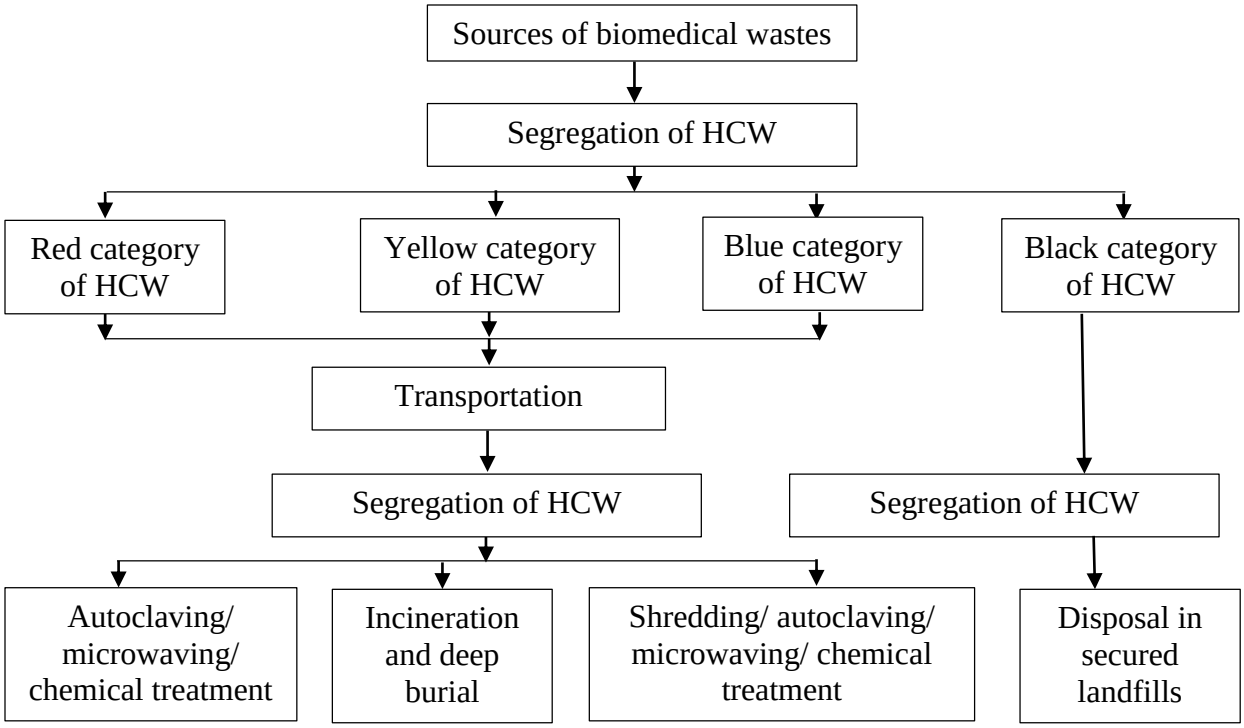

Figure 1: Overview of current HCWM system in India

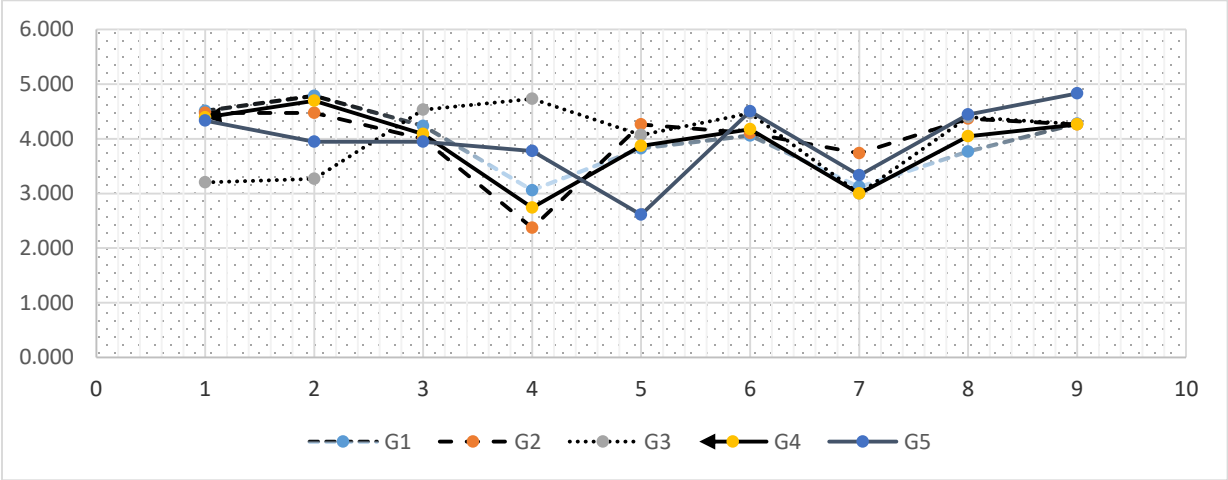

Figure 2: Weighted average scores for objectives within each group

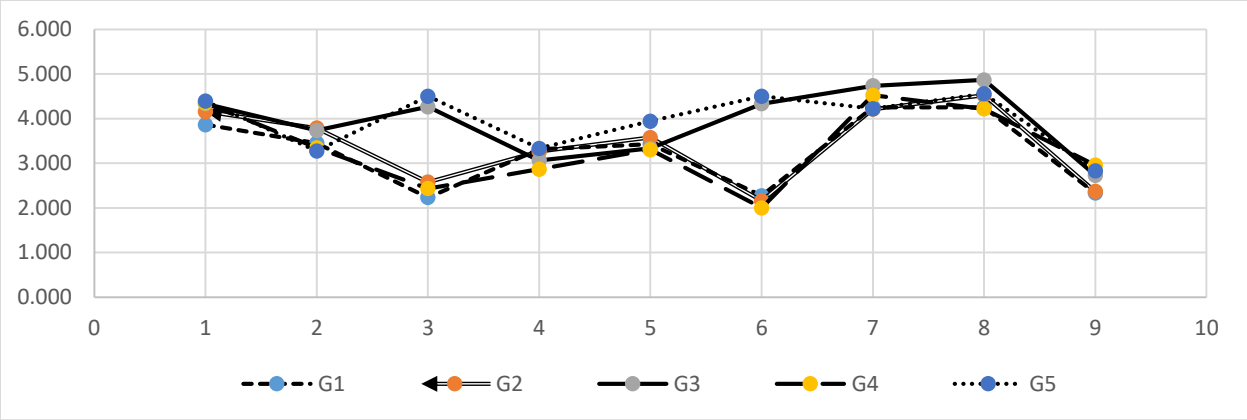

Figure 3: Weighted average scores for enablers within each group

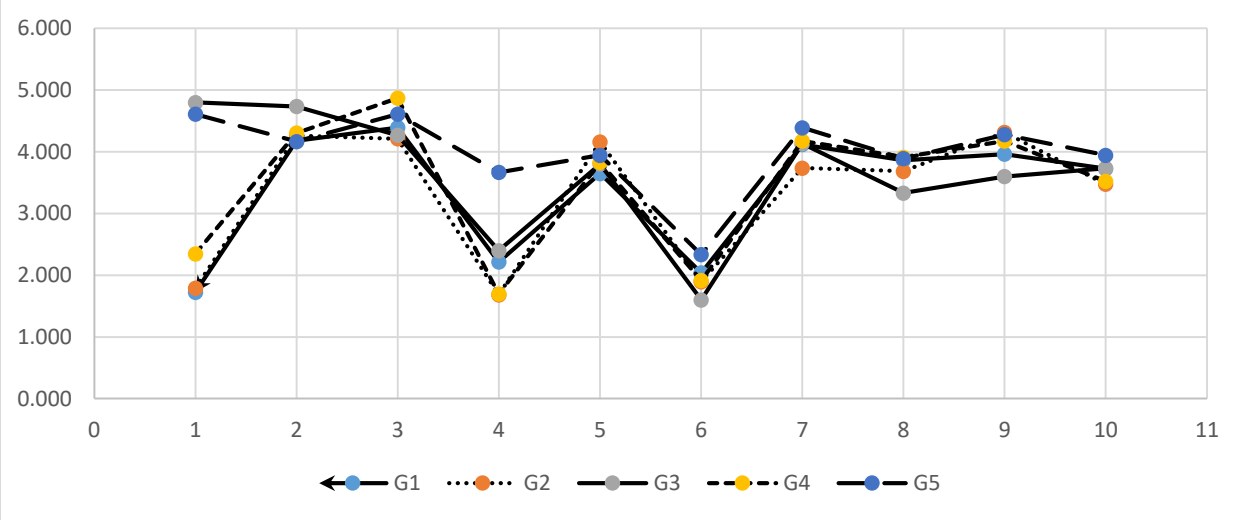

Figure 4: Weighted average scores for barriers within each group

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Table 1: Frequency distribution of respondents

Group No.	Group category	No. of samples
G1	Doctors	51
G2	Professors & doctors	19
G3	Hospital & CBWTF managers	15
G4	MD students & practitioners	23
G5	Government Regulatory Authority	18

Table 2: Group-wise weighted average score on the importance of HCWM system

	Profile-wise groups				
	G1	G2	G3	G4	G5
Degree of importance assigned (Weighted average score)	3.0	3.368	4.467	2.74	4.444

Table 3: ANOVA for hypothesis 1

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	54.911	4	13.728	21.563	1.89859E-13	2.447
Within Groups	77.034	121	0.637			
Total	131.944	125				

Table 4: Homogeneous subsets for hypothesis 1

Tukey HSD			
Groups	N	Subset	
		1	2
G4	23	2.74	
G1	51	3.00	
G2	19	3.37	
G5	18		4.44
G3	15		4.47
Sig.		0.085	1.000

The error term is Mean Square (Error) = 0.637.

Uses Harmonic Mean Sample Size = 21.014. Alpha = 0.05.

Table 5: ANOVA results for hypothesis 2

Source	Dependent Variable (Objectives)	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1	1837.227	1	1837.227	2544.689	.000	0.955
	2	1882.606	1	1882.606	3919.961	.000	0.970
	3	1818.279	1	1818.279	2567.821	.000	0.955
	4	1168.945	1	1168.945	833.367	.000	0.873
	5	1459.306	1	1459.306	1057.875	.000	0.897
	6	1907.578	1	1907.578	2679.223	.000	0.957
	7	1101.310	1	1101.310	798.059	.000	0.868
	8	1857.127	1	1857.127	1512.211	.000	0.926
	9	2015.408	1	2015.408	3711.267	.000	0.968

Source	Dependent Variable (Objectives)	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group	1	21.179	4	5.295	7.334	.000*	0.195
	2	32.595	4	8.149	16.967	.000*	0.359
	3	3.820	4	.955	1.349	0.256	0.043
	4	60.316	4	15.079	10.750	.000*	0.262
	5	30.457	4	7.614	5.520	.000*	0.154
	6	3.889	4	0.972	1.366	0.250	0.043
	7	7.657	4	1.914	1.387	0.242	0.044
	8	10.608	4	2.652	2.159	0.078	0.067
	9	4.926	4	1.231	2.268	0.066	0.070

*Significant at $\alpha = 0.05$.

Table 6: ANOVA results for hypothesis 3

Source	Dependent Variable (Enablers)	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	Enabler 1	1869.452	1	1869.452	2849.126	.000	0.959
	Enabler 2	1301.751	1	1301.751	1799.166	.000	0.937
	Enabler 3	1078.013	1	1078.013	1318.990	.000	0.916
	Enabler 4	1055.350	1	1055.350	1632.820	.000	0.931
	Enabler 5	1300.724	1	1300.724	1377.105	.000	0.919
	Enabler 6	979.419	1	979.419	999.942	.000	0.892
	Enabler 7	2023.549	1	2023.549	2701.705	.000	0.957
	Enabler 8	2112.692	1	2112.692	2594.919	.000	0.955
	Enabler 9	735.056	1	735.056	1109.771	.000	0.902
Group	Enabler 1	6.574	4	1.644	2.505	0.051	0.076
	Enabler 2	3.945	4	0.986	1.363	0.251	0.043

Source	Dependent Variable (Enablers)	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
	Enabler 3	103.551	4	25.888	31.675	.000*	0.512
	Enabler 4	3.833	4	0.958	1.483	0.212	0.047
	Enabler 5	5.203	4	1.301	1.377	0.246	0.044
	Enabler 6	123.809	4	30.952	31.601	.000*	0.511
	Enabler 7	4.007	4	1.002	1.338	0.260	0.042
	Enabler 8	5.843	4	1.461	1.794	0.134	0.056
	Enabler 9	8.713	4	2.178	3.289	0.013*	0.098

*Significant at $\alpha = 0.05$.

Table 7: ANOVA results for hypothesis 4

Source	Dependent Variable (Barrier)	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	Barrier1	980.466	1	980.466	1272.787	.000	0.913
	Barrier2	1968.824	1	1968.824	3534.594	.000	0.967
	Barrier3	2099.369	1	2099.369	2511.739	.000	0.954
	Barrier4	571.603	1	571.603	610.977	.000	0.835
	Barrier5	1577.749	1	1577.749	1606.667	.000	0.930
	Barrier6	402.013	1	402.013	533.740	.000	0.815
	Barrier7	1774.936	1	1774.936	1232.214	.000	0.911
	Barrier8	1466.864	1	1466.864	1037.461	.000	0.896
	Barrier9	1736.734	1	1736.734	1246.837	.000	.912
	Barrier10	1422.678	1	1422.678	1242.822	.000	0.911
Group	Barrier1	198.258	4	49.565	64.342	.000*	0.680
	Barrier2	3.879	4	0.970	1.741	0.145	0.054

	Barrier3	6.238	4	1.560	1.866	0.121	0.058
	Barrier4	49.623	4	12.406	13.260	.000*	0.305
	Barrier5	3.979	4	0.995	1.013	0.403	0.032
	Barrier6	4.831	4	1.208	1.604	0.178	0.050
	Barrier7	4.151	4	1.038	0.720	0.580	0.023
	Barrier8	4.133	4	1.033	0.731	0.573	0.024
	Barrier9	6.069	4	1.517	1.089	0.365	0.035
	Barrier10	2.791	4	0.698	0.610	0.657	0.020

*Significant at $\alpha = 0.05$.

Table 8: Recommendations to enhance the enablers of implementing HCWM system

Sl. No.	**Enablers**	**Action Plan**
1.	Knowledge and training aids to waste handling workers and staff	Conduct training programs for all workers and staff of HCFs and CBWTFs regularly. They should be made aware about the precautions to be taken while handling infectious waste.
2.	Appreciation and motivation	Develop incentive mechanism to share rewards to waste handling workers and motivate them by appreciating time to time.
3.	Infrastructure and convenience	Provide proper infrastructure and means to collect HCW and transport it to waste treatment facility.
4.	Collaboration and integration among HCFs and CBWTFs	Realize the importance of CBWTF for disposing waste and make decisions jointly with collaborated partner. The operational plans should be integrated with each other.
5.	Development of the performances matrices	Develop performance measurement tools to evaluate and control the activities of HCFs and CBWTFs.
6.	Budget allocation in HCWM	Proper budgetary plan should be developed for treating HCW by HCFs and CBWTFs.

7.	Adoption of latest technology in treating the waste	Replace outdated harmful treatment techniques with latest technology.
8.	Segregation and collection of HCW	Segregate waste into different categories at the generation point itself and collect into different color coded bins.
9.	Frequent transportation of HCW	Ensure the transportation of HCW from HCF to CBWTF within 48 hours after generation.

Table 9: Recommendations to overcome barriers of implementing HCWM system

Sl. No.	**Barriers**	**Action Plan**
1.	Lack of hospital administration and doctors' commitment	Enforcement of Biomedical Waste Handling and Management Rules, 1998 to hospital administration by SPCB. Involve the doctors for training the waste handling workers.
2.	Lack of infrastructure and convenience	Provide proper infrastructure for handling waste and regular monitoring of waste handling equipment.
3.	Budget problems	Allocate necessary budget for disposing HCW waste and installing latest technology.
4.	Lack of perception of self-harm	Educate workers and staff about the harm that may be caused by infectious waste.
5.	Lack of monitoring	Regular monitoring of waste handling activities.
6.	Lack of benchmark in India	Set standards for each activity involved in waste disposal process.
7.	Lack of awareness among waste handling staff and workers	Regular training and skills development workshop for staff and workers involved in waste handling process.
8.	No maintenance staff at treatment facility	Appoint maintenance engineer at each waste treatment facility to ensure no delay in disposing infectious waste.

9.	No frequent transportation of bio-medical waste from HCF to CBWTF	Establish strong logistic infrastructure in order to ensure frequent transportation of waste from hospital premises to treatment facility.
10.	Non-aligned operational objectives among HCFs and CBWTFs	Set combined operational goals for HCFs and CBWTFs to ensure proper tuning with outsourcing partner.