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A study of Hazardous and Non Hazardous Biomedical waste generated in the hospitals of Alwar city, India

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Abstract

Serious concerns over issues pertaining to bio medical waste management have been vocalized all around the globe in recent years. The first step in any waste management plan is the estimation of the amount of waste generated. Alwar city which is progressing steadily in the health sector thus suffers from the challenges put forward by the increasing amount of waste generated as a byproduct from these developing health care facilities. As such a scientific study on bio medical waste is the need of the hour. For our present study five major multi-specialty hospitals of the city were selected. All the selected five hospitals had a well-maintained record of bio medical waste generated, a compulsion as per the BMW rules 2016. So after a written permission biomedical waste generation raw data was sourced from the management of concerned hospitals which was then depicted as kg bed^{-1} day^{-1} to be presented in a scientifically acceptable value, next to determine the statistical significance of the chosen two variables i.e. number of patients and beds on the quantity of waste generated,statistical tool ANOVA was applied. The mean biomedical waste generated in 2021 was .79 kg bed^{-1} day^{-1}, of this hazardous biomedical waste had a mean value of .358 kg bed^{-1} day^{-1} and non hazardous waste mean value was .432 kg bed^{-1} day^{-1}, the ANOVA test gave a P value of .107. The results highlight that in the public hospitals waste management practices are followed more cautiously, because of which the amount of hazardous waste generated was lower than private hospitals, in the statistical test ANOVA the p value ($P < 0.05$) was observed emphasizing the dependence of waste generation rates on the above chosen variables.

Key words : Biomedical waste management; public; private hospitals; Alwar city; number of patients; beds; quantity of waste generated.

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The most indisputable agenda after the COVID-19 pandemic all over the world is improvements in the "Health Industry". Governments all over the world are improvising on various methods to modernize and improve the standards of health care services, but this has also led to the generation of tons of biomedical waste (BMW) that has adverse effects on human health and environment. Strict scientific management of BMW should be ascertained in the hospitals to minimize the quantity of BMW to reduce its harmful effects[7]. BMW has been categorized as a special waste due to its broad range of composition and also because of its infectious and hazardous nature (though only 10 to 25 percent of BMW falls in the above category). Since BMW is not an ordinary waste, an increasing number of strict waste disposal regulations are being imposed all over the world and strategic planning and monitoring is being done for the continuous improvements in waste generation, handling and disposal techniques[20]. Biomedical waste management (BMW M) starts from the point of its generation to its final disposal. The problem of BMW M has more so been recognised in developing nations as already they are resource constrained, lack technological advancements and have financial implications, further aggravating the issue. A survey conducted by International Clinical Epidemiology Network in 25 districts of 20 states of India has highlighted that only Chennai and Mumbai follow sustainable BMW M practices and overall the management of BMW in India is masked by shadows of unawareness. The quantum of BMW generated depends on the available infrastructural facilities, location of health care facility, number of patients and available beds[4]. Lacunae in the quantity of BMW generated exists as in most of the studies an estimation of the BMW generated is project based, still others do not clearly state the details of the basis of estimation of BMW generation rates[12]. Also data of ward wise generation of BMW is missing in most of the studies. In India BMW generation rates have been defined as .5 - 1.50 kg / bed / day[5]. Very few studies in developing countries are related to BMW generation rates, pretreatment and final disposal methods followed by qualitative estimations of the effects of disposed BMW. Thus in our study we have tried to assess the quantity of hazardous and non hazardous BMW generated in the selected five hospitals of our city Alwar depending on the infrastructural facilities and available beds and have presented our results as kg bed^{-1} day^{-1}, since BMW generated is calculated as kg bed^{-1} day^{-1}. For this, in our study we have applied the descriptive statistical methodology for calculating mean values after which statistical tool ANOVA using Microsoft Excel is used to emphasize the significance of both the above variables on the BMW generation rates. It is essential to analyze the quantity of BMW generated, because this is the first step in the management of the waste disposal system. An effective waste management system relies on the principles of waste minimisation which in the health care sector can be switching to use of reusable items rather than disposable medical devices.

As per the US EPA, medical waste is the 3rd largest emitter of dioxins and in the present scenario it is recognized as the 2nd most hazardous and potentially infectious waste. Realizing the hazardous potential of waste generated from HCFs in polluting the environment and consequently adversely affecting human beings, animals and plants strict legislations were framed globally by both developing and developed countries for its handling and disposal[1]. The emergent economies follow three strategies for BMW M: first framing harsh legislations, second practising robust management practices and third using novel scientific technologies for the safe and secure disposal of BMW[18]. On the other hand in emerging economies legislations are framed but are not harshly implemented, maybe due to resource crunch and lack of budget allocations, the management of waste is by and large in the hands of illiterate and untrained cleaning staff which most of the time are temporarily appointed and so unaware about the hazards of improper BMW M, the problem is further aggravated by the lack of any waste handling committee being appointed in these countries[2,17]. Thus the governments across the globe through BMW M rules plan to mitigate the influence of bio medical waste (BMW) in the society but these provisions still require a great deal of efforts and high level of scientific temperament for their implementation and the overall scenario of BMW handling and its disposal especially in emerging economies is grim and needs improvements[6]. BMW has become a major concern because of its increasing volume and simultaneous increase in its mismanagement[16]. The amount of infectious waste depends on how effectively waste is segregated, which is totally dependent on the awareness of the BMW handling staff. To emphasise this concept it is important to highlight that the quantity of BMW generated in developed countries is about 1.2 – 200 tonnes more as compared to the developing countries but the percentage of infectious waste is about 51 % in developed countries as compared to 63 % in developing countries[6,9]. The main issue dealing with BMW is not its generation because this is unavoidable but it is the quantity and composition of BMW that is a matter of grave concern since it varies from hospital to hospital depending on the type of facility it provides and most importantly the practices it follows in the waste management. Thus BMW M needs special attention. 2.4 billion tons of BMW is produced annually worldwide; which needs to be sustainably handled meaning dealing with its hazardous nature in an enviro friendly and budget favourable manner. To accomplish this agenda when the cost was calculated, some staggering figures came as a blow, as an approximate expenditure of $11.77 billion were spent in 2018, which is likely to rise upto $17.89 billion in 2026; an annual compound increase in expenditure rates for BMW management comes as 5.3% These figures are well above the annual incomes of many poor nations of the world (R&D reports and data, 2020). To emphasize BMW M is a multifaceted procedure, involving a wide range of issues and stakeholders. So, for a sustainable BMW M practice a myriad of principles, policies and practices should be considered, subjected to revisions with time and experience[3,8].

BMW M in Alwar city :

With evenly spreaded, adequate medical facilities existing in the city, the BMW produced too needs systematic management. As such we attempted to examine the BMW M facilities present in the city. There is a CBWTF located in the MIA area of Alwar, where by and large all the medical centers of the city are registered, however authorised permission to avail the CBWTF has only been granted to 83 health care centers out of the total 153 registered, apart from this facility 12 medical care centers have been granted permission for using in- situ disposal facility for final waste disposition, this makes a total of 95 out of the 153 registered HCF *i.e.* 62% of the health care centers are following the principles of BMW M as per the rules. (The numerical data of HCF's has been procured from the Rajasthan State Pollution Control Board RPSCB, annual report 2021). Thus the BMW, however negligible in quantity which is produced by the remaining registered HCF's, possibly is dumped along with the municipal solid waste.

Objective :

The general objective of the study was:

To express and analyze the quantity of hazardous and non hazardous BMW generated in terms of kg bed^{-1} day^{-1}.

To determine the functional significance of the waste generated with the number of patients and available beds in the chosen five hospitals of Alwar city, Rajasthan, India based on the observed P value. (P value < 0.05 was used as a cut point to determine the significance of the two independent variables on the dependent variable *i.e.*, BMW generation rate).

Sample :

The study has been conducted in a sample of five hospitals of Alwar city. Out of these five selected hospitals three are from public domain and two are from private domain. All the selected five hospitals have been coded as A, B, C, D, E and have necessary health care infrastructures catering to the needs of their patients.

Data collection and analysis :

Secondary data collection strategies were adopted for our study which included observations during physical visits, discussions related to BMW M practices and meetings with the hospital management to procure official data regarding BMW generation. Prior permission from the CMHO of a public hospital was taken to retract data from their management department, for procuring data from a private hospital the head of the hospital was contacted after which the waste manager handed over the data. Raw data on the amount of hazardous and non hazardous BMW generated in each hospital for one year, number of patients and number of beds was then converted into scientifically acceptable form by dividing the quantity of hazardous BMW generated to number of patients treated. To find a functional relationship between hazardous BMW, patients and beds a two-way ANOVA; analysis of variance was done using Microsoft excel.

Data about patient inflow and BMW generated: The number of out patients (OPD) and in patients (IPD), hazardous, non hazardous and total BMW generated all were tabulated , their mean values were calculated and then from this data BMW generated in kg / patient / day was calculated. A total of 3,25, 425 patients were treated in the selected 05 hospitals in the year 2021 - 22. Out of these 1,06,969 were OPD patients (app. 33%), rest IPD *i.e.* 2,18,456. The total amount of BMW generated during the tenure was 2,89,875.7 kg of which hazardous BMW was 1,26,534 (app. 44%). The results are shown in the tables 1-5 and Figs. 1-5.

Table-1. Total amount of BMW generated during the period Dec 2021 - Dec 2022

Hospitals	H BMW generated (in Kg)			TH BMW (in Kg)	TNH BMW (in Kg)
	Yellow	Red	Blue		Black
A (public)	46598	12495	5359	64452	153519
B (public)	16945	6895	3082	26922	59808.9
C (public)	1970	847	51	2868	7113.85
D (private)	12820	4865	356	18041	39040.4
E (private)	9974	3975	302	14251	30393.55

Of the Total amount of hazardous BMW produced 70% (88,307 kg) was of yellow, incinerable waste, 23% belonged to the red category waste *i.e.* plastic reusable medical items (after autoclaving at the CBWTF) and the remaining was the blue category waste *i.e.* glass & metal waste.

Table-2. Highlights the mean values (kg / day) for the different categories of hazardous BMW generated

Hospital	Y BMW	R BMW	B BMW	mean H BMW kg / day
A	3883	1079	447	180.3
B	1412	575	257	74.8
C	164	71	4	7.96
D	1068	405	30	49.9
E	831	331	25	39.8

Y BMW = Yellow bag (incinerable Biomedical Waste)
R BMW = Red bag (infectious plastic Biomedical waste, which after sterilisation can be recycled)
B BMW = Blue bag (glass items used in medical care)

Table-3. Depicts the mean values for patients flow (per day) and non hazardous BMW generated in kg / day

	Patient flow / yr	Av patient / day	Av NH BMW kg / month	Av NH BMW kg / day
A	135386	376	7213	240.3
B	97160	266	2672	89.06
C	18505	51	346	11.53
D	36938	101	1712	57.06
E	37436	103	1304	43.47

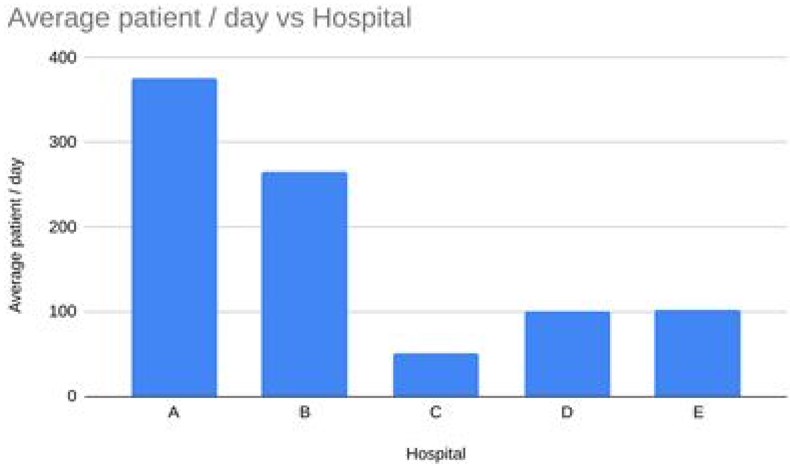

Figure 1- shows the average patient inflow per day in the selected hospitals.

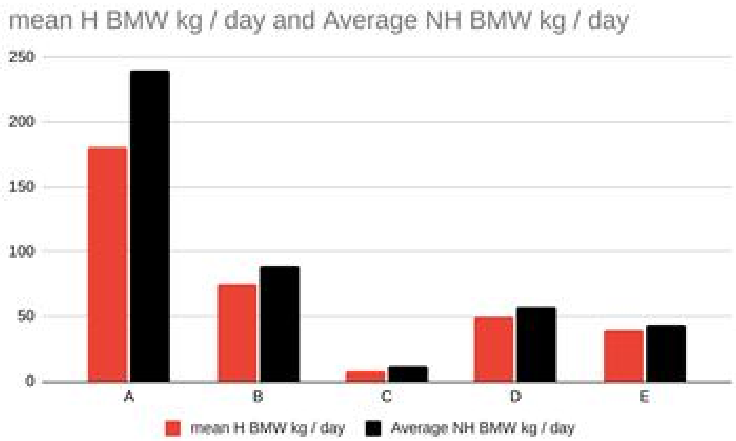

Figure 2- depicts the mean values of H BMW & NH BMW in the selected five hospitals.

Table-4. highlights the BMW generated in kg / day / bed.

Hospital	Av patient/ day	AvT BMW kg / day	BMW /day / bed
A	376	420.6	1.11
B	266	163.86	0.61
C	51	19.49	0.38
D	101	106.96	1.05
E	103	83.27	0.80

Table-5. Shows the mean values for H & NH BMW in kg / day / bed.

Hos-pital	Mean BMW kg / bed / day	Mean H BMW kg / bed / day	Mean NH BMW kg / bed /day
A	1.11	0.47	0.64
B	0.61	0.28	0.33
C	0.38	0.16	0.22
D	1.05	0.49	0.56
E	0.8	0.39	0.41
Total mean	0.79	0.358	0.432

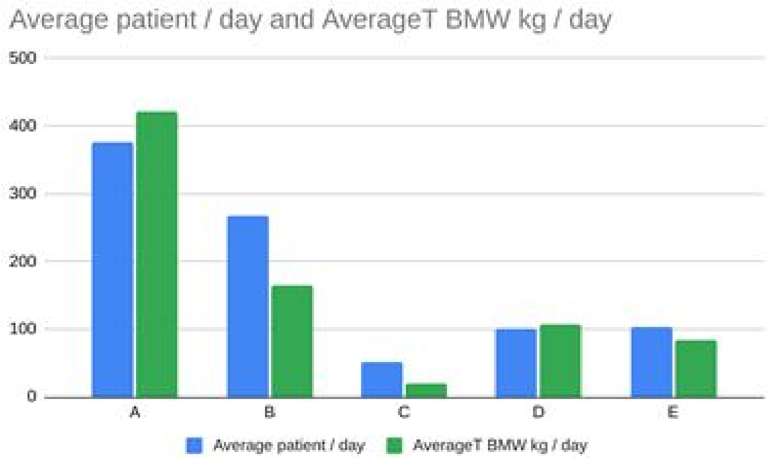

Figure 3- presents a comparison of the average patients / day & the T BMW produced / day.

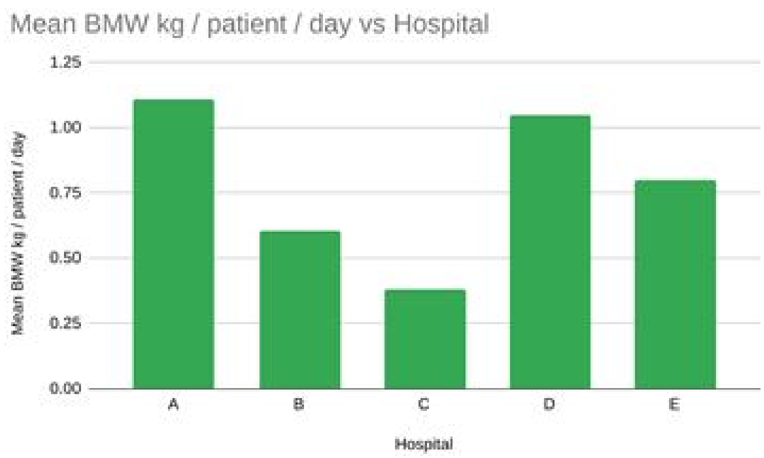

Figure 4- depicts the mean BMW produced in terms of kg/patient/day.+

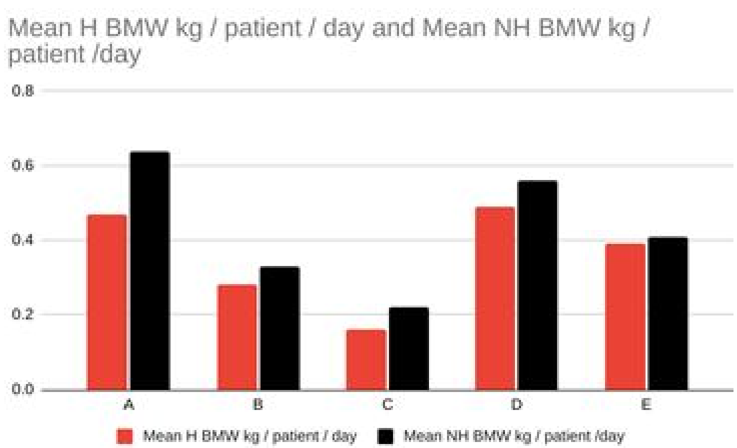

Figure 5 - shows a comparison of the average H & NH BMW produced in terms of kg/ patient/day.

Before starting our discussions on BMW management, it is worthwhile to briefly mention the color coding of BMW - black, yellow, red and blue are the different kinds of waste categories. Black bags contain general hospital waste, yellow bags include infectious and hazardous waste, red color bags contain contaminated waste which is recyclable and blue bags include broken or discarded and contaminated glass. Black bags are same as municipal waste; yellow, red and blue bags are sent to CBWTF for their final disposal where yellow bag waste is incinerated, red bag waste is recycled and or mutilated, blue bag waste is also recycled to authorized recyclers and or discarded; rest left hazardous waste is incinerated.

The total amount of hazardous waste generated in the city for the year 2021 was 2,78,860 kg (data sourced from RSPCB, annual report) of this 1,26,534 kg i.e. 46% was generated by the selected 05 hospitals thus highlighting the importance of these 05 hospitals in the medical care they are providing to the city dwellers. **The mean BMW generated in 2021 was .79 kg bed^{-1} day^{-1}**, of this hazardous BMW had a mean value of .358 **kg bed^{-1} day^{-1} and non hazardous waste mean value was .432 kg bed^{-1} day^{-1}.** The earlier studies by [4,12]. had stated that the amount of BMW generated in India ranges from .5 - 1.6 **kg bed^{-1} day^{-1} of which** hazardous BMW ranges from .1- .5 kg bed^{-1} day^{-1}. Since 70% of the hazardous waste generated was yellow incinerable waste, for which it is generally accepted that after incineration the ash released is 8 to 9 % of the total quantity that was incinerated, thus on calculating this comes to be 7,065 kg / yr for the selected 05 hospitals. This ash can be in the form of bottom ash or fly ash and it can be hazardous, non hazardous or inert. Keeping the nature of ash aside, the final disposal method for BMW ash is land filling but in our study we found the open dumping of ash which as per BMW M rules is not at all acceptable as BMW ash has been included in the hazardous waste material list (EPA, 2003). Also because of limited land resources and socio economic issues alternate technologies for the reutilisation of this ash should be considered *i.e.* using this ash with concrete for constructing roads, microbial treatment of ash to convert it into non hazardous, friendly manure[15]. When ANOVA test was conducted to determine the relationship between the two variables *i.e.* number of patients and available beds on the quantity of hazardous waste generated, a P value of 0.107 was obtained, which is greater than 0.05 our cut value taken. Thus our null hypothesis (H_0) which states that the number of patients and beds influence BMW generation holds true. This is also in accordance with the earlier results of Sabour *et al.*,[16] and Tsakona *et al.*,[19].

The quantity of hazardous BMW generated for the selected three government hospitals has a mean value of 0.303 ± 0.16 kg per bed^{-1} per day^{-1}, whereas it is on a higher side for the private hospitals with a mean value of 0.44 ± 0.07 kg per bed^{-1} per day^{-1}.

Public hospitals are more aware and follow scientific practices for BMW management as compared to private hospitals. Proper segregation of waste results in lowering the quantity of hazardous waste. Private hospitals may, due to financial implications, follow a less scientific method of BMW management.

The ANOVA test shows an F value of 2.70 and P value of 0 .107 which is greater than 0.05 our cut value taken. Thus, our null hypothesis (H_0) which states that the number of patients and beds influence BMW generation holds true.

Limitations

The first limitation of the present study is that the sample consists of only five hospitals. Second, the primary source of data collection is based on the data provided by the hospital staff for which no physical verification was done. This method might not be accurate as manipulations in data are possible to lessen the financial costs of managing BMW as per BMW rules 2016 and open burning /dumping of BMW could be a possibility. However, we have tried our best to make the required data authentic. Finally, BMW management in our study is solely based on efforts done by human resources which in itself is incomplete as management should consider financial and operational costs and other streams of sciences should also be applied for safe management of BMW.

Abbreviations

ANOVA: Analysis of variance (a statistical tool), BMW: Biomedical waste (the waste that is produced during any type of medical care), BMW M: Biomedical waste management (the quantification, collection, storage and transportation of waste for final disposal), CBWTF: Common Biomedical Waste Treatment Facility (an authorised site where hazardous biomedical waste collected from registered hospitals is brought for final treatment and disposal), CMHO: Chief medical health officer, H BMW: Hazardous biomedical waste (a portion of biomedical waste which is infectious and pathogenic), HCF: Health care facility (hospitals, clinics dispensaries, diagnostic centers), IPD: Inpatients department (patients admitted in the hospital for treatment), NH BMW: Non hazardous Biomedical waste (paper, cardboards and hospital kitchen waste), OPD: Outpatients department (non admitted patients), T BMW: Total Biomedical waste (includes hazardous and non hazardous biomedical waste), US EPA: United States Environmental Protection Agency.

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