

COVID-19 Biomedical Waste Management: Knowledge Assessment Among Medical Professionals in a COVID-19 Dedicated Hospital, a Cross Sectional Study.

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1 **COVID-19 Biomedical Waste Management: Knowledge Assessment among Medical**
2 **Professionals in a COVID-19 Dedicated Hospital, a Cross Sectional Study.**

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38

39 **ABSTRACT**

40 Background

41 Nations have faced significant challenges with the COVID-19 related biomedical waste since
42 its outbreak. Before the pandemic, Indian hospitals typically generated 500g of BMW per bed
43 each day, which has now risen to about 2.5-4 kg per bed per day. Proper BMW aims to reduce
44 waste generation, ensures efficient collection, handling and safe disposal that it controls
45 infection and improves safety for the medical professionals. Hence, the present study was
46 conducted to assess the level of knowledge among medical professionals regarding biomedical

47 waste segregation , transport and treatment and thereafter provide constructive suggestions to
48 reduce mismanagement practices.

49 Methodology

50 An e-survey was done to assess the knowledge and awareness of management of Biomedical
51 Waste generated due to COVID-19 among Medical Professionals (students, residents and
52 consultants) of tertiary care hospital of North India.

53 Result

54 The average knowledge score about BMW waste generated due to COVID-19 was found to
55 be: for segregation - 27.46%, 59.615%, and 49.8%; transport of waste from site of generation
56 to the site of disposal- 63.66%, 89.1% and 95.2% ; disposal of waste generated- 29%, 71.96%,
57 and 68.24% in students, residents, and consultants respectively. Overall, the knowledge score
58 was 41.4%, 67.98%, and 61.34% among the students, residents and consultants respectively.
59 We found that participants with greater years of experience (residents and consultants) had
60 better knowledge compared to that of the students($p < 0.05$).

61 Discussion

62 Our study found that the mean score was 56.9% which is comparably more than the knowledge
63 score of few Low and Middle Income Countries but less than the knowledge score of some
64 European countries. Studies have found that the chances of infection directly correlates with
65 the low level of knowledge. This underlines that training aspects of health-care waste
66 management should be strengthened, not only for the practising medical professionals but also
67 of the students so that the current, existing, and future regulations are practiced diligently and
68 uniformly. Hence, it is of paramount importance that we strengthen the training aspects of not
69 only the practising medical professionals but also of the students. Periodic evaluation and
70 assessment should become routine to enforce adherence to waste management.

71

72 **Keywords:** COVID-19, Biomedical Waste, Pandemic, Medical Professionals, Infection,
73 Knowledge, Segregation, Assessment

74

75 **Background**

76 The global pandemic, that began in November, 2019, from Wuhan, China¹ has affected more
77 than 170 million people around the world with over 3.5 million deaths as on May 31, 2021,
78 says a report from Coronavirus Resource Center , Johns Hopkins University. India alone has
79 reported more than 28 million cases, as on May 31, 2021.²

80 Amidst the coronavirus disease 2019 (COVID-19) pandemic, health care settings are
81 experiencing high demand of Personal Protective Equipment (PPE) from all strata of health
82 care workers , to protect themselves from infection and also owing to fear of infection. Almost
83 all COVID-19 related waste cannot be reused, adding to increased biomedical waste(BMW).
84 One of the direct consequences of the pandemic has been a 40 per cent increase in the global
85 production of biomedical waste.⁰ Analysis revealed that on an average, each COVID-19
86 infected patient in India generates approximately 3.41 kg/d of BMW and average proportion
87 of yellow BMW (which is highly infectious) in it is 50.44%.³

88 Massive amounts of medical waste have already been generated and disposed of into the
89 natural environment ⁴ and waste mismanagement practices can increase the contamination risks
90 in developing countries.⁵ At this time of crisis, with limited resources and manpower available,
91 these are difficult to store and transport.⁶

92 The hospital waste management has diverse ramifications as it not only affects the health of
93 patients but also of medical professionals (doctors, nurses, sanitary staff, etc.) and general
94 public. Inadequate and inappropriate knowledge of handling of biomedical waste may have

95 serious health consequences and a significant impact on the environment.⁷ The common use
96 of surgical facemask and hand gloves is being largely consumed and due to their size and
97 lightweight, there is a chance that these wastes may be disposed of with other solid waste. It is
98 also essential to guarantee that this waste doesn't mix with regular household waste. Since
99 COVID-19 gets transmitted through direct touch and tainted surfaces and items⁸, it could even
100 speed up the growth of COVID-19 in developing countries that lacks appropriate resources to
101 handle the waste. It could lure rag pickers as it is an access for some quick money. Some
102 studies also reported the illegal resale and reuse of BMW .^{9, 10, 11}

103 Medical waste management issues are less examined in India due to poor details and waste
104 statistics data. This indicated the need to have a comprehensive waste management strategy as
105 well as raising awareness among all those involved either in the generation, segregation or
106 treatment of COVID-19 waste. On this background, this paper aims to provide an assessment
107 of knowledge of medical professionals for segregation, transportation, treatment and final
108 disposal of biomedical waste, especially during increased waste generation of COVID-19
109 pandemic as they are directly involved in the management of COVID-19 patients in assessing,
110 clinical examination, sampling, and treatment.

111

112 **Methodology**

113 It was an e-survey based study. The study involved undergraduate students and the frontline
114 healthcare workers, i.e., Medical Officers, Interns, Post Graduates, Senior Residents, and
115 Consultants at a dedicated COVID-19 facility in Delhi which is also one of the largest teaching
116 tertiary care hospitals in India. The ethical clearance for the study was obtained from the
117 Institutional Ethics Committee. The sample size was calculated to be 323, with a confidence
118 level of 95% in a population size of 2000 healthcare professionals. A questionnaire using the

119 Google form was made. A scoring system was added which awarded points for correct answer.
120 The questionnaire was divided into 4 sections. The first section (Q 1-10) collected demographic
121 details of the participants. The next section (Q 11-17) assessed knowledge of the participants
122 regarding management and policies of Biomedical wastes. The third section(Q 18-33 with
123 subsections) tested the knowledge regarding segregation, transport, treatment and final disposal
124 of waste. The last section(Q 34-38) sought the opinion on the waste management practices
125 prevalent in their hospitals and their suggestions on how to improve on them. This
126 questionnaire was shared with the medical professionals via E-mail and other social networking
127 website such as-WhatsApp. Participation in the survey was purely voluntary and anonymous.
128 On submission of the form, the participants were directed to Infection control manual and
129 guidelines from WHO¹² , CDC¹³, ICMR for their perusal and awareness. A reminder was sent
130 after 15 days, to participate in the study. The data were collected and assessed statistically by
131 Google form, Google Sheets, Microsoft Excel. Chi square test was used to compare proportions
132 across different groups.

133

134 **Results**

135 The survey was sent to around 825 people and the response percentage was 50.42% (416
136 participants). Out of the 416 participants, 22.35% (93) participants were directly involved in
137 COVID-19 care(Table 1). 83% of these participants had received training or read guidelines
138 for management of biomedical waste, in general whereas only 34.4% were aware about
139 management of Biomedical waste generated by COVID-19 waste. Though 92.5% (385)
140 participants thought it is important to know about biomedical waste generation, hazards, and
141 legislation, yet only 42% were aware of the government's regulations and legislation on
142 COVID-19 waste management. 86.6% (360) were aware how inadequate management of
143 COVID-19 waste can lead to cross infection. We found that only 27.46% students knew about

144 the correct methods of segregation of waste, whereas 59.6% of residents and 49.8% consultants
145 were aware of the correct methods (Table 2). With regards to transport of waste, 67% of the
146 students and more than 90% of experienced medical professionals are aware that only licensed
147 personnel can transport the waste (Table 3). The knowledge regarding disposal and treatment
148 of liquid waste is lacking in all strata (knowledge score found to be 60% in residents and 26%
149 among students) (Table 4). Overall, there was significant difference in the knowledge of the
150 students (knowledge score was found to be 41.4%,) and the experienced medical professionals
151 (67.98%, and 61.34% among the residents and the consultants respectively).

152

153 **Discussion**

154 In India, 103 billion ton of plastic waste has been produced during the pandemic in 2020 ,
155 which is second only to China that produced around 108 billion ton of plastic waste.¹⁴ Delhi
156 generated 382 tonnes of COVID-19 bio-medical waste in September 2020, according to the
157 CPCB data.¹⁵ As the pandemic continues, so will the waste, and keeping that garbage safe and
158 contained will continue to be a challenge for communities until the crisis is over.¹⁶ In our
159 study, we found that 86.6% were aware how inadequate management of COVID-19 waste can
160 lead to cross infection. Ahmed MA while evaluating knowledge of cross infections in dentists
161 during COVID-19 pandemic found that 80% participants agreed that proper disposal of waste
162 is crucial for cross-infection control.¹⁷

163 In a study in Thailand conducted to assess the knowledge of medical professionals regarding
164 BMW management, the overall scores were found to be at a higher level (89.5%).¹⁸ Similarly,
165 the average knowledge score in three Low- and Middle-Income countries Ethiopia, Nigeria
166 and Sri Lanka were found to be 56.8%, 45% and 40.5% , respectively.^{19, 20, 21}

167 The improper disposal of COVID-19 bio-medical waste poses severe risks to public health and
168 the environment as it acts as a host of variety of pathogenic microorganisms. Pathogens present
169 in BMW, if not managed well, may enter the human body through a puncture, abrasion or cut
170 in the skin, mucous membrane, inhalation, and ingestion. Emphasis must be laid on the proper
171 management of waste generated in the course of COVID-19 treatment. It has found that there
172 are gaps in knowledge and practice in the implementation of BMW management protocol.²² A
173 systematic review of the literature reported that the pooled prevalence of healthcare associated
174 infection was 7.6% in high-income countries and 10.1% in low and middle-income countries
175 where average knowledge score was low.²³ Studies also found that, in Africa including
176 Ethiopia, the prevalence of hospital-acquired infection was significantly high (12–35%).
177 ^{24, 25, 26, 27} Thus, significant relation can be established between level of knowledge among
178 healthcare professionals regarding BMW management and healthcare associated infection.

179 The most essential step to Biomedical Waste Management is sequential handling, that is
180 Generation → Segregation/Separation → Collection → Transportation, storage → Treatment →
181 Final disposal. The proper awareness of the long process of handling of waste, can help to
182 minimize infections in persons at risk, esp. those who the handle of waste. We found that 92.2%
183 of the residents knew about the correct sequence whereas only 64% of students were aware.
184 Due to the ravaging pandemic, the Government of India has decided to utilize the services of
185 students, therefore students must possess adequate knowledge about management of BMW for
186 proper disposal of COVID-19 Infected waste and their own safety. Although there are rules
187 and regulations for Biomedical Waste Management, adherence to the basic rules of biomedical
188 waste, segregation and management is still low in India.²⁸ We found that only 27.46% students
189 knew about the correct methods of segregation of waste, whereas 59.6% of residents and 49.8%
190 consultants were aware of the correct methods (Table 2). Our results were better as only 30%
191 of the participants had knowledge regarding segregation of the hospital in one study.²⁹

192 Knowledge was found to be less compared to other study of Ethiopia, where 83.9% doctors
193 had knowledge about the correct ways of segregation of waste.¹⁸

194

195 In our study, we found that there were gaps in knowledge about the fate of the waste after it
196 was segregated, followed by how were they treated and the safe transportation of biomedical
197 waste from the hospital. This is comparable to another study where knowledge score was 64%
198 amongst students³⁰. In a survey done in China in times of COVID-19 pandemic, it was found
199 that the majority proportion (37.8%) were non-compliant to guidelines related to the
200 management of medical waste. Out of these, 71.4% of respondents lacked knowledge of proper
201 disposal, collection of waste.³¹ With regards to transport of waste, we found that about 67% of
202 the students and more than 90% of experienced medical professionals are aware that only
203 licensed personnel can drive the waste to the final disposal site.(Table 3). 77% students and
204 90% trained healthcare workers are aware that personnel involved in BMW handling should
205 wear appropriate gear, including boots, aprons, long-sleeved gowns, thick gloves, masks, and
206 goggles or face shields, according to recommendations from the World Health Organization³².
207 Data used from Hospital Infection Control(HIC) manual helped in assessment of knowledge
208 regarding management and treatment of spills, liquid waste, shared toilets, and certain
209 possessions such as garments, phones, mattress. The knowledge amongst experienced medical
210 professionals is found to be excellent (approximately 96%) regarding management of spills,
211 whereas, students are not quite well aware (average score = 67%)(Table 4). Students must be
212 provided training to combat these frequently encountered situations such as spills. Our
213 questionnaire also aimed to assess the knowledge regarding the proper method of disposal of
214 homemade masks, waste containers, anatomical waste, IV tubes, catheter, syringe, sharps,
215 vials, soiled gloves, dressings, PPE kits and liquid wastes. Only 44.28% of students knew about
216 the right methods of disposal and treatment of waste whereas, 72% residents and 68%

217 consultants answered these questions correctly. (Table 4). Correct knowledge about treatment
218 of these wastes is lacking in all strata. Low level of awareness regarding final disposal of
219 wastes, not only increases the risk of infectivity once waste has left hospitals, but also has
220 adverse environmental impact, in the form of soil pollution. Added to this issue are the
221 increase in the use of single-use plastic, and the reduction of plastic recycling due to the curfew
222 generated by the pandemic, further aggravating plastic pollution.³³

223 Significant relation was found between years of experience and knowledge score (Figure 2).
224 Trained professionals had higher knowledge score (67.98%, and 61.34% among the residents
225 and consultants respectively) as compared to that of students (41.4%). Low level of knowledge
226 has direct implication on waste management practices. Mismanaged BMW can lead to
227 infection spread. From the results, it has become clear that there is still a need to educate the
228 students and residents about the problem of biomedical waste. Healthcare professionals are the
229 key workers in the management of BMW generated by health care practices, and the
230 management of the COVID-19 waste is all the more essential to reduce its infectivity and
231 spread across the country. Unless the healthcare professionals are aware, it cannot be ensured
232 that the waste ended up at the right place. Thus, providing training is a very critical step to
233 reduce waste generation and cost saving. According to a study conducted in Spain, there was a
234 significant reduction in the monthly average health care waste volume of 6.2%, after an
235 interventional training. Significant differences regarding BMW segregation before and after
236 the intervention ($p < 0.05$) were found. The significant BMW weight reduction and the
237 improvement of waste classification also helped reduce monthly expenditure by €125,205.³⁴

238 Another study by El-Sharkawy, also reported significant improvement of knowledge from
239 25% to 78% after the educational intervention.³⁵

240 Repeated and comprehensive training (starting with induction of all new appointees to once a
241 year thereafter) should be done. The right practices in the form of avoiding of injuries,

242 importance of vaccinations and following of universal regulations for waste management
 243 should be promoted. Although Central Pollution Control Board has made it mandatory for all
 244 healthcare centers to display signages for Biomedical Waste Management, around 35% of
 245 participants said that there were no signages displayed in their institution. This highlights
 246 intervention of administration to bring about a change. 90% of the participants think it is
 247 difficult to remember the steps for management. Therefore, it becomes more essential to put
 248 up signages at all required sites.

249 Table 5: Framework for BMW Management in COVID-19 era³⁶ (based on WHO multimodal
 250 strategy)

1. Build it	<p>Build an HIC committee with dedicated trained professionals and multi-disciplinary team for the management of biomedical waste</p> <p>Administrating support to ensure availability and accessibility of colour coded garbage bins</p>
2. Teach it	<p>Training and education of individuals, especially the younger medical workforce</p> <p>It should be made compulsory for healthcare facilities to get their healthcare personnel (medical and paramedical staffs) trained inhouse HIC committee.</p>
3. Check it	<p>Regular monitoring and feedback by periodic assessment among Medical Professionals</p> <p>Regular audit to identify deficient areas</p> <p>Remain updated with latest evidence and guidelines</p>

4. Sell it	Easy readout placards/posters placed at point of generation and segregation in wards and other areas Using promotional/reinforcing messages Planning for periodic campaigns
5. Live it	Adequate measures for biomedical waste management should become a part of institutional culture and propagated regularly

251

252 **Strengths and Limitations**

253 It is one of its kind surveys about Biomedical Waste especially in the time of COVID-19. A
 254 scoring system was used that helped understand the shortcomings and correct answers were
 255 provided to rectify them. Firstly, the response rate to the survey(50.42%) was moderate, in line
 256 with other studies. The survey participation rate was good among the students. Secodly, there
 257 is lack of studies in this subject in the indian context; when COVID-19 waste segregation and
 258 disposal awareness is the need of the hour. This assessment is useful due to poor available data
 259 of medical waste flow of Biomedical Waste generated due to COVID-19. Lastly, our study
 260 also assessed the knowledge of students who are also going to be recruited for COVID-19
 261 management in hospitals. Hence, an evaluation of their gap of knowledge becomes of
 262 paramount importance to reduce cross-infection by mishandled Biomedical Waste.

263

264 Our study also had a few limitations. Firstly, response rate was moderate among residents and
 265 less response rate was observed from consultants. Secondly, it is a single centre study, the
 266 results cannot be generalized at a national level. As this is a questionnaire-based online survey
 267 with voluntary participation and those who did not participate may be systematically different
 268 from those who participated, thus the possibility of respondent bias cannot be ruled out. The

269 survey was essentially for doctors; however, the nursing and paramedical staff also must
270 possess adequate knowledge and awareness about BMW management.

271

272 **Conclusion**

273 Overall, the knowledge score was found to be 41.4%, 67.98%, and 61.34% among the students,
274 residents and consultants respectively. Low level of knowledge has been shown to have direct
275 impact on infection spread. Thus, it is of paramount importance to dispose of the COVID-19
276 waste carefully to prevent spread of infection. Training aspects of health-care waste
277 management should be strengthened so that the current, existing, and future regulations are
278 practiced diligently and uniformly. Periodic evaluation and assessment should become routine
279 to enforce adherence to waste management. Strict implementation of biomedical waste
280 management rules is the need of the hour.

281

282 **Abbreviations**

283 COVID-19 – Coronavirus Disease-19

284 PPE- Personal Protective Equipment

285 BMW- Biomedical Waste

286 WHO- World Health Organization

287 CDC- Centers for Disease Control and Prevention

288 ICMR- Indian Council of Medical Research

289 CPCB- Central Pollution Control Board

290 HIC- Hospital Infection Control

291

292 **Legends**

293 Table 1: Demographic Details and Assessment of General Information

294 Table 2: Average Score among Participants regarding Segregation of Waste

295 Table 3: Average Score among Participants regarding Transport of Waste

296 Table 4: Average Score among Participants regarding Final Treatment

297 Table 5: Framework for BMW Management in COVID-19 era

298 Figure 1: Comparison of Scores among Students, Residents and Consultants

299 Figure 2: Comparison of Scores based on Years of Clinical Experience

300

301

302 **Declarations**

303 **Ethics Approval and consent to participation**

304 The ethical approval was obtained from the Institutional Ethics Committee of Maulana Azad
305 Medical College. Consent for the participation was incorporated in the survey questionnaire,
306 only those who consented were eligible to participate.

307

308 **Consent for Publication**

309 Consent for the publication was incorporated in the survey questionnaire, only those who
310 consented were eligible to participate.

311

312 **Availability of Data and Materials**

313 Not available.

314

315 **Competing Interest**

316 The authors declare that they have no competing interests.

317

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320

321 **Authors' Contributions**

322 LB and APA conceptualized the manuscript. APA and LB designed the study, co-ordinated
323 the execution of the study. APA, LB and AKM reviewed the literature, analyzed data, and
324 made major contribution to the writing of the manuscript. LB, AM, AD supervised the
325 execution and provided important intellectual contributions to design, co-ordination and
326 analysis of the study. APA, LB, AKM, AD, SA and DK performed final review and editing of
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328

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333

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Figures

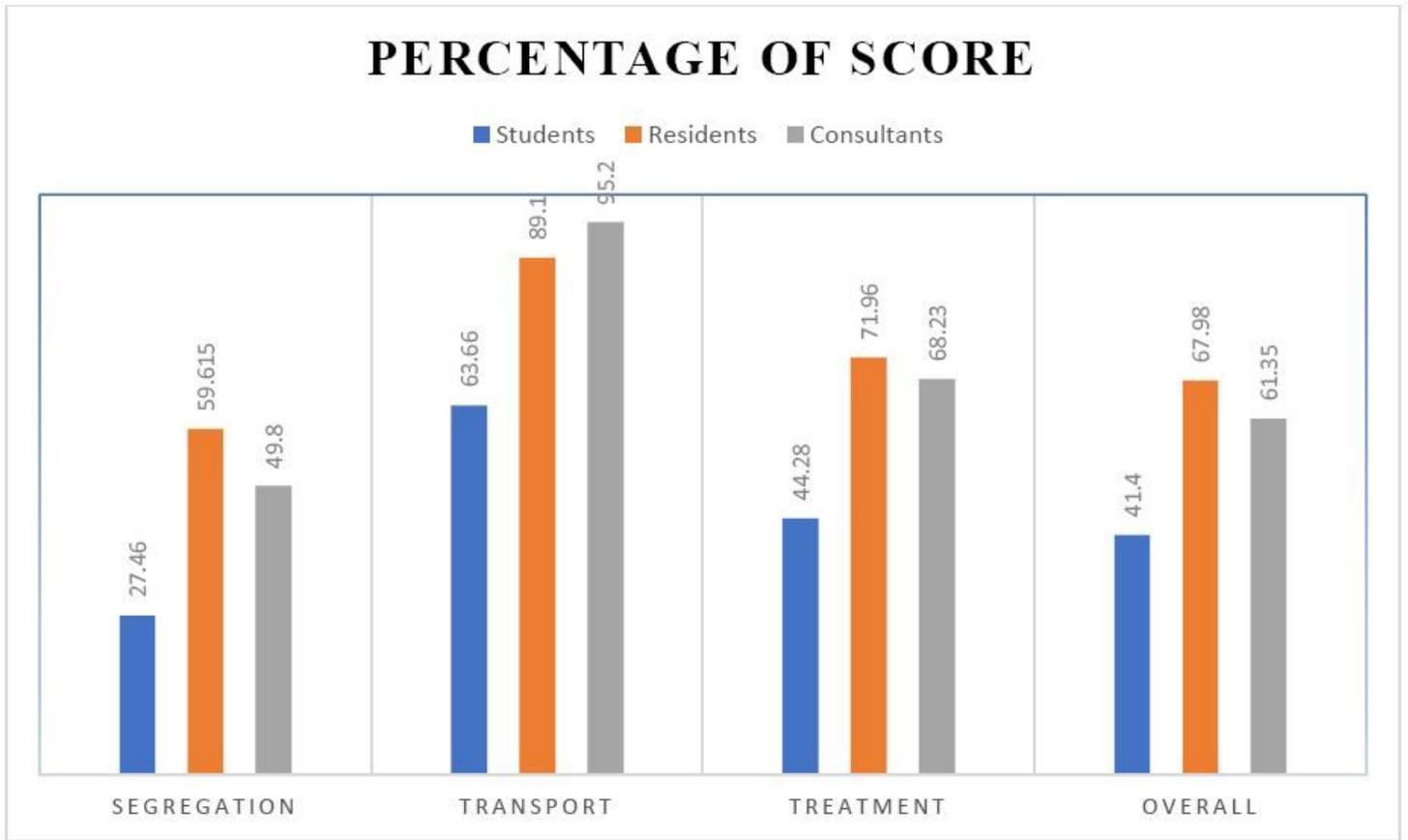


Figure 1

Comparison of Scores among Students, Residents and Consultants



Figure 2

Comparison of Scores based on Years of Clinical Experience

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