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RESEARCH ARTICLE

BIOMEDICAL WASTE MANAGEMENT PRACTICES IN PUDUCHERRY REGION INDIA: A CASE STUDY OF THREE SELECTED HEALTH CARE FACILITIES

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Abstract

Biomedical waste (BMW) has become an environmental and health hazard in many countries, including India. Careless disposal of these wastes by Healthcare facilities (HCFs) has become a significant concern for medical staff, patients, general community and largely the environment. Characterization and quantification of BMW generation in selected HCFs was analyzed to assess the current BMW management practices including segregation, collection, transportation, storage, treatment and final disposal strategies and health /safety practices for the health care personnel involved in BMW Management. The average daily per bed production of infectious BMW was 0.2 kg/bed/day at JIPMER, 0.3 at GH and 0.6 at MH. However, the percentage of infectious waste produced in the MH (40%) was higher than GH (28%) and JIPMER (23%). BMW management had not received adequate attention in Puducherry region. BMW was dumped and mixed with domestic waste, which was collected, transported and disposed off in a similar manner as that of the Municipal solid waste. The safety measures taken by waste handlers were not satisfactory due to poor awareness of potential health hazards. This violates the BMW Rules, 1998. Thus, it is concluded that there should be strict implementation of a waste management policy, ideally by an infection prevention and control team for all large/major hospitals and a dedicated resident doctor in charge for this purpose in all other hospitals and periodic training and motivation must be given paramount importance to meet the current needs and standards of BMW management.

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Introduction

Biomedical waste is defined as any solids, liquids, sharps waste including its containers and any other intermediary product, which is generated during the diagnosis treatment or immunization of human beings or animals in research pertaining there to, or in the production or testing (The Gazette of India 1998; Pruss et al., 1999). These solid wastes can be classified into 10 main categories; Human anatomical waste, animal waste, microbiology & bio-technology waste, waste sharp, discarded medicines & cytotoxic waste, solid waste (soiled), solid waste (plastic), liquid waste, incineration ash, chemical waste (solid) (The Gazette of India 1998). One of the first critical steps in the process of developing a reliable waste management plan is characterization of wastes (Shinee et al., 2008). Different categories of BMW must be separated and identified as per the rules and regulation (Chaerul et al., 2008). Most of the wastes generated in HCFs, including food waste are no more hazardous than general municipal solid waste, but become infected as they are mixed with infectious wastes at source. Therefore, BMW should be

segregated into infectious wastes and non- infectious wastes and disposed off accordingly (The Gazette of India 1998; Pruss et al., 1999).

Most of the developing nations are facing many challenges and environmental degradation from unscientific management of BMW. Increase in population and rapid growth in the number of HCFs also elevated this problem (Patil and Pokhrel, 2005; Coker et al., 1999). The last century witnessed the rapid mushrooming of HCFs in the public and private sector, dictated by the demand from the increasing population, and the advent and acceptance of "disposable wastes" has made the generation of BMW a significant factor in present HCFs. (Rahman et al., 1999; Silva et al., 2005; Verma et al., 2008; CEET, 2012). India is no exception to this as it is estimated that more than 15,000 small and private HCFs and nursing homes are operating in this country and they generate a huge quantity of wastes (Mohankumar and Kottaiveeran, 2011). Recently, there is also growth in number of clinics and pathological labs that generate sizeable amounts of BMW. India generates around three million tons of BMW every year and it is growing at a rate of 8% per annum (Chakrabarti et al., 2006). Thus, BMW disposal has emerged as a major problem in India. The quantity of BMW and proportion of infectious waste is definitely higher than one would expect in India due to extensive use of medical and non-medical disposals (CEET, 2012).

There is an increasing concern over unscientific and improper disposal of BMW India and they are still disposed along with domestic wastes, thus creating risks to both public health and environment pollution (Gupta and Boojh, 2006; Bdour et al., 2007; Silva et al., 2005; Bendjoudi et al., 2009). Hence, BMW disposal in the HCFs has become an issue of increasing concern, prompting healthcare administration to seek new ways of scientific, safe effective management of the BMW, to protect general public, healthcare and sanitary workers who are regularly exposed to them and also to avoid occupational health hazards (CDCP, 2001; Yong et al., 2009).

The need of proper BMW management system is of prime importance and is an essential component of quality assurance. This focus has assumed great importance in India, especially in the light of honorable Supreme Court Judgment and the notification of the BMW (Management and handling) Rules, 1998. Proper BMW management ensures control of HCFs infections as well as ensures that the HCFs are not a source of infection or other type of hazards to the community. Though the major HCFs have started implementing poor waste management systems, there are a number of HCFs, which dump their wastes in the municipal garbage dumps. rag pickers, who can sort these wastes by hand, to pick up plastics like glucose bottle, disposable syringes and needles, other disposables like catheters, tubing and IV sets, frequently, visit these dumping sites (Gupta and Boojh, 2006).

Lack of ability to follow minimum standards of BMW management not only decreases the quality of life and health in a society but also increase the workload of health services. The Government of India 'notification, 1998' specifies that BMW management is a branch of HCFs hygiene and safeguarding activities (The Gazette of India, 1998). This involves management of range of natural activities, which are mainly engineering functions, such as segregation, collection, transportation, operation or treatment of processing systems and final disposal of BMW. However, primary segregation and storage activities are the straight responsibility of nursing personnel who are engaged in the HCFs. If the infectious components get mixed with the general non infectious waste, the whole mass becomes potentially infectious. If the wastes contain pathogens with sufficient virulence and quantity, exposure to the waste by a susceptible host could result in an infectious disease (Blackman, 1996; Info Nugget, 2003).

It has now become mandatory for HCFs to dispose of BMW as per the regulation. The onus lies with the HCFs to ensure that there are no adverse health and environmental consequences as a result of their waste handling, treatment and disposal activities (The Gazette of India, 1998). For that reason, there is an urgent need to plan and implement updated procedures and practices at different levels of BMW management plan, which is associated with environmental and public health. For a reliable and successful BMW management, it is essential to characterize and quantify BMW.

Materials and methods

Direct Observation

The present study was carried out in three selected HCFs in Puducherry region - Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Government General Hospital (GH) and Government of Maternity Hospital (MH) for the study period (January to December 2009). Several methods were used to collect data, such as direct observations from hospitals to dumpsites, direct interviews and survey questionnaires. Data collection regarding waste generation, separation, collection, labeling, storage, transportation and final disposal of BMW were carried out for selected HCFs. These visits were conducted to provide information about the BMW

management and working conditions of personnel involved in handling of BMW as well as to identify the main hazards to environmental health and safety, resulting from the existing practices (Henry et al., 1994). Besides observation, checklists were used during site visits based on the BMW (Management and Handling) Rules 1998 and the recommendations of the WHO for assessment of BMW management practices (The Gazette of India, 1998; Pruss et al., 1999).

Questionnaires Survey

The questionnaires were prepared to evaluate the knowledge and BMW management practices among BMW handlers and their risk perception associated with BMW. Questionnaires were distributed to the concerned staff in various departments in each chosen HCF. There were few reasons for not being able to collect the reliable data. One of them was the fact that the personnel of the HCFs do not have records of the wastes generated from their institutions. The other reason is that they were thinking that the information collected will be used against their institutions, that penalties may be assessed, and that this would jeopardize their image. Finally, they did not have any training about the subject and they thought that it was waste of time to complete the questionnaires. Subsequently, personal interviews with the responsible authorities of the HCFs were started to complete the questionnaires. Face to face interviews yielded good results and the relevant data were obtained. Confidentiality was ensured and all the forms were anonymous. The questionnaires involved five schedules grouped into 28 issues. Table 1 summarizes the schedules and the subjects/issues related to each schedule. Data from the questionnaires were stored and coded in a database for further analysis.

BMW Estimation

Characterization and quantification of the BMW in all the HCFs was carried out using spring scale having a maximum capacity of 25 kg (±100 g) as per the method suggested by Patil and Pokhrel, 2005; Bdour et al., 2007. The data on the beds and patients occupied for each HCF was obtained from respective hospital records. The average generation of various infectious, non-infectious waste and recyclable waste items per hospital unit area was manually recorded. Average total BMW generated (kg/day) was estimated from January to December, 2009. The average number of patients occupied beds per day, average waste per capita bed per day and average infectious (A) and non-infectious (B) wastes generated (kg/day) and net BMW generation (kg/day) at each source at each HCFs was calculated using the standard formula.- A+B=T. Then, the average collection of recyclable wastes, that is, plastic e (P) and glass waste (G) and net recyclable BMW generation (kg/day) at source in each hospital were also calculated by using the prescribed formula-P+G=R (Rampal et al., 2002). Besides, the average BMW incinerated (kg/day) (T-A=I) and average Net BMW disposed at dumpsite (kg/day) at each of the study site was also calculated (T-R+I=D).

BMW Characterization

Characterization of the BMW was carried out as per the standard methods suggested by several researchers (OTA, 1990; USEPA, 1991; Wong et al., 1994; Pruss et al., 1999 and Coker et al., 2009). Ward-wise BMW characterization and quantification was done for JIPMER and GH during the study period. However, ward wise data could not be recorded for MH as it is not divided into wards. For, collecting the data, five to seven small trash bins were arranged around the cardboard boxes near the spring scale used for weighing, placed in the temporary storage room/dump site. Special precautions like regular apron, thick impermeable gloves for protection against potential liquid contaminants and needle pricks along with a face mask were taken during the study. The researcher (Jcboss.U) and the BMW handlers involved in the study were inoculated against hepatitis B virus and tetanus. Tongs were used to handle the waste. Before characterization, all the BMW bags were weighed. The colored bags containing BMWs were dumped into the cardboard box one by one. Simultaneously, BMWs were separated out and put into small trash bins arranged around the cardboard box. After the sample characterization, the bags were used again by the hospital workers, if necessary. The percentage composition for each sub-category was estimated. The quantification of recyclable (Plastic and Glass) wastes was done only at the dumpsite with rag pickers as volunteers (Fig. 1a).

Results

Sources of BMW

The BMW generated in selected HCFs was basically observed from emergency ward, operation theatre, maternity ward, Injection Room, Ward, outpatient department (OPD) Store dressing room etc. and the information on the infectious and non-infectious waste is presented in Table 2. The selected HCFs in Puducherry region are multi-specialty, sophisticated HCFs known for their advanced diagnostic and treatment facilities. Also, these are the major referral institutions for primary and secondary level HCFs not only for all the rural/urban health areas in Puducherry region, but also for the adjoining districts of Tamil Nadu. Every year, thousands of patients from the

surrounding area come to Puducherry region to receive medical treatment mainly from these HCFs. This leads to increased generation of BMW from these facilities.

BMW Generations Rate

During the study period, there were 859 beds at JIPMER Hospital, 733 beds at GH and 330 beds at MH along with average bed occupancy of 841±24 Hospital per day (98%) at JIPMER, 624±39 (85%) per day at GH and 327±4 (99%) per day at MH. However, the average daily per bed production of BMW was found to be 0.9 kg/bed/day at JIPMER and GH, and 1.5 kg/bed /day at MH. The average daily production of infectious BMW was found to be 0.2 kg/bed/day at JIPMER, 0.3 kg/bed/day at GH and 0.6 kg/bed /day at MH. Besides, the recyclable (plastic and glass wares) BMW generation was 0.1 kg/bed/day at both JIPMER and GH, 0.2 kg/bed /day at MH.

The Ward/type wise BMW generation in JIPMER and GH are presented in Tables 3 and 4. The pediatric ward in GH is the biggest with 112 beds, with an estimated BMW generation of 110.15 ±9.74 kg/day, accounting for 11.4 % of the total waste. The male and female medical wards of GH have 42 and 30 beds each respectively, constituting the second and third largest wards of GH. Both wards (72 beds) generated 67.1±4.0, and 57.4±5.3 kg/day of BMW, thus jointly contributing about 21.2% of the total wastes. The least amount of non-infectious waste is generated in the GH special ward for very important persons (VIPs) - 0.6±0.3 kg/day, followed by Nurse Sick Room (NSR) ward (0.7±0.4 kg/day) individually accounting for a mere 0.1%.

The surgery ward in JIPMER exhibited the highest generation of BMW of about 212.5±26.6 kg/day (211 beds), constituting 27% of the total wastes, followed by the Obstetrics and Gynecology wards with a BMW generation rate of 153.2±22.6 kg/day (110 beds), accounting for 19.5% of the total waste. The Emergency wards generated BMW at the rate of 42.6±9.1kg/day (21 beds) constituting 5.42% of the total wastes. Though the emergency ward has only 21 beds, the BMW contribution was higher- 2.03 kg/bed/day (22.23%) as it required more dressings and cotton.

Characterization of BMW

Average quantity of BMW generated (mean ± SD) from all the HCFs and their contribution to the gross quantity of wastes (kg/day) (infectious, non-infectious, recyclable), quantity incinerated and net BMW disposed at dumpsite were computed and presented in Table 5. Table 5 shows that the percentage of infectious wastes produced in the JIPMER GH and MH were 23, 28 and 40%, respectively. Characterization and quantification of both infectious and non-infectious wastes generation (Mean ± SD) in JIPMER, GH and MH are presented in Tables 6 and 7, respectively. The recyclable BMW accounted for 15, 12 and 15 % in JIPMER, GH and MH respectively. Estimated generation of both plastic ware and glassware (Mean ± SD) in JIPMER, GH and MH are presented in Tables 8 and 9. Among recyclable wastes, plastic accounted for 40% in JIPMER, 66% in GH and 44% in MH; while glassware accounted for 60% in JIPMER, 34% in GH and 56% in MH. The net BMW directly disposed at dumpsite was 88% for GH, 85% for both MH as well as JIPMER.

BMW Handling and Management

Poor Maintenance of HCFs

Field surveys and site visits revealed that in MH, the buildings were poorly maintained, bed sheets were dirty. Often, up to three persons had to share one bed. Patients were exposed to odorous and damp surroundings. Toilets were not cleaned with bad odor. Un-segregated BMW of the wards were often dumped in dustbins near the toilets and corners. The floors were filthy. Thus, the hospital wards had suffocating surroundings inside. The researcher experienced the unbearable effluvium emanating from BMW dump room near the main entrance of GH and MH, which could be an indicator of the health risks involved for the workers handling BMW, as well as patients and visitors in the vicinity (Fig. 2). This is not the case in JIPMER, where the temporary storage room, segregation room and incinerator room all located in the backside of the HCF and main entrance and were relatively clean/hygienic.

Personal Hygiene of BMW Handlers

BMW waste handing employees in all the selected HCFs handling BMW generally wear their casual clothes, unless they are informed that there is an "inspection" at the institution. They were neither provided with protective gloves, masks, etc. nor were protected with Tetanus toxoid as was done more often in JIPMER.

Segregations of BMW

The type of container and color coding that should be used for BMW disposal with reference to compliance and non-compliance of Biomedical waste (Handling and Management) Rules 1998 is presented in Table 10. The rules specify segregation of BMW and also advise for strict use of black colored bags for general waste whereas yellow colored bags for infectious waste. This was not followed in all the HCF facilities. HCFs have segregated wastes according to guidelines and in spite of presence of bags, but inadequate knowledge regarding segregation,

majority of infectious and sharps waste were disposed off in black bags which were treated as general waste thus causing a great threat to the society. In addition to this, color-coded bins were not placed; if present they were not with closed fitting covers. However, all the bins were labeled accordingly as per Schedule III (as per the BMW Rules, 1998). It was observed that all selected HCFs did not strictly adhere to the color coding system. The different colored bags for different types of wastes were emptied together in the storage room. Due to lack of appropriate containers, BMW bags were dumped anywhere around the hospital, mostly near the lobby or just in front of the hospital. Nevertheless personal observations indicated that infectious, non-infectious and recyclable wastes were always dumped into the same bags. Since the segregation of the BMW was not applied efficiently, as it was primarily done by sweepers, the risks were obvious and perhaps inevitable for both the workers and patients in all the selected HCFs.

Onsite Transport

Except at JIPMER, there was no proper organized system for the collection and storage of BMW. Collection of infectious and non-infectious wastes in all the HCFs 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 GH and MH. The transfer of BMW from the selected hospitals was not done appropriately.

Temporary Storage Area

At all the selected HCFs, BMW was temporarily stored in a central room. More often, it was found that the waste bags leaked thus eluting out fluids from infectious and pathological wastes. These wastes can easily enter the MSW stream. The room was not locked. At GH and MH, the temporary BMW dump room was located near the main entrance of the hospital.

Offsite Transport

Only two Municipal staff were engaged in collecting BMW from GH and MH, respectively. Especially during weekends in GH and MH, there was a delay of more than 48 hours as Saturdays and Sundays are holidays for Municipality workers. GH and MH did not have separate BMW segregation/management section, as it would mean additional financial burden/administrative responsibility. In JIPMER, BMW was collected, treated (incineration) and disposed off every day.

Incineration and Final Disposal

Though the BMW received at the incineration plant in JIPMER was often inadequately segregated, the incinerator workers (on contract) segregate the wastes before incineration. Infectious BMWs were loaded into the incinerator and the non-infectious waste dumped at the dumpsite inside the premises. Since GH and MH did not have segregation room as well as their own incineration facility, their BMW were sent to a common BMW incinerator facility for these hospitals at the Govt. Chest Clinic. Due to the excess load of BMW as well as non-cooperation of workers, the incinerator was not used regularly. Hence, all the BMW from these two HCFs were sent directly to Karuvadikuppam Municipal dump yard, 4 km outside Puducherry city, situated adjacent to the Sewage Treatment Plant, at the North Eastern side of the Puducherry Airport. At the dump site, waste was burnt instead of being compacted and covered by soil (Fig. 3). The dump site is not secured from animals. At times, stray dogs could be seen feeding on still born child or amputated organs that are dumped along with MSW at Karuvadikuppam dump yard (Fig. 4).

Health Impact on BMW Handlers

It was also observed that the BMW handlers often got injured during handling process. Besides, rag pickers were also found at various dumping sites rummaging (Fig.1 b and c) for plastic bags, needles, surgical blades, surgical gloves and other items made of plastic (glucose bottle, syringes, drip set, urine bag, ryle tube, blood bag, kidney tubing and needle cover), glass (Injection vials /bottles, Ampoules and Syrup bottles), and aluminum etc., thereby exposing themselves to various infectious diseases. Several items collected by hospital sweepers, municipal waste handlers as well as rag pickers at HCFs and dump sites were sold in the market for medicinal or non-medicinal use both of which are hazardous for human health (Fig. 5).

Table 1
Contents of BMW Survey Questionnaires

Schedules	Aspect of Questions
1. HCFs information `	1. Facility name, location and type 2. Number of sections/wards

	3. Number of beds
	4. Number of inpatients and outpatients
	5. Number of medical staff
2. Assessment of BMW management	6. BMW daily contact
	7. Quantity of hazardous healthcare waste generated
	8. Segregation methods
	9. Type of bags and containers used
	10. Appropriate use of color coded containers and bags
	11. Wastes separation according with legislated groups
	12. Waste tracking records
	13. Waste handling procedure/instruction
	14. Frequency of waste collection
	15. Availability of central storage area and whether dedicated for hazardous waste only
	16. Waste storage location, condition, security and cleanness
	17. Frequency of cleaning the storage area
	18. Availability of dedicated trolleys for on-site hazardous waste transport
	19. Type of off-site transport for hazardous waste
	20. Availability of dedicated vehicles for hazardous waste
	21. Off-site transport responsibility
	22. Transport vehicles condition and registration
3. Risk perception	23. Of different medical wastes
	24. Of several BMW management operations in HCFs
4. Accidents	25. BMW accidents
	26. Sharps and needles accidents
5. Medical staff training	27. Participation of medical staff in BMW management training programs
	28. Medical staff knowledge about risks

Table 2
Sources of Waste Generation in the HCFs

Areas of Waste Generation	Activities Performed	Types of Waste Generated
Emergency ward and operation Theatre	Minor and major Surgical Procedures Accidental operative procedures and Ophthalmic surgeries	Blood and body fluids, soiled waste, swabs, cotton, syringes and needles, blades, gloves and masks
Maternity hospital/ and child delivery ward and operation Theatre	Gynecological surgeries and treatment including Child birth and family planning operations	Placenta, blood and body fluids, soiled waste, cotton, swabs, syringes and needles, blades, tubings and IV sets masks and gloves
Pathological Laboratory	Culture preparation, sample collection. Microscopic observation and testing of all diseases	Blood and body fluids, syringes and needles, gloves, slides, sputum and sputum cups, chemical waste and liquid waste
Injection room	Immunization and treatment	Syringes and needles, ampoules, vials, broken

	injections	glasses, gloves and vaccine waste
Ward of hospitals	In-patient services	Blood and body fluids, syringe and needle, slides, ampoules, vials, chemical waste, liquid waste, broken thermometer and soiled waste
OPD	Out-patient services, routine examination of patients	Blood and body fluids, syringes and needles, slides, ampoules, vials, broken thermometer, plaster cast chemical waste and liquid waste
Pharmacy	Distribution of the medicine	Empty card board boxes, metal boxes, out dated medicine, discarded medicine, paper waste, polythene covers and empty medicine bottle
Administration	Administration	Paper waste, card board boxes and packaging materials
Hospital kitchen (diet section) and canteen	Distribution of diet foods to the patients	Food waste like rice, chapatti, bread, egg shell, fruits and other liquid item such as milk, fruit juices ,water bottle
Patient visitor hall, veranda, street within the hospitals buildings or campus	Eating foods	Food waste, fruit, flower waste, water bottle and dressing cloth

Table 3
Quantity (kg/ day) of Ward-wise BMW Generated (Mean ± SD) in GH

Ward	No. of Beds	Average BMW (kg/ day)	%
Casualty	5	7.0±1.6	1.2
Female medical emergency	10	9.4±1.8	1.6
Trauma ward male	15	11.8±2.5	2.0
Trauma ward female	8	8.1±1.9	1.4
Trauma neuron surgery female	4	6.8±1.8	1.2
ICCU I	7	2.2±0.8	0.4
ICCU II	4	2.3±0.7	0.4
ICU II neuron surgery	3	2.6±0.7	0.4
Super specialty female			
a) Cardiology	6	3.4±1.0	0.6
b) Nephrology	6	1.6±0.6	0.3
c) Neurology medicine female	3	2.7±0.9	0.5
Super specialty male			
d) Cardiology	11	2.4±0.7	0.4
e) Nephrology	6	2.9±0.9	0.5
f) Neurology medicine female	5	2.0±0.8	0.3
Male medical emergency	12	14.8±2.9	2.5
Neurology female medicine	5	2.7±0.7	0.5
Neurology female surgery	8	1.9±0.7	0.3
Surgery pediatrics	16	7.6±1.7	1.3
Post operative -I	11	10.4±2.0	1.8
Post operative –II	10	7.9±1.7	1.4
Urology ENT	4	2.0±0.9	0.3

Urology post operative	9	7.2±1.2	1.2
Urology male	17	2.1±0.9	0.4
Urology female	11	2.1±0.6	0.4
Dialysis			
Peritoneal dialysis	7	4.4±1.7	0.7
Haemo dialysis	5	1.8±0.6	0.3
Special ward			
a) VIP	1	0.6±0.3	0.1
b) Type A	7	1.9±0.6	0.3
c) Type B	14	7.9±1.9	1.4
d) Type C male	16	12±2.5	2.0
e) Type C female	4	1.9±0.4	0.3
f) Type D male	12	7.0±1.9	1.2
g) Type D female	12	5.6±1.9	1.0
Ortho pediatric male	17	7.4±1.7	1.3
Ortho pediatric female	17	11.9±2.4	2.0
Ortho pediatric emergency male	11	9.7±1.9	1.7
ENT male	10	1.9±0.5	0.3
ENT female	11	2.3±0.8	0.4
Ophthalmology male	15	9.1±2.3	1.6
Ophthalmology female	19	9.6±2.6	1.6
NSR(Nurse Sick Room)	1	0.7±0.4	0.1
Medical pediatrics	112	110.2±9.7	18.8
Plastic surgery female	8	3.6±2.2	0.6
Geriatrics female	8	7.1±1.6	1.2
Medical ward male	42	67.1±4.0	11.4
Medical ward female	30	57.4±5.3	9.8
IMCU(Intense Medical Care Unit)	5	1.9±0.7	0.3
Surgery ward male	38	24.0±4.8	4.1
Neurosurgery male	6	1.9±0.5	0.3
Surgery ward female	18	13.4±2.1	2.3
Burns female	8	7.1±1.8	1.2
Surgical emergency female	15	12.6±2.1	2.2
Surgical emergency male	27	45.8±5.7	7.8
Burns male	4	2.4±0.9	0.4
Plastic surgery male	6	2.4±3.3	0.4
Skin male	6	2.3±0.7	0.4
Skin female	6	2.4±0.8	0.4
Psychiatric male	4	1.1±0.5	0.2
Psychiatric female	4	1.3±0.4	0.2
Infectious ward	11	3.0±0.8	0.5

Table 4
Quantity (kg/ day) of Ward-wise BMW Generated (Mean ± SD) in JIPMER

Ward	No. of Beds	Average BMW (kg/ day)	%
Medicine including Skin, Leprosy and Psychiatry	197	115.3±21.3	14.7
Paediatrics	69	69.3±11.2	8.8
Surgery	211	212.5±26.6	27.0
Orthopaedics	58	68.2±12.2	8.7
Eye and E.N.T.	67	35.8±11.7	4.6
Obstetricis and Gynaecology	110	153.2±22.6	19.5
Emergency wards	21	42.6±9.1	5.4
Special Wards	65	43.2±9.3	5.5
Other (Dental, Radiotherapy, D.T.C.D., G.E., I.D. etc)	62	45.9±10.0	5.8

Table 5

Average Composition of Infectious, Non-infectious and Recyclable BMW Generation in Three Major HCFs

HCFs	Average BMW Generation (kg/day) at Source		Net BMW Generation (kg/day) (A+B=T)	Average Recyclable BMW Generation (kg/day) at Source		Net Recyclable BMW Generation (kg/day) at Source (P+G=R)	BMW Incinerated (kg/day) (T-A=I)	Net BMW Disposed at Dumpsite (kg/day) (T-R+I=D)
	Infectious (A)	Non-infectious (B)		Plastic (T-P)	Glass (T-G)			
JIPMER	180.2±14.2	605.8±65.5	786.0±67.6	45.9±3.9	68.6±2.4	114.5±4.2	264.0±11.2	407.5±67.4
GH	165.2±12.7	421.3±16.3	586.5±23.4	45.8±3.9	24.0±3.3	69.8±4.3	-	516.7±22.6
MH	192.3±14.0	284.0±18.9	476.3±27.3	31.7±3.8	41.1±2.1	72.8±4.0	-	403.5±27.6

Table 6
Characterization and Quantification of Infectious BMW Generation (Mean ± SD) at GH, MH and JIPMER

Category of Infectious Waste	Average Infectious BMW Generated (kg/day)					
	JIPMER		GH		MH	
	Weight	%	Weight	%	Weight	%
Metallic ware	1.6±0.3	0.9	0.8±0.2	0.5	1.2±0.2	0.6
Disposable needle	1.8±0.3	1	1.6±0.4	1	1.1±0.3	0.6
Surgical blade	1.1±0.4	0.6	0.8±0.4	0.5	0.4±0.4	0.2
Plastic ware	9.6±4.6	5.3	8.0±3.2	4.8	5.7±3.2	3.0
Disposable syringe	9.2±3.4	5.1	10.7±3.4	6.5	6.8±3.4	3.5

Scalpvein set	0.8±0.5	0.5	1.7±0.6	1	0.7±0.5	0.4
Medicut	1.1±0.3	0.6	1.0±0.5	0.6	0.4±0.3	0.2
Dripset	9.6±2.6	5.3	8.8±2.6	5.3	7.8±2.6	4.0
Urine bag	3.4±1.2	1.9	3.9±1.2	2.4	2.8±1.2	1.5
Ryle tube	4.1±1.5	2.3	3.2±1.5	2	2.2±1.0	1.2
Blood bag	3.9±1.3	2.2	2.4±1.3	1.5	2.3±0.9	1.2
Kidney Tubing	2.6±0.8	1.5	1.8±0.8	1.1	1.6±0.8	0.8
Rubber	9.7±2.6	5.4	8.7±2.6	5.3	5.5±2.6	2.9
Catheter	2.0±0.4	1.1	1.0±0.4	0.6	0.8±0.4	0.4
Gloves	2.6±0.8	1.4	1.7±1.1	1	1.3±1.0	0.7
Cotton	25.7±9.6	14.3	23.2±9.6	14	43.3±9.6	22.5
Cloth ware	5.6±1.0	3.1	4.8±1.0	2.9	9.7±1.5	5.1
Bandage	7.7±1.4	4.3	6.3±1.4	3.8	3.4±1.4	1.8
Rolled Bandage	4.2±0.7	2.3	3.2±0.7	1.9	1.9±0.7	1.0
Bandage cloth	12.1±2.1	6.7	11.1±2.1	6.7	8.8±2.1	4.6
Gauze	10.7±1.7	5.9	10.4±1.7	6.3	7.6±1.7	3.9
Tape roll	2.4±0.8	1.3	1.8±0.5	1.1	1.5±0.6	0.8
Adhesive	4.3±0.8	2.4	3.7±1.6	2.2	1.9±1.4	1.0
Gypsona with plaster of paris	9.4±3.2	5.2	9.7±3.2	5.9	6.0±3.0	3.1
Disposable mask	1.2±0.4	0.7	0.9±0.4	0.5	0.7±0.5	0.4
Gynae waste	14.1±3.1	7.8	15.0±3.1	9.1	37.8±4.0	19.7
Human blood and blood products [(1)]	2.8±1.2	1.6	2.2±1.5	1.3	8.9±6.0	4.6
Pathological waste [(2)]	9.8±2.8	5.4	8.8±2.8	5.3	15.3±4.8	8.0
Contaminated animal carcasses, body parts, and bedding[(3)]	1.7±0.3	0.9	1.3±0.3	0.8	3.7±1.0	1.9
Contaminated sharps[(4)]	2.0±1.1	1.1	3.7±1.8	2.2	1.3±1.0	0.7
Isolation wastes[(5)]	1.9±1.4	1	1.9±1.6	1.1	-	-
Cultures and stocks of infectious agents and associated biological(6)	1.6±1.0	0.9	1.2±0.8	0.7	-	-

1) Human blood and blood products- Waste blood, serum, plasma, and blood products
2) Pathological waste-Tissues, organs, body parts, blood, and body fluids removed during surgery, autopsy, and biopsy

3) Contaminated animal carcasses, body parts, and bedding-Contaminated animal carcasses, body parts, or blending of animals that were intentionally exposed to pathogens
4) Contaminated sharps-Contaminated by hypodermic needles, syringes, scalpel blades, Pasteur pipettes, and broken glass
5) Cultures and stocks of infectious agents and associated biological-Specimens from medical and pathological laboratories Cultures and stocks of Infectious agents from clinical, research, and industrial laboratories; disposable culture dishes and devices used to transfer, inoculate and mix cultures Waste from production of biological
6) Isolation wastes-Wastes generated by hospitalized patients who are isolated to protect others from communicable diseases

Table 7

Characterization and Quantification of Non-infectious BMW Generation (Mean ± SD) at GH, MH and JIPMER

Non infectious waste	Average Non -Infectious BMW generated (kg/day)					
	JIPMER		GH		MH	
	Weight	%	Weight	%	Weight	%
Cotton(1)	91.5±6.8	21.7	91.5±6.8	21.7	67.2±9.1	23.7
Metallic ware(2)	1.4±0.9	0.3	1.4±0.9	0.3	1.3±0.9	0.4
Plastic ware(3)	45.8±5.0	10.9	45.8±5.0	10.9	13.8±5.0	4.8
Glass ware(4)	24.0±3.4	5.7	24.0±3.4	5.7	11.3±3.4	4
Rubber(5)	1.8±1.0	0.4	1.8±1.0	0.4	1.5±0.9	0.5
Paper(6)	114.3±9.0	27.1	114.3±9.0	27.1	68.5±9.0	24.1
Polythene(7)	51.7±3.2	12.3	51.7±3.2	12.3	42.4±3.2	14.9
Food(8)	71.8±10.4	17.1	71.8±10.4	17.1	65.0±10.4	22.9
Inert Material(9)	15.0±4.6	3.6	15.0±4.6	3.6	10.0±4.6	3.5
Flower(10)	3.9±1.4	0.9	3.9±1.4	0.9	3.0±1.4	1

1. Cotton – cotton swabs, cloth
2. Metallic ware - Metallic seal, tablet covers, aluminium foil, ointment tube etc.
3. Plastic ware - Glucose bottles, hydrogen peroxide bottles, spirit bottle, etc.
4. Glass ware - Injection vials, ampoules, bottle, syrup bottles etc.
5. Rubber - Bottle stoppers
6. Paper - Newspaper, wrappings, bags and soap covers etc.
7. Polythene- Polythene bags etc.
8. Food - Rice, meat, peeling, chapatti, egg shell, etc.
9. Inert material - Dust, sand, paper bits, soil, etc.
10. Flower - Flower

Table 8
Estimated Generation of Recycled Plastic Ware from GH, MH and JIPMER

Category of Plastic ware		Average Weight (g)	Average of Plastic Ware Generated (kg/day)					
			JIPMER		GH		MH	
			No.	Weight (kg)	No.	Weight (kg)	No.	Weight (kg)
Glucose bottles	Small	22.5	236±16	5.3	256±19	5.8	183±23	4.1
	Large	38.7	397±26	15.4	302±16	11.7	278±18	10.8
H_2o_2 bottle	-	8.6	103±9	0.9	89±13	0.8	52±8	0.4
sprit bottle	-	7.2	112±17	0.8	72±9	0.5	49±13	0.4
Needle cover	-	1.0	2324±56	2.2	1698±19	1.6	428±21	0.4
Glucose drip set	-	37.0	543±33	20.1	428±11	15.8	234±26	8.7
Miscellaneous	-	-	-	1.3		9.7 -		7.0

Source: Rag picker survey from dump site.

Table 9
Estimated Generation of Recycled Glassware from GH, MH and JIPMER

Category of Glassware		Average Weight (g)	Average of Glassware Generated (kg/day)					
			JIPMER		GH		MH	
			No.	Weight (kg)	No.	Weight (kg)	No.	Weight (kg)
Injection vials /bottles	Small	12.6	106±22	1.3	95±15	1.2	63±13	0.8
	Medium	16.7	63±16	1.1	48±11	0.8	32±9	0.5
	Large	30.4	27±13	0.8	19±5	0.6	16±11	0.5
Ampoules	Small	5.3	152±12	0.8	106±18	0.6	94±16	0.5
	Medium	9.0	124±19	1.1	78±12	0.7	86±6	0.8
	Large	11.8	66±13	0.8	42±9	0.5	63±7	0.7
Syrup Bottles	Small	102.4	123±17	12.6	36±7	3.7	53±23	5.4
	Medium	206.4	58±9	12.0	28±4	5.8	42±5	8.7
	Large	800.2	37±7	29.6	7±3	5.6	21±8	16.8
Miscellaneous	-	-		8.6	-	4.6	-	6.3

Miscellaneous include other minor items, such as cans, boxes.
Source: Rag picker survey from dump site.

Table 10

Types of Container and Color Coding for Disposal of Hospital Waste in Three Major Hospitals of Puducherry Region (India)

BMW(Management & Handling) Rule 1998 India		Color of Bags Used		
Recommended Colors	**Types of Container & Waste Category (Cat)**	**GGH**	**GMH**	**JIPMER**
Yellow	Plastic bag with Cat 1 human anatomical waste Cat 2 animal waste Cat 3 microbiology waste Cat 6 soiled waste	Yellow	Yellow	Yellow
Red	Disinfected container/plastic bag Cat 3 Microbiological Cat 6 soiled Cat 7 solid waste (Waste IV tubes catheters, etc.)	Brown	Brown	**
Blue/white	Plastic bag/puncture proof containers Cat 4 waste sharps Cat 7 plastic disposable tubings, etc.	*	*	Blue
Black	-do- Cat 5 discarded medicines Cat 9 incineration ash Cat 10 chemical waste	Brown or Black	Brown or Black	Black

* "GH and MH" This category waste mixed with any one of Black, Brown and Yellow
**"JIPMER" This category waste mixed with any one of Black, Blue and Yellow

Fig. 1. BMW being Weighed (a) Recyclable Plastic (b) and Glass by Rag pickers (c)

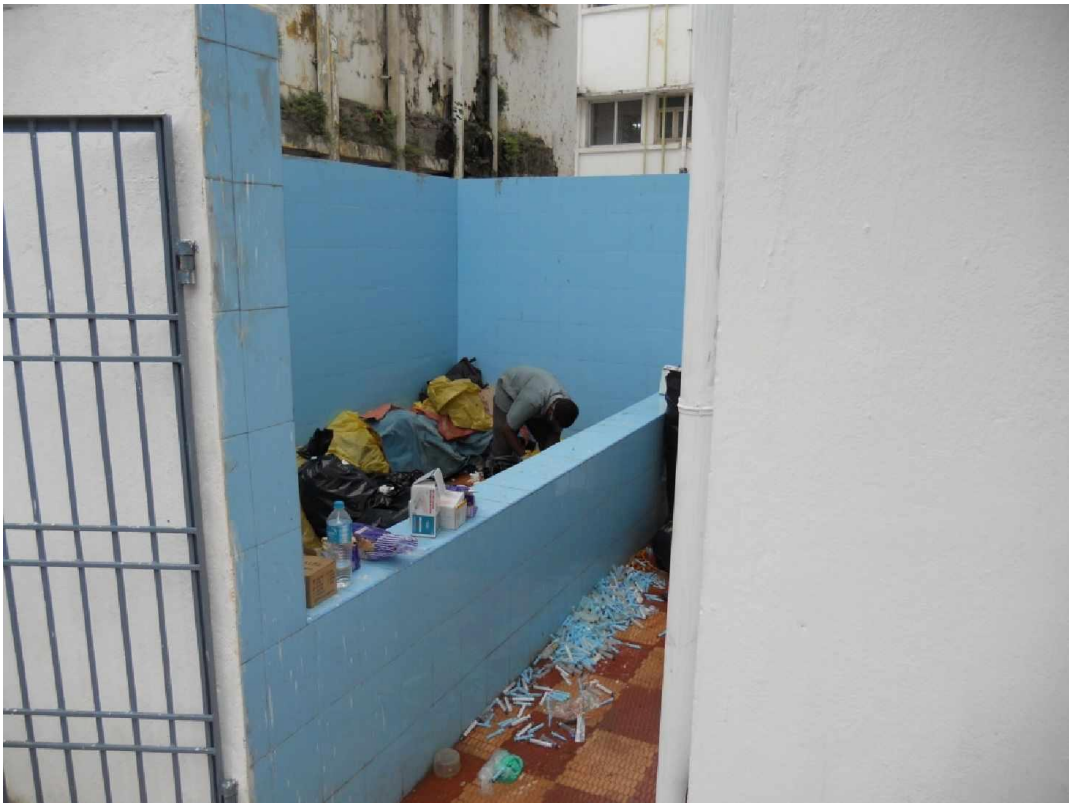

Fig. 2. Temporary Storage Space Close to the Western Entrance of GH Puducherry (2009)

Fig. 3. Karuvadikuppam Municipal Solid Waste Dumping site along with BMW Spread over, Compacted & Covered with a Layer of Soil (2009)

Fig. 4. Stray Dogs Feeding on Amputated Organ Dumped along with MSW at Karuvadikuppam Dump site (2009)

Fig. 5. A Flea Market for Sharps and Metal Wastes (sold along with other items) in Sunday Market, Mahatma Gandhi Road, Puducherry (2009)

Discussion

The results indicated that BMW generation rates depend on several factors, such as the type of HCF, level of status, degree of treatment and location as reported by several workers (Mato and Kaseva, 1999; Silva et al., 2005; Bdour et al., 2007; Nemathaga et al., 2008). MH generated a higher rate of infectious waste (0.6 kg/bed/day). The higher value reported for MH probably is due to the excess number of patients who have to sleep on the floor at MH, due to the shortage of bed. However, MH is attracting a larger number of patients not only from Puducherry UT but also from adjacent states due to the quality of care during delivery and post operative care, mostly free of cost. As a consequence, the hospital infrastructure at MH could not meet the escalating demand. Most often the number of patients for the delivery always exceeds the available beds. Hence, several patients had to sleep on the floor. When compared with the other hospitals, MH was the highest contributor for infectious waste materials for the reason that infectious waste items, such as cotton (22.5%), cloth ware (5.1%), gynecological waste (19.7), human blood and blood products (4.6%) pathological waste (8%) and body parts, and bedding (1.9%), were generated more, due to increasing numbers of child birth. It could be due to being a women hospital and higher number of surgeries related to pregnancies among women and other gynecological and obstetrics related medical cases.

Segregation and collection of waste was found regular at hospital level, but no proper disposal method other than municipal dumping was found. This ultimately led to the excess production of infectious BMW that could not be effectively segregated, handled, treated and disposed due to insufficient and poorly trained staff. More or less, the same situation was prevalent in GH. JIPMER is one of the leading medical institutions of India. It has excellent Super specialty departments of Neurology, Cardiology, Neurosurgery, Cardiothoracic Surgery, Clinical Immunology, Urology & Neonatology, Clinical Pharmacology, Clinical Haematology and Surgical Gastroenterology and major surgical units and therefore, most of the surgeries are conducted at JIPMER and most of the patients treated belong to low socio-economic group. Therefore, the daily BMW load of 786±67.6 kg/day and infectious waste load of 180.2±14.2 kg/day from JIPMER is due to the increased number of beds/patients.

The percentage of infectious waste at all selected HCFs in Puducherry (30.3%) was much higher than that of Netherlands (5%), Sweden (9 %) Germany (14%), equal to that of Denmark (25%) USA (28%) and lower than that of Philippines (63%) (Monreal, 1991; Rahman et al., 1999; Asian Development Bank 2003). In India, infectious

waste ranged from 15% to 35% of the total BMW (BAN and HCWH 1999; Glenn and Garwal, 1999). The higher infectious waste fraction in India reflects the lack of pre cautionary measures adopted in HCFs. These data indicate that the target should be to minimize the infectious waste stream for working towards the waste minimization strategies.

People handling the BMW should wear special clothes, shoes, gloves, etc. as suggested by several workers to prevent the spread of nosocomial infections, while such recommendations were rarely adopted in the HCFs studied (Pruss et al., 1999; Alago and Kocasoy, 2008). Thus, the waste handlers are exposed to very high level of risks for dangerous diseases. Several earlier workers reported that BMW handlers often got injured while handling BMW containing hazardous wastes, such as used needles, sharps putting them at risk of dangerous diseases (Pokrovskii et al., 1990; Hersch et al., 1991; Pruss et al., 1999; Mast et al., 1999; Askarian et al., 2004a; Askarian et al., 2004b; Marinkovic et al., 2005; Wilburn and Eikemans, 2005; Rasheed et al., 2005; Mbongwe et al., 2008; Verma et al., 2008). Sharps should be disinfected in a solution of bleach and deformed/crushed before placing them in a metal box which when full, is to be put into a rigid, leak-proof, puncture-resistant container (Alagoz, and Kocasoy, 2008b; Coker et al., 2009). The container must be specially labeled as infectious wastes, ultimately to be incinerated (Treasure and Treasure 1997, Punchanawat et al., 1998, Alagoz and Kocasoy, 2008b). However, sharps were not being collected and disposed at all HCFS studied as required by the regulation, leading to injuries during collection and transportation.

HCFs have a duty of care for the public health and for environment, and have particular responsibilities in relation to the waste they produce (Hsu *et al.*, 2007; Gupta *et al.*, 2009; WHO, 2011). The onus is on such facilities to ensure that there are no adverse health and environmental consequences of their waste handling, treatment, and final disposal activities (Pruss et al., 1999; Patil and Pokhrel, 2005).

It is important that the HCFs have to improve their hygiene and sanitation by adopting adequate safety and precautionary measures for handling/treatment/disposal of BMW as suggested by several workers to prevent /reduce nosocomial infections (Askarian et al., 2004a; Patil and Pokhrel, 2005; Soliman and Ahmed, 2007). To facilitate this, BMW disposal should be supported through appropriate education, training and the commitment of the healthcare staff, management and healthcare managers within an effective policy and legislative framework.

Conclusions

The existing rules have to be revised based on the international WHO standards (Pruss et al.1999). For instance, there is no rule pertaining to using protective gloves, masks, and the need for (Tetanus Toxoid) injections. The central and state pollution control board had not been able to strictly enforce the legal provisions and make healthcare establishments legally responsible for the safety of all concerned. The present study reveals a serious need to disseminate and strictly implement BMW (Management & Handling) Rules, 1998 to control and improve the current situation in Puducherry region.

The management at all selected HCFs exhibited a careless attitude and the collection, handling, transfer and transport to the final disposal site is being conducted in a manner that poses serious health challenges. The persons responsible for the handling of BMW were not adequately trained and equipped and did not realize the potential dangers associated with these wastes. The containers used for the transportation of BMW were usually old and corroded and without lids. Due to poor management of BMW in Puducherry, it was observed that at all the selected HCFs, no proper segregation plan was followed for either incineration or proper dumping at a lone landfill site in the Karuvadikuppam dumping yard. Insufficient segregation, no color coding of bags and inadequate/no treatment of waste were noted at all the HCFs. BMW was dumped and mixed with domestic waste, which was collected, transported and disposed off in a similar manner as general municipal solid waste. Therefore, proper containers with prescribed color coding system were needed in all selected HCFs /wards to prevent mixing of wastes. Appropriate segregation and collection of sharps and needles in rigid, puncture-proof containers that are then subject to prescribed treatment and disposal methods should be on high priority. It is very important to segregate the waste before treatment and disposal which will help to identify hazardous and potentially infectious waste. Segregation should be done at the point of waste generation and this can be achieved through proper training, cleanliness standards and tough enforcement.

Awareness, education and training initiatives should cover everyone concerned with BMW management. Adequate budget allocation for this activity is the need of the hour. Media should be used effectively to create awareness among the general public. The Puducherry Pollution Control Committee has to enforce the legal provisions and make HCFs legally responsible for the safety of all concerned. The private sector should be encouraged to enter into BMW management to increase the capacity and effectiveness of the disposal and recycling of waste. A treatment and disposal facility located away from the city is most suitable. The facility should overcome

the difficulties faced by individual HCFs and also meet the statutory requirements. Disposal sites should be separate and properly secured so that no animals can access them. Such a Common Bio-Medical waste Treatment Facility, has been recently established at Thuthipet village (20 Kms from Puducherry city) by M/s Pondicherry Solid Waste Management Company Pvt. Ltd that started its operations by July 2011. This unit has installed an incinerator with 30 m chimney, autoclave, shredder and compacter to dispose the Bio-Medical Waste with a wet scrubber as the Air Pollution Control System. The scrubbed water is let out into the Effluent Treatment Plant (ETP) and Constructed ETP with aerator and final discharge after RO treatment. Adequate greenbelts have been developed around the vacant site of the facility. So far, 93 Health Care Facilities (HCF) including Clinical Laboratories have entered agreements with this facility for disposal of their Bio-Medical waste. 24 pharmaceutical industries also entered agreement with this facility for disposing their date expired medicines.

Recommendations

Keeping the above facts in mind, the following management strategies are suggested to overcome the problem of improper handling/disposal of BMW in Puducherry region.

- Segregation of BMW should be done at the sources of generation (as per the categories mentioned in the prescribed rule. ii.)
- The transportation of BMW is to be done through designated vehicles specially constructed for the purpose.
- Proper treatment of different wastes is to be done after the segregation.
- All the generators of BMW should adopt universal precautions and appropriate safety measures while doing the therapeutic and diagnostic activities and also handling the BMW.
- Periodic training should be imparted to all the categories of medical staff and other BMW handlers, such as municipal waste loading workers, lorry driver and rag pickers in appropriate language / medium and in an acceptable manner.
- The annual reports, accident reports as required under BMW rule should be submitted to the concerned authority as per BMW Rule.
- Establish effective and sound recycling policy for plastic recycling and get in touch with authorized manufacturers.
- There should be co-ordination between hospitals and outside agencies or non- government organizations.
- A new diploma course in BMW Management in local language may be offered. This course must be more practical oriented rather than theoretical and candidates must be directly exposed to the problem.
- Each HCFs depending upon the size must have a team of qualified/dedicated persons who are capable of managing BMW. Large/major hospitals must have an infection prevention and control team as is the case now in few leading hospitals in India. All the hospitals /biomedical labs (either big or small) have to send their BMW to the CBMWTF at Thuthipet village.
- All HCFs generating any kind of waste must be registered and regularly monitored by a Government agency.

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