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Original Research Article

# Biomedical waste disposal practices among healthcare workers during COVID-19 pandemic in secondary and tertiary care facilities of Tamil Nadu

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ABSTRACT

*Purpose:* The ongoing COVID-19 crisis has drastically changed the practice of biomedical waste (BMW) generation and management. Studies venturing into the facility level preparedness at various levels of healthcare delivery during pandemic situation is the need of the hour. Hence, we did this study to assess the BMW disposal practices amongst secondary and tertiary health facilities during COVID-19 pandemic in Tamil Nadu.

*Materials and methods:* This cross-sectional survey was conducted amongst doctors, nurses and allied healthcare staffs across various departments in 18 public health facilities across six districts of Tamil Nadu. Multivariable logistic regression analysis was done based on the random-intercept model to assess the determinants of BMW disposal practices. The effect size was reported as adjusted odds ratio (aOR) with 95% confidence interval (CI).

*Results:* In total, 2593 BMW disposal observations were made. During nearly three-fourth of the observations (73%), the BMW was disposed of appropriately. Nurses (aOR = 1.54; 95%CI: 1.06–2.23) and doctors (aOR = 1.60; 95%CI: 1.05–2.45), healthcare workers in Paediatrics department (aOR = 1.77; 95%CI: 1.13–2.76), healthcare workers in inpatient department (aOR = 2.77; 95%CI: 1.95–3.94) and injection outpatient department (aOR = 2.69; 95%CI: 1.59–4.47) had significantly better odds of having appropriate BMW disposal practices.

*Conclusion:* Our study shows that nearly during three-fourth of the observations, healthcare workers performed appropriate BMW disposal practices. However, measures should be taken to achieve 100% compliance by healthcare workers especially the target groups identified in our study by allocating appropriate resources and periodically monitor the BMW disposal practices.

## 1. Introduction

Wastes generated in health care facilities are often regarded as the most hazardous form along with the radiation wastes [1]. Healthcare wastes are unique in generation, composition, handling and disposal [2,3]. Improper management of healthcare wastes can prove detrimental not just for the operators and waste handlers but also for the general public. Improper disposal of hazardous healthcare wastes can result in several hospital-acquired and blood-borne infections and poses serious occupational hazards [4–6].

Biomedical waste (BMW) refers to "any waste including solid or liquid generated as a final or intermediate product generated during diagnosis, treatment, or research on animals or human beings" [7]. Disparities in knowledge and practice towards BMW management across the globe, even amongst the healthcare personnel, has emerged as an important challenge in patient safety and hospital management. Limited interest and priority, lack of formal training and surveillance by the hospital administration has further heaped on this challenge [8]. With around 1.6 million health care workers employed in more than 28,000 health facilities, India is never an exception to this challenge [9]. Data suggest that approximately around 2 kg of biomedical wastes are generated per bed per day in India [10].

WHO has proposed the core principles to achieve such safe & sustainable BMW management in the year 2007. The proposal has stressed up on the necessity of right investment in resources with complete commitment to reduce level of harmful effects for the people and environment due to BMWs [11]. WHO also released the second edition of "The Blue Book" in the year 2014, adopting newer practices compared to the first edition published in 1999 [11]. Government of India has also released the first BMW management guidelines around the same timeline (in the year 1998), which was subsequently amended in 2000, 2003 and 2011 [12,13]. The latest BMW management

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guidelines was published in the year 2016 [14]. Despite these, vast majority of the health facilities in India fail to operationalize the existing BMW management guidelines.

In addition, the ongoing COVID-19 crisis has drastically changed the practice of BMW generation and management. Everyone has started using various forms of PPE. Masks, gloves, face shields, visors, full body suits, and splash-proof aprons, are available for use to general public also [15]. The waste generation is bound to increase due to such practices and hence, the assessment of BMW practice is essential more than ever to determine whether the public health facilities are in line with the standard guidelines and has the ability to withstand the paradigm shift during the ongoing COVID-19 crisis. Although several studies have explored the attitude and practice of healthcare workers towards BMW management, majority have focused only on the private sectors, older guidelines and only tertiary care institutions [16–18]. Studies venturing into the facility level preparedness at various levels of healthcare delivery during pandemic situation is the need of the hour. To bridge this knowledge gap, we did this cross-sectional survey to assess the BMW disposal practices amongst secondary and tertiary care institutes during COVID-19 pandemic in Tamil Nadu, South India.

## 2. Methods

### 2.1. Study design and setting

This cross-sectional survey was conducted as a part of large-scale mixed methods study on patient safety practices across public health facilities in Tamil Nadu. Healthcare services in the state of Tamil Nadu are provided by a three-tier structure delivery system. We have conducted this survey amongst secondary and tertiary care facilities in Tamil Nadu.

### 2.2. Sampling strategy

A two-stage stratified random sampling was performed for the selection of public health facilities (Supplementary Fig. 1).

#### 2.2.1. Stage 2

In the first stage, all the districts were stratified into three categories (low, medium and high) based on their human development index (HDI) scores [19]. The HDI was chosen to stratify the districts because its indicators reflected the key demand-side factors that explain health status, healthcare seeking behaviour, and service consumption. Two districts from each of these strata were selected randomly. Selection of districts was done randomly using lottery method.

#### 2.2.2. Stage 2

In the second stage, a total of 18 public health facilities were selected covering the secondary and tertiary care levels of healthcare delivery. The selected facilities were 6 tertiary care hospitals/medical colleges in each selected district, 12 Government Hospitals (two GHs from each district) summing up to 18 public healthcare facilities in Tamil Nadu (Supplementary Table 1).

### 2.3. Sample size

Sample size was calculated based on the assumption that at least 20% of the observations will be non-compliant to appropriate BMW disposal practices, 10% relative precision and design effect of 1.75, the minimum number of BMW disposal opportunities to be observed will be 2685 (to round it off and gather equal number of observations across each facility, the required sample size was 2700 observations). Since we have a sample of 18 facilities, we must observe 150 BMW disposal opportunities from each facility ($150 \times 18 = 2700$).

### 2.4. Data collection process

Research assistants were recruited as data collectors for this survey. Before starting the data collection process, a week-long training was provided to familiarize them on data collection methods, tools, and the observations at the facility level. The research assistants were then asked to conduct a direct non-participant structured undisguised observation of the BMW disposal practices by healthcare professionals.

HCWs of varying cadres such as doctors, nurses, laboratory technicians, pharmacists were observed from the selected secondary and tertiary care facilities. The observations were done in the following departments: General Medicine, General Surgery, Obstetrics & Gynaecology, Orthopaedics and Paediatrics. In each of these departments, the observations were conducted in the out-patient department (OPD), in-patient department (IPD), injection OPD, Procedure room and intensive care unit (ICU). The data collection process was monitored periodically by the Principal Investigator and Co-Investigators.

Observation checklists were made after consensus with the subject experts and literature search. The observation was considered as appropriate BMW disposal practice if the wastes were disposed of in the appropriate colour coded bins as per the latest BMW management guidelines (Supplementary Table 2) [13]. Information related to BMW management practices such as presence of separate BMW committee, standard operating procedures, training and management facilities were also obtained in the individual facilities as part of the patient safety study.

### 2.5. Statistical analysis

Data was entered into EpiCollect5, and analysis was performed using STATA software version 14.2 (StataCorp, CollegeStation, TX, USA). Continuous variables were summarized as mean and standard deviation (SD) and categorical variables as frequency and percentages. Outcome variable (appropriate BMW disposal practice) were reported with 95% Confidence Interval (CI). Appropriate BMW disposal practice was considered as the dependent variable and type of HCWs, department, section of the department, BMW management practices in the individual facility were considered as explanatory variables. Logistic regression model was done to assess the determinants of appropriate BMW disposal practices. Factors with p-value less than 0.20 in the univariable analysis were included in the multivariable analysis.

Multilevel modelling was performed to adjust for the multiple levels involved in the sampling strategy. The effect of clustering at the level of healthcare facility was evaluated using a random-intercept model [20]. Likelihood ratio test (LR test) was done to compare this model with the naïve model (the final model in multiple logistic regression). Multivariable logistic regression analysis was done based on the random-intercept model for the outcomes reporting significant LR test. The effect size was reported as adjusted Odds Ratio (aOR) ratio with a 95% confidence interval. Variables with p-value less than 0.05 were considered statistically significant.

## 3. Results

In total, 2593 BMW disposal observations were made across the surveyed healthcare facilities. Majority of the observations were made amongst the nurses (66.3%) followed by doctors (22.2%) and other allied staffs (11.5%). More than half of the observations were made in general medicine department. Almost half of the observations were made in IPD (44.7%) followed by general OPD (28.3%) and injection OPD (19.2%) (Table 1).

Majority of the facilities (15 out of 18 facilities – all 6 surveyed medical colleges and 9 GHs) had a separate BMW management committee. Regarding the BMW practices, all the 18 facilities provide PPE for BMW handlers, BMW storage facility and availability of bins and trolleys

**Table 1**
Biomedical waste management observations across public health facilities in Tamil Nadu (n = 2593).

| Characteristics | Categories | Frequency (%) |
|---|---|---|
| Designation | Doctor | 575 (22.2) |
| | Nurse | 1719 (66.3) |
| | Other allied staffs[a] | 299 (11.5) |
| Department | General Medicine | 1611 (62.1) |
| | General Surgery | 272 (10.5) |
| | Obstetrics & Gynecology | 276 (8.8) |
| | Pediatrics | 260 (10.0) |
| | Orthopedics | 224 (8.6) |
| Division | Outpatient department | 734 (28.3) |
| | Inpatient department | 1159 (44.7) |
| | Injection OPD | 498 (19.2) |
| | Procedure room/Operation theatre/Intensive care unit | 202 (8.0) |
| Districts & Hospital | | |
| Tirunelveli | Tirunelveli Medical College | 150 (5.8) |
| | Government hospital, Ambasamudram | 154 (5.9) |
| | Government hospital, Tenkasi | 146 (5.6) |
| Tiruchirappalli | Tiruchirappalli Medical College | 140 (5.4) |
| | Government hospital, Srirangam | 100 (3.9) |
| | Government hospital, Musiri | 150 (5.8) |
| Salem | Government Mohan Kumaramangalam Medical College | 148 (5.7) |
| | Government hospital, Omalur | 154 (5.9) |
| | Government hospital, Attur | 197 (7.6) |
| Pudukkottai | Government Medical College, Pudukkottai | 150 (5.8) |
| | Government hospital, Ilupur | 150 (5.8) |
| | Government hospital, Aranthangi | 151 (5.8) |
| Villupuram | Government Medical College, Villupuram | 151 (5.8) |
| | Government Hospital, Vikravandi | 145 (5.6) |
| | Government Hospital, Tindivanam | 146 (5.6) |
| Theni | Government Medical College, Theni | 63 (2.4) |
| | Government Hospital, Bodinayakanur | 149 (5.7) |
| | Government Hospital, Periyakulam | 149 (5.7) |
| Whether BMW was disposed of appropriately during the observation | Yes | 1893 (73.0) |
| | No | 700 (27.0) |

[a] Laboratory technicians, pharmacists.

for transporting of BMW. Majority of the facilities (15 out of 18) had SOP for BMW practices, conducted training for staffs on BMW practices (14 out of 18), mechanism for reporting needle stick injuries to the hospital administration (14 out of 18) and linkage to common treatment facility (13 out of 18).

During nearly three-fourth of the observations (73%), the BMW was disposed of appropriately. Table 2 shows the determinants of appropriate BMW disposal practices amongst HCWs in public healthcare facilities of Tamil Nadu. First, we checked the clustering at the level of healthcare facility and found a significant LR test ($p < 0.001$), depicting a significant effect of clustering at the facility level on the BMW disposal observations. Intra-class correlation coefficient (ICC showing between cluster variability) was found to be 0.20. Hence, the logistic regression was run with a random intercept model at healthcare facility level.

In the unadjusted analysis, designation, department, section of department, presence of separate committee and SOP for BMW management were significant determinants and all of these factors were included in the adjusted analysis. In the multivariable model, designation, department and section were statistically significant. Nurses (aOR = 1.54; 95%CI: 1.06–2.23) and doctors (aOR = 1.60; 95%CI: 1.05–2.45) had significantly better odds of having appropriate BMW disposal practices when compared to other allied healthcare staffs. HCWs in Paediatrics department had significantly higher odds of complying to appropriate BMW disposal practices (aOR = 1.77; 95%CI: 1.13–2.76) when compared to HCWs in General Medicine department. HCWs in IPD (aOR = 2.77; 95%CI: 1.95–3.94) and Injection OPD (aOR = 2.69; 95%CI: 1.59–4.47) had significantly better odds of having appropriate BMW disposal practices when compared to HCWs in general OPD.

**Table 2**
Determinants of appropriate BMW disposal practices amongst HCWs in surveyed public healthcare facilities of Tamil Nadu (N = 2593).

| Characteristics | Total, N | Appropriate BMW waste disposal, n (%) | Adjusted Odds Ratio[c] (95%CI) | P-value |
|---|---|---|---|---|
| **Designation** | | | | |
| Nurses | 1719 | 1292 (75.2) | 1.54 (1.06–2.23) | 0.02[a] |
| Doctors | 575 | 395 (68.7) | 1.60 (1.05–2.45) | 0.03[a] |
| Other allied staff[b] | 299 | 206 (68.9) | Ref | – |
| **Department** | | | | |
| General Medicine | 1611 | 1112 (69.0) | Ref | – |
| General Surgery | 272 | 213 (78.3) | 1.20 (0.79–1.81) | 0.40 |
| Obstetrics & Gynaecology | 276 | 169 (74.8) | 1.29 (0.85–1.96) | 0.23 |
| Paediatrics | 260 | 219 (84.2) | 1.77 (1.13–2.76) | 0.01[a] |
| Orthopaedics | 224 | 180 (80.4) | 1.49 (0.98–2.28) | 0.06 |
| **Section** | | | | |
| OPD | 734 | 488 (66.5) | Ref | – |
| IPD | 1159 | 885 (76.4) | 2.77 (1.95–3.94) | <0.001[a] |
| Injection OPD | 498 | 378 (75.9) | 2.69 (1.59–4.47) | <0.001[a] |
| Procedure room/ OT/ICU | 202 | 142 (70.3) | 1.21 (0.91–1.61) | 0.18 |
| **Standard Operating Procedure for BMW management** | | | | |
| Absent | 440 | 261 (59.3) | Ref | – |
| Present | 2153 | 1632 (75.8) | 1.78 (0.44–7.14) | 0.41 |
| **Presence of BMW management committee** | | | | |
| Absent | 448 | 274 (61.2) | Ref | – |
| Present | 2145 | 1619 (75.5) | 2.02 (0.50–8.13) | 0.32 |

Ref - Reference value.
[a] p value statistically significant.
[b] Laboratory technicians, pharmacists.
[c] Clustering at the level of healthcare facilities was adjusted using random-intercept model.

## 4. Discussion

### 4.1. BMW Management policies and their implementation

The safe & sustainable management of the BMWs is a legal and social responsibility of all the people involved in provision or utilization of healthcare services (i.e., patients, families, HCWs, hospital administration and health system). The BMW Rules, 2016 (further amended in 2018 & 2019) is a joint product of research made by agencies such as Centre for Chronic Disease Control, Health Care without Harm, and Centre for Environmental Health under Public Health Foundation of India [21]. This guideline was introduced to bring out a stringent and elaborate set of rules and bring a change in the way BMWs are managed in India. Monitoring the activities in health facility and its compliance to the standard guidelines is important as proper compliance to BMW practices ensures safety to patients and HCWs.

Most of the surveyed facilities were better performing in terms of almost all the BMW management practices (except reporting of needle stick injuries to NACO). Similar findings were reported in previous survey conducted in an Indian setting regarding the satisfactory adoption of latest BMW guidelines in secondary and tertiary care setting [22]. The possible reason for such positive finding could be the ongoing COVID-19 crisis which might have influenced a positive change in the waste disposal practices as most facilities has conducted training to HCWs on BMW disposal practices and management. Compliance to these practices was also heavily scrutinized during this period, which might have also influenced the positive finding with respect to these indicators. This shows that the public health facilities in Tamil Nadu are working towards the positive direction in handling BMW management practices. One major area of concern with many facilities were the non-reporting of

needle stick injuries to NACO. This again makes it difficult to determine the impact of BMW management practices implemented across the public health facilities in Tamil Nadu, as the ultimate aim or objective of any intervention is to achieve the desired outcome.

### 4.2. Improper BMW disposal practices

We have conducted a direct observational survey of BMW disposal practices amongst various set of HCWs in the surveyed public health facilities. BMW disposal practices was significantly better as nearly three-fourth of the observations followed appropriate BMW disposal practices. Similar finding was found in previous studies assessing the BMW disposal practices across various cadres of HCWs [17,22,23]. Such positive findings is encouraging given that the COVID-19 pandemic has raised the amount of BMW generated and ability of the virus to remain active on different surfaces for a variable period of time has made them hazardous [24]. In addition, fomite transmission has also been described as one of the modes of COVID-19 transmission [25]. However, there is always a scope for improvement despite the positive findings obtained in our survey, as some of the facilities had compliance as low as 40%. All the HCWs handling BMW across all the facilities should take utmost care and training or additional interventions should be targeted towards these facilities with compliance less than 50%.

Depending on the type of HCWs, nurses and doctors had better compliance when compared to other allied staffs. This finding was also similar to previous studies in Southern India and other similar setting, as the doctors and nurses had almost similar BMW disposal compliance or slightly better compliance amongst nurses [17,22,26,27]. Possible reason for such finding could be high amount of responsibility on BMW management practices are assigned to nurses and doctors in public health facilities of Tamil Nadu. In addition, doctors and nurses have better access to BMW management training, guidelines and equipment compared to other allied staffs. However, such practice should be changed and all the HCWs are equally important in preventing the transmission of infection in health facility. Though, training programs are conducted for every HCWs in the health facility, not all HCWs are motivated enough to attend the training as reported during the qualitative interviews. Hence, the training on BMW management should be made as a strict mandate for all the hospital staffs. Attendance of staffs during the training programs should be considered for the annual appraisal or promotion of staffs.

We also found that HCWs in IPD/Injection OPD had better compliance to BMW disposal practices compared to those working in the general OPD. The possible reason for such finding could be the hectic nature of work in the OPD especially in the government healthcare facilities. This makes the HCWs allocate less time to each patient and prone to inappropriate disposal of BMWs. However, measures should be taken to ensure proper compliance by HCWs even in OPDs by allocating appropriate resources and periodically monitor the BMW disposal practices in general OPDs.

### 4.3. Strengths and limitations

Our study has certain strengths. We have utilized a standard framework/guideline (released by Government of India) for assessing the BMW management policy implementation. We have also conducted the survey on BMW disposal practices across 18 secondary and tertiary care facilities across different settings (OPD/IPD/Procedure room/Injection OPD/ICU/OT) and type of HCWs (doctors/nurses/allied staff). Despite these strengths, our survey had some limitations. Observer bias was possible during the BMW disposal observations, as the Dean/MS/RMO were informed that such observations will be made on the HCWs in a defined period of time. Hence, the communication of this information to all the HCWs in the facility might have influenced their practices during the survey. Finally, primary healthcare facilities were not included in our survey.

## 5. Conclusion

Our study shows that nearly during three-fourth of the observations, healthcare workers performed appropriate BMW disposal practices. However, measures should be taken to achieve 100% compliance by healthcare workers especially the target groups identified in our study by allocating appropriate resources and periodically monitor the BMW disposal practices.

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## Ethical approval

This study was approved by Institutional Ethics Committee of ESIC Medical College & PGIMSR, Chennai dated 04.05.2021 with IEC No. IEC/2021/1/12.

## Conflict of Interest

None declared.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijmmb.2022.08.011.

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