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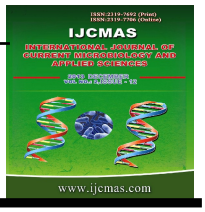

Original Research Article

Evaluation of biomedical waste management in the primary and community health centers in Puducherry region, India

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A B S T R A C T

The management of Bio medical waste (BMW) is of great importance due to its potential environmental hazards and public health risks, in the context of rapidly expanding health care facilities in developing countries. There are well defined set of rules and regulation for handling BMW worldwide. Unfortunately, carelessness and lack of adequate training and awareness in implementation of these rules have lead to serious health and environmental impacts. This study took into consideration both the quantity and quality of the generated wastes to determine generation rates and physical properties of BMW.Periodical visits were made during the period June 2010-May2011 to analyse awareness about BMW management among health care personnel in all the 29 PHCs and CHCs. All the 29 PHCs and CHCs in Puducherry region adopted less appropriate practices when it comes to the handling, storage, and disposal of wastes generated in comparison to the developed countries. There are no defined methods for handling and disposal of these wastes, starting from the personnel responsible for collection to those who transport was followed by anyone the wastes to the disposal site. Besides there was a lack of knowledge and awareness regarding legislations on BMW management even among qualified hospital personnel were observed.

Keywords

Biomedical waste; healthcare establishment; infectious waste; waste management; health problems.

Introduction

Health care facilities (HCFs), diagnostic centers, blood banks, dental centers and research centre are visited by patients for diagnostic and treatment procedures in the process which generate a variety of wastes are generated (Coker *et al.,* 2009). A few examples of waste categories are dressing material ,food waste, anatomical body parts, plastic disposable items, needles, drugs, chemicals, mercury,corrosive agent, radioactive substances-all of which ultimately become part of the BMW (Lee, 1989; Baveja *et al.,* 2000; Gupta and Boojh, 2006). Waste generated in HCFs is much more complex than the general municipal solid waste (MSW) as it poses a direct threat to human as well as the environmental health (Baveja *et al.,* 2000; Mahmood *et al.,* 2001; Batterman, 2004; Abdulla *et al.,* 2008; Chaerul *et al.,* 2008;

Marinkovic *et al.,* 2008; Shinee *et al.,* 2008). These wastes if not managed properly potentially expose the health care workers, waste handlers, patients, scavengers and the community at large to infection, injuries and toxic effects, and risks polluting the environment (Sandhu and Singh, 2003; Patil and Pokhrel, 2005). With rapid urbanization and population pressure, nature's 'cleansing system' has started breaking down.

Most HCFs in developing countries have outdated waste management procedures (Bos and Izadpanah, 2002). Hence, improvement of waste management in HCFs is urgently needed for safeguarding the population, eliminating occupational health hazards and protecting the environment. It is imperative that all BMW materials are ideally segregated at the point of generation, properly treated and disposed of securely.

BMW from most of HCFs in India, until, very recently was not being managed but was simply 'disposed off'. The disposal of BMW can be very dangerous particularly when it gets mixed with MSW and is dumped in uncontrolled or illegal landfills such as vacant lots in neighboring residential areas and slums. This can lead to a higher degree of environmental pollution, apart from posing serious public health risks such as Hospital-acquired infections, AIDS, Hepatitis, cholera, plague, etc. Where waste is dumped into areas without restricted access, children may come into contact with contaminated waste and play with used needles and syringes. Recent epidemiological studies indicate that a person who experiences one needle stick injury from a needle used on an infected source patient has risks of 30%, 1.8%, and 0.3% respectively of becoming infected with HBV, HCV and HIV (WHO, 2011).

HCFs in India produce a significant quantity of waste, posing serious problems for its disposal. Very few detailed studies have been conducted on BMW in India (Patil and Shekdar 2001; Lakshmi 2003; Patil and Pokhrel 2005; and Gupta and Boojh, 2006; Jcboss *et al*., 2009). From such studies, it was established that HCFs did not have proper means of managing BMW. Furthermore, most of our knowledge of BMW composition and management is limited and is unreliable as well. According to the estimate performed by Patil and Pokhrel (2005), the average rate of BMW produced at Bangalore metropolitan city (Karnataka State in India) hospital is 2.31 kg/patient/day. For most of the smaller HCFs in India, there are no official data about BMW, and in some cases the BMW are mixed with domestic wastes. The present study was carried out to determine the amount of waste generated, to assess separation of waste, containers used for collection and on-site transportation, temporary storage site, treatment of waste and final disposal, along with the training given to personnel and current rules and regulations concerning this issue. Suggestions for solving these problems and providing improvement in the present situation are given.

Materials and Methods

A series of intensive surveys were conducted to evaluate the quantities of BMW generation rate at all the 29 primary and community health centers in Puducherry region for the period June 2010-May2011.

For the quantification of the BMW in the HCFs, a suspension spring scale having a maximum capacity of 25Kg (±100 g) was used with the assistance of the trained

hospital sweepers and rag pickers. Around 3-4 HCFs everyday were randomly chosen for estimation of BMW generation. On an average, this was done for 7 days for each PHCs and CHCs, distributed randomly over one year to determine the total quantity of BMW generated. The gross quantity of wastes for each PHCs and CHCs (infectious, non-infectious wastes) were estimated and tabulated by modifying/improving the methods suggested by Patil and Pokhrel (2005) and Bdour *et al.,* (2007). The daily production of infectious waste and non-infectious waste at these establishments were estimated. The total numbers of patients were counted on the sampling dates for calculation of BMW generation per bed.

Table 1 summarizes details of questionnaire schedules used in the present study with topics covered. The surveys included site observations and in depth interviews to check the reliability of the given information. The respondents were asked to indicate their views on waste management policy, practices and their attitude related to the issue. Opportunity was also given to give details regarding certain questions asked. To document waste management practices, photographs were taken. Detailed investigations were carried out for BMW segregation, handling, collection, labeling, treatment, transport and final disposal practices in relation to Bio-medical Waste (Management and Handling) Rules, 1998 and personnel involved including administrative head of the PHCs and CHCs. All data management and analysis were carried out using Microsoft Excel.

To establish the a basis for evaluating how study facts and figures correlate, visual assessment and field investigations were conducted in all the 29 PHCs and CHCs. Various BMW management practices were investigated through visual inspection and in depth field studies. This allowed the collection of firsthand information and experience of how BMW was actually managed in all the PHCs and CHCs under normal working conditions. The assessment and investigations were also conducted to aid in the selection and design of the estimation procedure for the quantities generated in each PHCs and CHCs.

Results and Discussion

The Union territory (UT) Puducherry has four non-contiguous regions namely, Puducherry, Karaikal, Mahe and Yanam. Puducherry region is the largest of all the four. There are 88 government and private HCFs in the entire UT (including PHC and CHC) (HFWD, 2005; DES, 2005; PPCP, 2005; PCDP, 2007). This study is restricted only to Puducherry region, which accounts for 69 (78%) HCFs out of 88 for the entire UT. The PHCs and CHCs which account for 29 (42%) out of 69 were located in Puducherry region.

The average BMW generated from 29 PHCs and CHCs of Puducherry region was estimated on daily basis and the details of the production of the BMW are shown in Table 2. The total BMW produced (including infectious and non-infectious waste) was 97.1±3.4 kg per day, infectious waste- 18.9±2.5 kg per day and non-infectious wastes 78.2±2.2 kg per day. The average percentage composition of infectious and non-infections wastes is given in Figure 1 and 2 which show that cotton, bandage cloth, dripset, gauze, cloth ware, disposable syringe and plastics were the highest positions of infectious wastes generated and non-infectious wastes dominated the generated wastes that

include paper, cotton, food, polythene cover, plastic and glasses. It was found from all PHCs and CHCs in Puducherry around 80.5% BMW was general non-infectious wastes similar in properties to domestic wastes. The remaining 19.5% was infectious wastes.

Pruess *et al* (1999) found that 10–25% of BMW was termed as infectious, pharmaceutical and sharps which may produce a variety of health and environmental risks. In France, 15–20% of BMW is infectious wastes (Galtier and Bekaert, 2002) Germany (14%), Denmark (25%) and 15% was considered as infectious wastes (Lee and Huffman, 1996; Rahman *et al.*, 1999). The indicated differences may be due to geographical location, living habits and standards, availability of different treatment facilities, and perhaps to the ways in which BMW are categorized in different countries (Rahman *et al.*, 1999). All the PHCs and CHCs in the region had 141 beds, therefore, the average generation rate (kg/ bed/day) of total BMW was about 0.7 which is much lower than that of 4.5 in USA, 2.7 in Netherlands and 2.5 in France. However, the average BMW generation rates were in the range of 1 – 4.5 kg/bed/day in Latin American countries like Chile, Brazil, Argentina, Venezuela (Monreal, 1991). For all the PHCs and CHCs in the region, the inpatient BMW generation was 0.03 kg per (head/per/day).

Moisture Content of BMW

The moisture content of the BMW was calculated by "wet weight method". The moisture content is given by following formula:

$$M = \frac{(W - D)}{W} \times 100$$

Where,

M = Moisture content in %
W = Initial weight of the sample, g
D = Weight of sample after drying at 105^0C

The moisture content of the BMW was randomly measured for one week. The average moisture content of BMW of all PHCs and CHCs was 32.24%. The typical range in India for the moisture content is 20 to 45%. A study was done at Mauritius showed the BMW moisture content in the range of 50–65 % (Mohee, 2005).The moisture content is in the typical range of (Pruess *et al.*, 2000). In India values greater than 45% of moisture content is not uncommon because of an arid climate. The effect of moisture content is that it increases the weight of BMW and consequently the cost of the collection and transportation of the BMW also increases. It is, therefore, essential to protect the BMW from rainfall and other extraneous water. Moisture content of waste is essential for estimating the calorific value, landfill and incinerator sizing.

The following practices were identified as problematic in PHCs and CHCs as they are in violation of BMW Rules 1998.

The BMW management practices observed in all PHCs and CHCs (based on questionnaire, direct interview, visual inspection and field investigations) revealed that they were not in line with Government recommended practices. It was observed that in almost all the PHCs and CHCs chief doctors, and head nurses did not pay any attention to the BMW, both because of their insufficient knowledge about the significance of the subject and their apparent lack of interest. Additionally, in most of the PHCs and CHCs no person was assigned the responsibility managing of BMW.

Table.1 Content of BMW survey questionnaires

Component	Contents
Healthcare facility information	Facility name, location and type
	Number of sections/wards
	Number of beds
	Number of inpatients and outpatients
	Number of medical staff
Waste generation and segregation	Quantity of hazardous healthcare waste generated
	Segregation methods
	Type of bags and containers used
	Appropriate use of colour coded containers and bags
Waste collection and storage	. Waste tracking records
	. Waste handling procedure/instruction
	. Frequency of waste collection
	. Availability of central storage area and whether dedicated for hazardous waste only
	. Waste storage location, condition, security and cleanness
	. Frequency of cleaning the storage area
Waste transport	. Availability of dedicated trolleys for on-site hazardous waste transport
	. Type of off-site transport for hazardous waste
	. Availability of dedicated vehicles for hazardous waste
	. Off-site transport responsibility
	. Transport vehicles condition and registration
Waste treatment and disposal	. Treatment and disposal methods for hazardous BMW types at the surveyed facilities
General waste management issues	. Healthcare waste management, including: responsibilities, procedures, training, supervision, facility audit and inspection
	. Indian regulatory requirements and their practices

Table.2 Average BMW generations from different PHCs and CHCs in Puducherry region (period of June 2010-May2011)

Sr. No.	HCFs	No of beds	Average BMW (kg/bed /day)	Daily outpatient /day	Average BMW (kg/head /day)	Average Infectious waste generated (kg/day)	Average Non-infectious waste generated (kg/day)	Average Total BMW generated (kg/day)
1	Murungapakkam	3	1.0	120	0.03	0.5±0.3	2.6±0.6	3.1±0.7
2	Thirukanur	2	1.7	110	0.03	0.6±0.4	2.8±0.5	3.5±0.6
3	Koodapakam	2	1.7	90	0.04	0.6±0.2	2.8±0.5	3.4±0.5
4	Gorimedu	2	1.8	95	0.04	0.6±0.2	2.9±0.5	3.5±0.6
5	Kosapalayam	3	1.3	130	0.03	0.6±0.3	3.3±0.5	3.8±0.7
6	Lawspet	4	1.0	136	0.03	0.7±0.4	3.4±0.5	4.1±0.7
7	Katterikuppam	4	0.8	100	0.03	0.5±0.2	2.6±0.4	3.0±0.4
8	Ariyur	2	1.5	85	0.03	0.5±0.1	2.5±0.5	2.9±0.5
9	Sorapet	2	1.4	80	0.04	0.5±0.2	2.4±0.4	2.8±0.4
10	Sadarapet	4	0.8	90	0.03	0.4±0.2	2.7±0.5	3.1±0.6
11	Sooramangalam	2	1.5	111	0.03	0.6±0.3	2.5±0.5	3.1±0.5
12	Abhishegapakkam	3	1.0	123	0.02	0.6±0.3	2.3±0.7	2.9±0.8
13	Bahour	4	0.8	98	0.03	0.6±0.3	2.7±0.6	3.3±0.6
14	Nettapakam	10	0.3	105	0.03	0.5±0.2	2.5±0.5	3.0±0.6
15	Madukarai	4	0.6	123	0.02	0.4±0.2	2.0±0.5	2.4±0.6
16	Karayamputhur	5	0.5	124	0.02	0.6±0.3	2.1±0.5	2.7±0.6
17	Ariankuppam	4	0.8	102	0.03	0.7±0.3	2.3±0.6	3.0±0.6
18	Villianur	5	0.8	135	0.03	0.7±0.4	3.5±0.9	4.2±1.1
19	Mettupalayam	2	1.4	100	0.03	0.6±0.4	2.1±0.6	2.8±0.6
20	Thirubuvanai	3	0.9	102	0.03	0.5±0.2	2.2±0.4	2.7±0.5
21	Mudaliarpet	3	1.0	108	0.03	0.4±0.1	2.6±0.6	3.0±0.6
22	Muthialpet	2	1.5	96	0.03	0.4±0.2	2.6±0.7	3.0±0.8
23	Thavalakuppam	3	0.9	108	0.02	0.4±0.2	2.3±0.5	2.7±0.4
24	Odian salai	3	1.0	97	0.03	0.3±0.1	2.6±0.6	3.0±0.6
25	Reddiarpalayam	4	0.6	112	0.02	0.4±0.2	2.1±0.8	2.5±0.9
26	Kirumampakkam	4	0.6	121	0.02	0.4±0.1	2.2±0.6	2.5±0.5
27	Kalapet	2	1.6	90	0.03	0.4±0.1	2.8±0.6	3.1±0.7
28	Mannadipet	20	0.3	180	0.04	2.4±0.4	4.0±0.6	6.4±0.7
29	Karikalapakkam	30	0.3	198	0.04	2.6±0.3	5.2±0.5	7.8±0.6

Figure.1 Percentage composition of infectious BMW and their type

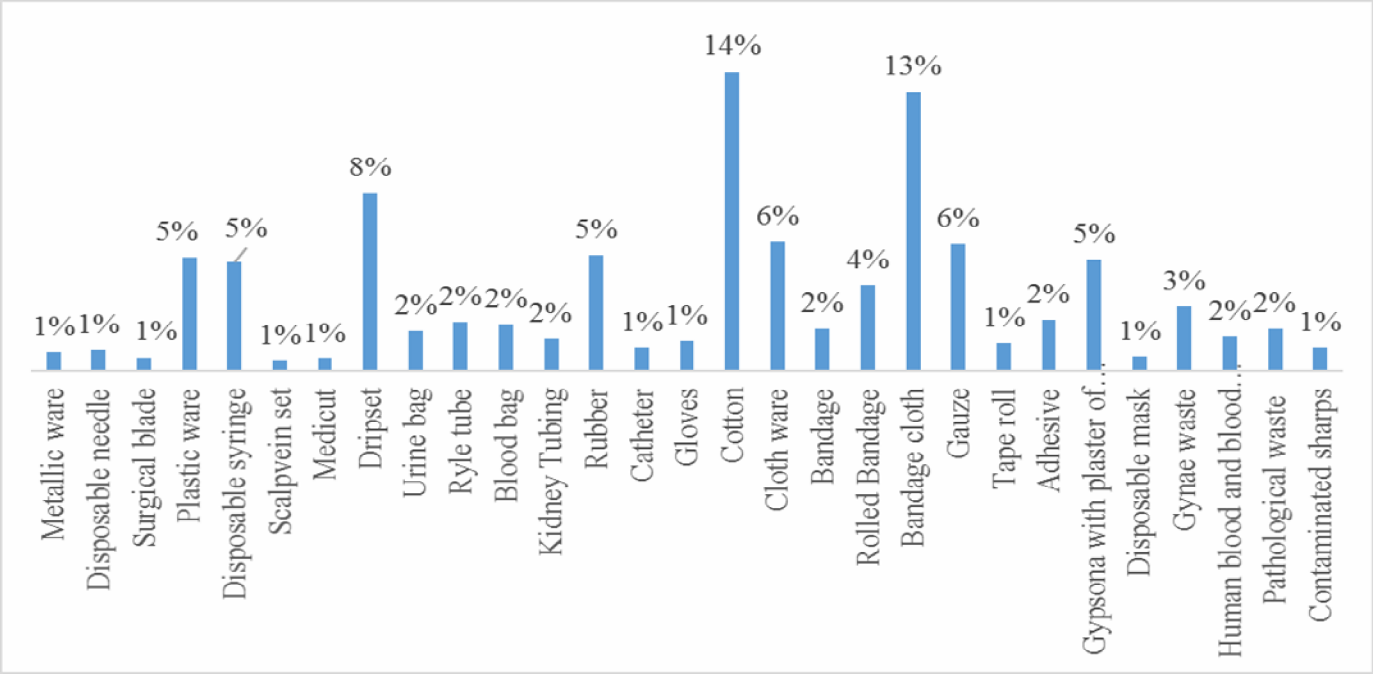
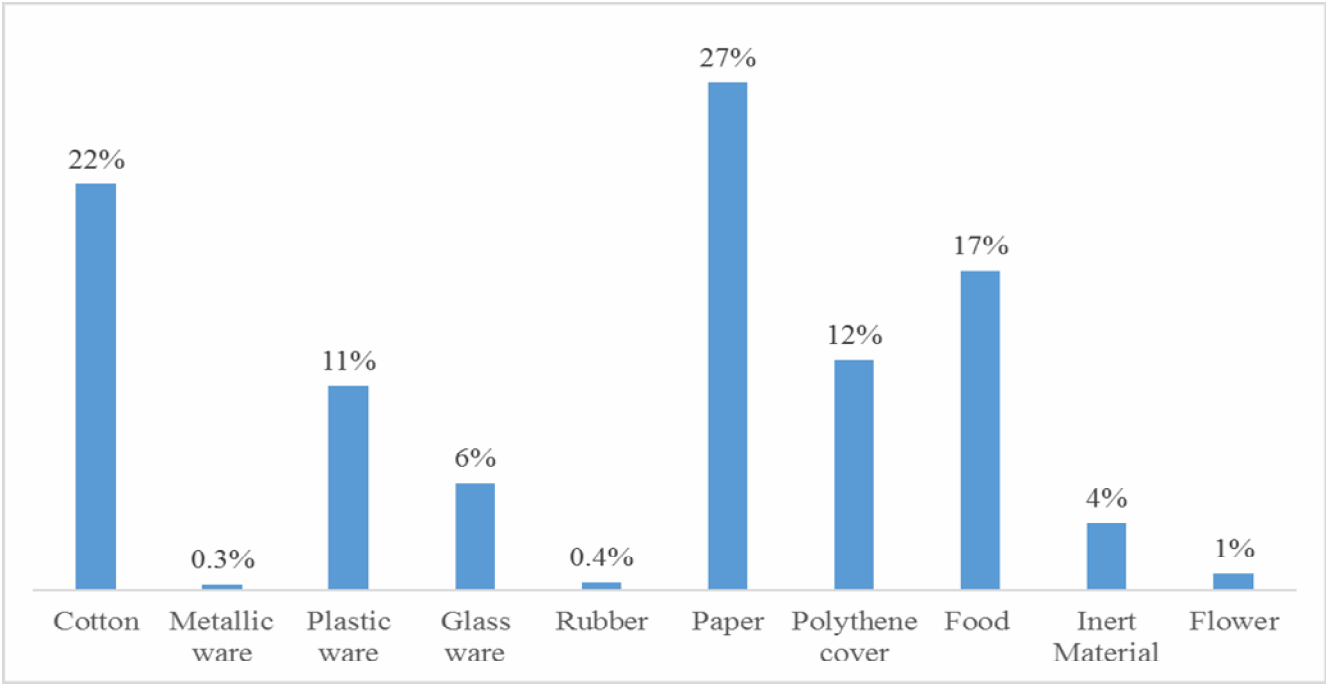


Figure.2 Percentage composition of non-infectious BMW and their type



Mixing of the different types of BMW at the point of generation made it difficult for some practices in the flow chart to be efficiently implemented. In the implementation of the BMW regulation 1998 and the budg*et al*located for the management of the BMW was very limited. The responsible personnel were not given adequate training, which led to inappropriate management and insufficient implementation of the regulation. Implementation of the regulation on integrated pollution and waste management for all the PHCs and CHCs in the region had, therefore, a number of gaps that need to be addressed. Most of these are discussed in detail below.

The present study showed that 7% of the CHCs indiscriminately used black, brown and yellow colored bags and containers for the collection for all BMW while 17% of urban PHCs used only black colour bags to collect all mixed BMW and the remaining PHCs had not used any coloured bags for segregating all BMW (Figure.3).

Transport of BMW

Invariably, all the PHCs and CHCs were not handling, transporting, treating and dispose of their BMW. The transfer of BMW from the hospital wards in the almost all the PHCs and CHCs to temporary storage area was not accomplished appropriately. Collection of infectious and non-infectious wastes in all the PHCs and CHCs studied was invariably done by a team of two waste collectors; one pulled the hand-driven trolley and the other collected bags from each ward. The waste was heaped in a corner of the HCFs and the collected BMW were dumped at the temporary storage room, located invariably behind the all the PHCs and CHCs.

BMW transport equipments

All the PHCs and CHCs lacked of dedicated transport equipment (e.g. carts, or trolleys) for on-site BMW transfer and also lack special containers designed to collect the BMW disposal, those who have them, do not clean them on a regular basis with proper maintenance . HCF managers must take adequate precautions about this situation and collect their wastes in suitable containers (Pruess *et al.,* 2000; The Gazette of India 1998).

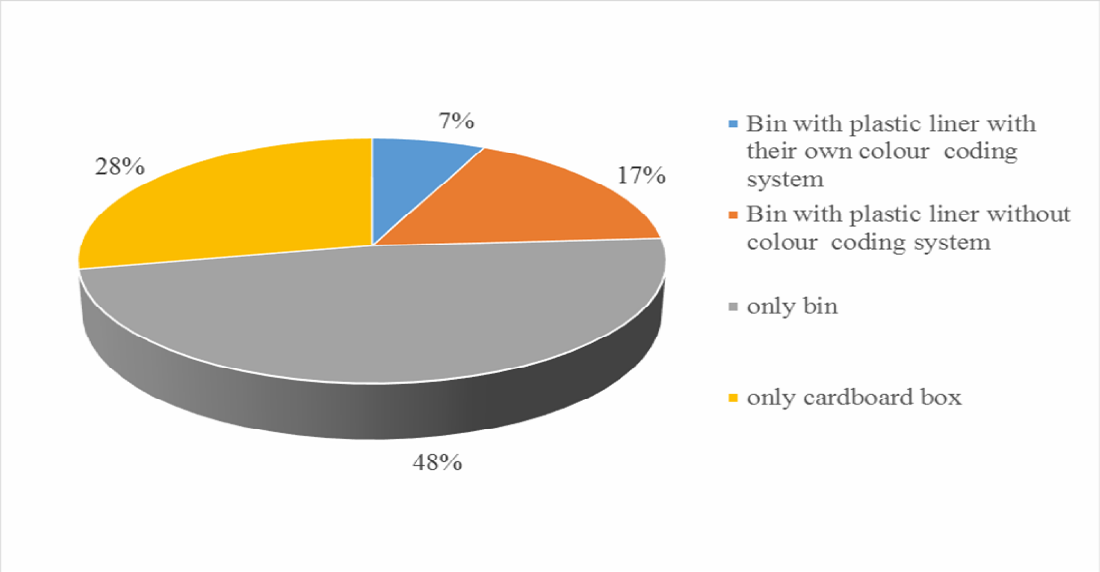
Temporary waste storage area

Only 16% PHCs and CHCs had temporary storage room or containers, and the ones that do have a temporary storage room, have a room that is not maintained or operated according to the criteria given in the WHO standard regulations (Pruess *et al* 2000). The different coloured bags having different types of wastes can be stored in the same chamber. In some PHCs, due to the lack of appropriate containers, the bags are deposited anywhere around the HCFs. This can be at the lobby or just in front of the HCFs.

Training/instruction in handling of BMW

A formal short duration training (2 days) was given to doctors and nurses only, that too not very frequently, while a majority of the waste handlers – especially the ward boys, sweepers and sanitary workers from large, medium, all the PHCs and CHCs in Puducherry region had not undergone any training for safe handling of BMW and hence were probably unaware of the related health risks.

Figure.3 Storage practices at source



Regular medical inspections

When asked about regular medical inspections, all the respondents replied in the negative. Although healthcare workers were engaged in a hazardous activity that exposed them to biological, physical and toxic wastes of all sorts, there were no routine medical inspections carried out at any of the PHCs and CHCs in Puducherry region.

Final disposal of BMW

(17%) of all urban PHCs, the Puducherry municipality was responsible for off-site transport of waste. The BMW was transported to the final site of disposal site by municipal trucks every day. In the remaining rural PHCs and CHCs (83%) disposed of their BMW inside the hospital grounds using open disposal and were burnt periodically to reduce the volume. However, burning plastics emit carcinogenic toxic chemicals among other air pollutants - dioxins and furans that are some of the most toxic chemicals known to science.

Questioners survey of BMW handlers

Protective wear

During the handling and collection of BMW, none of the waste handlers were found wearing any protective gears, spectacles, shoes and hand gloves in any of the PHCs and CHCs. The employees handling the BMW generally wear their daily clothes, unless they are informed that there will be an inspection at the institution. Because the provision of protective ware was so limited to gloves and masks only that too in limited quantities. These items were considered to be luxury and were believed to hinder the work. Besides they complained that the same were provided only rarely by their employers. Though waste handlers do realize the links between handling BMW and diseases, they replied that they have been doing the same

for a very long time and as a consequence, they might have developed immunity to many health problems. In the present study, the waste handlers were not apparently aware of the necessity for taking any precautionary measures while disposing of hazardous BMW in all the PHCs and CHCs. Even the nurses were no exception as it was revealed by the inputs derived from the detailedquestionnaire.

Identification / differentiation between infectious and non-infectious wastes

All waste handlers said that they couldn't differentiate between infectious and non-infectious wastes.

Separate collection of infectious waste and non-infectious wastes

Twelve percentage of the waste handlers replied that they collected infectious wastes separately from non-infectious wastes. However, they were dumped together in bags before disposal. 88% said that the two kinds of wastes were collected in the same containers and they have not followed any regulations (Pruess *et al* 2000; The Gazette of India 1998).

Collection / carriage in closed containers

Sixteen percentage of the waste handlers collected and carried the wastes in closed, tied bags. 84% carried the wastes in open containers or buckets (Pruess *et al.*, 2000; The Gazette of India, 1998).

Needle destroyer

Seventy nine percent of PHCs and CHCs in Puducherry are not using needle destroyer regularly to dispose of the needles.

History of injury from BMW in the study period

Nearly 86% of waste handlers had received injuries from handling of BMW wastes on one or more occasions, whereas 14% had never received any injury.

Conclusions

The present study has indicated that nearly all PHCs and CHCs in the study area practiced poor BMW management. Typically, handling of BMW was assigned to poorly educated and inadequately trained workers who performed all the tasks without proper protection, and guidance. Insufficient segregation, classification and treatment of BMW were noted at all surveyed PHCs and CHCs. For the most part, BMW was dumped and mixed with domestic waste, which was collected, transported and disposed off in a similar manner as general MSW.

The present study reveals a serious need to establish and implement a proper BMW management strategy to control and improve the current practice of BMW management in all PHCs and CHCs in Puducherry region. Necessary steps include protecting the safety of HCFs employees. Equally important is training regarding the handling and management of BMW for all personnel in contact with BMW. Waste handlers and other health care workers must be taught to classify BMW into infectious and non-infectious. Considering the differences in the educational level and understanding ability of the different stake holders involved, we need to develop specific modules on BMW handling and management, wherever needed in the local language. Adequate interim waste storage facilities must be installed, and these must include

designated separate infectious waste storage containers. In addition, sterilization methods are essential to stop contamination of open dump sites by infectious waste.

The State Pollution Control Board with its limited man power could not strictly enforce /implement the relevant legal provisions and make PHCs and CHCs legally responsible for the safety of all concerned. The PHCs and CHCs should also undertake a detailed risk assessment of the waste. Segregation should be done at the point of waste generation and can be achieved through proper training, cleanliness standards and tough enforcement. Use of non-disposable items such as stainless steel trays, ceramic mugs, etc., in place of disposable items needs to be encouraged. In view of the increasing number of smaller hospitals and the economics of scale, it was felt that a common BMW treatment facility is essential. Even larger hospitals preferred to opt for outsourcing BMW treatment /disposal.

The most immediate threat to human health is the careless disposal of sharps. Proper segregation and collection of these materials in rigid puncture-proof containers, which are then subject to appropriate treatment and disposal, should be a high priority. Using needle cutters and needle boxes would minimize the risk at the source of waste generation. Training on handling and management of sharps is essential.

Introducing awareness programs, education and training initiatives should cover all stakeholders concerned with BMW management. There should be a proper budgetary allocation for this activity. Media should be used effectively to create awareness among the waste handlers and general public.

Recommendations

Based on these findings, it can be noted that there is significant potential to improve the BMW management in the local context. To overcome these obstacles, the following recommendations are presented for BMW management in Puducherry region.

Apart from the weight, the types, sources, and the characteristics of BMW generated should be monitored based on the BMW (Management and Handling) Rules, 1998 and subsequent amendments. There is an urgent need to manage the life-cycle of every type of medicine, materials in all HCFs, which consists of purchasing, using, collection, segregation, transportation and final disposal.

Proper training should be provided to everyone involved in the BMW management process regarding appropriate segregation practices and the potential hazards associated with improper procedures such as handling without protective measures (Patil and Shekdar, 2001;Askarian *et al.*,2004a; Askarian *et al.*, 2004b; Marinkovic *et al.*, 2005; Jcboss *et al*., 2009.

A system of color coding or labeling of waste containers/bags strictly according to the requirements of the BMW (Management and Handling) Rule 1998, 6 - Schedule II should be used consistently.
Separate collection of the different types of BMW should be consistently followed as stated in the BMW (Handling & Management) Rule 1998. Hospital managers must take precautions about the

use of inappropriate containers and must collect their wastes in suitable containers according to BMW (Handling & Management) Rule 1998.

Infectious waste should not be mixed with the stream of domestic refuse for disposal. Sharps should be collected together, regardless of whether or not they are contaminated. In puncture-proof containers fitted with covers. They should be rigid and impermeable, so that they safely retain not only the sharps but also any residual liquids from syringes.

To discourage abuse, containers should be tamper-proof, and needles and syringes should be rendered unusable. Where plastic or metal containers are not available or too costly, containers made of dense cardboard are recommended.

Strict control of temporary storage areas should be implemented. Only BMW handlers should be allowed to enter these areas and there is a need to keep the storage areas clean and hygienic.

The BMW handlers should be provided with slip-resistant/puncture proof shoes and should be prohibited from jumping on and jumping off of the riding step unless the vehicle is at a complete stop (Rao *et al*., 2004; Tsakona *et al*., 2007; Alagoz and Kocasoy, 2008; Abdulla *et al*., 2008).

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