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Knowledge and Practice of Biomedical Waste Management among Nurses at a Tertiary Level Hospital in Bangladesh

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ABSTRACT

Biomedical waste (BMW) poses significant health risks due to its potential to spread infections and environmental harm. Effective management is crucial to mitigate these risks. This study aimed to assess the knowledge and practices of senior nurses at a tertiary hospital in Bangladesh regarding BMW management. A descriptive correlational study was conducted from July 2019 to July 2020. Data were collected using validated questionnaires on sociodemographic characteristics, knowledge (14 items), and practices (13 items) related to BMW management. Statistical analyses, including descriptive statistics and bivariate analyses, were performed using SPSS. The study included 112 senior nurses with an average age of 29.26 years. Majority were female (88.4%) with basic B.Sc. or post basic B.Sc. education (59.8%). The nurses demonstrated varied levels of knowledge (low: 36.6%, moderate: 39.3%, high: 24.1%) and practices (low: 41.1%, moderate: 25.9%, high: 33.0%) regarding BMW management. A significant correlation was found with higher education level in both knowledge (p=0.024) and practice (p=0.049) levels. However, no significant correlations were observed based on age, sex, years of experience, or specific workplaces. The study highlighted gap in knowledge and practices among senior nurses regarding BMW management at the tertiary hospital. Targeted training programs and policy improvements are recommended to enhance BMW management practices, thereby reducing health risks and environmental impact associated with BMW.

Keywords: knowledge; practice; biomedical waste; management

INTRODUCTION

Biomedical waste (BMW) encompasses any waste generated during the diagnosis, treatment, or immunization of humans or animals, as well as from research activities, posing significant health risks due to potentially harmful microorganisms (Mitiku et al., 2022). Examples of BMW include sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices, and radioactive materials. The common sources of biomedical waste are diverse, ranging from hospitals, nursing homes, and clinics to laboratories, physicians' and dentists' offices, veterinary practices, healthcare services, and funeral homes (Mitiku et al., 2022). This widespread waste generation underscores the critical need for effective BMW management practices.

Annually, hospitals alone generate nearly 3.2 million tons of biomedical waste (Mitiku et al., 2022). The amount of BMW production varies significantly between developing and developed countries. In developing countries, the production ranges from 1 to 2 kg per bed per day, while in developed countries, it is about 4.5 kg per bed per day (Kumar et al., 2017). This discrepancy highlights the differing capacities and infrastructures for waste management between regions. Ineffective management of this waste can lead to the spread of infections within hospital settings and the general public, emphasizing the need for stringent waste segregation, handling, treatment, and disposal protocols. Ensuring proper BMW management is essential to mitigate the associated health risks and protect both healthcare workers and the broader community.

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Hospital waste composition indicates that approximately 85% is non-hazardous, 10% is infectious or biologically hazardous, and 5% comprises toxic chemicals, pharmaceuticals, and radioactive materials (Uddin et al., 2014). Recent observations highlight that health institutions generate significant amounts of biological waste, which are potential sources of infection transmission, particularly hepatitis B and C, HIV, and tetanus. For instance, contaminated syringes have been implicated in 21 million hepatitis B infections, 2 million hepatitis C infections, and 260,000 HIV infections (Amita et al., 2017; Syed et al., 2012). The hazardous nature of biomedical waste poses substantial risks to healthcare personnel, patients, and nearby communities (Anozie et al., 2017). Indirectly, it also poses a detrimental effect on the well-being of living beings through the release of pathogens and toxic pollutants into the environment (World Health Organization, 2018). Thus, addressing these challenges requires a concerted effort to improve the knowledge and practices regarding biomedical waste management, ensuring a safer healthcare environment and protecting public health.

The most pressing issues related to medical waste management include the absence of proper waste management systems, a lack of awareness regarding the health hazards posed by medical waste, insufficient financial and human resources, and inadequate control over waste disposal (Musa et al., 2020). Effective biomedical waste management (BMWM) encompasses several critical steps: collection, segregation, transportation, treatment, and disposal (Bansod and Deshmukh, 2023). In hospital settings, nurses play a pivotal role in ensuring the accurate segregation of biomedical waste at the point of generation. This involves categorizing waste into different types, such as sharps, non-sharps, infectious waste, and hazardous chemicals. Proper segregation is essential to the entire waste management process, ensuring that waste is treated and disposed of in the safest manner possible. However, nurses are at a heightened risk of infection from blood-borne pathogens due to clinical blood exposure and injuries from sharp instruments and needle sticks if infection control measures are not strictly followed (Nwozichi et al., 2018). Key measures to prevent infection from biomedical waste for healthcare workers, including nurses, include hand hygiene, personal protective equipment (PPE), safe injection practices, environmental cleaning and disinfection, aseptic technique, respiratory hygiene/cough etiquette, monitoring and reporting, and vaccination (Sharma and Bachani,2023).

Given the critical role of nurses, they must possess adequate knowledge about BMW management and implement these practices in their daily routines to mitigate the risks posed by biomedical waste to themselves, patients, the community, and the environment. A study published in 2022 reported that medical waste generation in Dhaka ranges from 1.63 to 1.99 kg per bed per day, a figure that has increased significantly following the COVID-19 pandemic (Farhan, 2023). Despite the substantial volume of medical waste, Bangladesh suffers from inadequate legislation and a lack of comprehensive waste management plans (Farhan, 2023), resulting in arbitrary management practices in individual hospitals (Hasan et al., 2008). Various studies have explored the knowledge and practices of BMW management among healthcare workers, including nurses, in Bangladesh, revealing a mix of adequate and poor knowledge and good and poor practices (Sen et al., 2023; Sarker et al., 2014; Uddin et al., 2014). However, there is a scarcity of studies focusing specifically on the knowledge and practice levels of senior nurses in tertiary hospitals in Bangladesh. Senior nurses' advanced knowledge and practices are crucial for ensuring a safe healthcare environment, reducing infection risks, and setting a standard for junior staff. Therefore, this study aimed to investigate the knowledge and practice levels of senior nurses to provide the higher authorities of the selected hospital better understand the current situation regarding biomedical waste management.

METHOD

This descriptive correlational study was conducted to assess the knowledge and practice of biomedical waste management among nurses and to examine the relevancy of their knowledge and practice. The study was carried out from July 2019 to July 2020. The study population comprised registered senior staff nurses at Bangabandhu Sheikh Mujib Medical University, a 1500-bed tertiary-level hospital in Shahbag, Dhaka, Bangladesh, employing 900 nurses. Using G-power analysis for sample size estimation, with an acceptable minimum significance level (α) of 0.05, an expected power of 0.80 (1-β), and an effect size of 0.30, the calculated sample size was 84. To account for a 20% attrition rate, the final sample size was increased to 112. Participants were selected using convenience sampling based on the following inclusion criteria: registered male and female nurses with more than two years of job experience working in the Medicine Ward, Surgery Ward, ICU, or Gynae Ward, and providing consent for the study.

The study utilized a three-part questionnaire. The Nurse's Sociodemographic Questionnaire (NSQ) was comprised of five items: age, sex, educational qualification, job experience, and workplace. The Nurse's Knowledge on Biomedical Waste Management Questionnaire (NKBWMQ) included 14 validated multiple-choice items developed by a previous author and his colleagues (Al Balushi et al., 2018), with scores categorized into low, moderate, and high knowledge levels. The Nurse's Practice on Biomedical Waste Management Questionnaire (NPBWMQ) featured 13 validated items on a 4-

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point Likert scale developed by a team of researchers with scores categorized into low, moderate, and high practice levels (Al Balushi et al., 2018). The instruments were validated by a panel of three experts and tested for reliability, yielding a Cronbach's Alpha coefficient of 0.695. The questionnaires were available in both Bangla and English.

Data were collected using structured questionnaires after obtaining approval from the Institutional Review Board (IRB) of the National Institute of Advanced Nursing Education and Research (NIANER) and Bangabandhu Sheikh Mujib Medical University (BSMMU), along with permissions from relevant authorities and participants' consent. Confidentiality, anonymity, and privacy were strictly maintained, with participants able to withdraw at any time without penalty. A set of questionnaires was placed on a desk near the nurses' duty station, and the nurses participating in the study voluntarily picked them up. Participating nurses were requested to drop the completed questionnaires in a dedicated research box within two weeks from the pick-up date. It was supposed to take about 20 minutes to complete. The researchers collected the completed questionnaires from the research box at the end of two weeks. Each questionnaire and data file was identified by a code number, with participant identification numbers and data stored separately and accessible only to the researcher. Data analysis was conducted using SPSS-24 (Statistical Package for Social Science), employing descriptive statistics (frequencies, percentages, mean, and standard deviation) to describe participants' demographic characteristics and bivariate analyses, including independent t-tests, ANOVA, and Pearson Product Moment Correlation, to examine the relationship between knowledge and practice of biomedical waste management.

RESULTS

This chapter presents the study findings, detailing the socio-demographic characteristics of the participants, the distribution of their knowledge and practices regarding biomedical waste management, and the relationship between their knowledge and practices in this area.

Table 1 presents that the study included a sample of 112 nurses with an age range of 24 to 39 years, and an average age of 29.26 years with a standard deviation of 3.437 years. The majority of the participants were female, comprising 88.4% (99 nurses), while males made up 11.6% (13 nurses).

In terms of education, 33.0% (37 nurses) held a diploma, 59.8% (67 nurses) had a Basic B.Sc. or Post Basic B.Sc., and 7.1% (8 nurses) had an MPH or MSS degree. The participants had job experience ranging from 2 to 15 years, with an average of 4.58 years and a standard deviation of 2.556 years.

Regarding their workplace, 25.0% (28 nurses) worked in the Medicine ward, 24.1% (27 nurses) in the Surgery ward, 33.0% (37 nurses) in the ICU, and 17.9% (20 nurses) in the Gynecology ward.

Table 1. Distribution of Sociodemographic Characteristics of Participants (N=112)

Variables	Category	Number (n)	Percentage (%)	Mean ± SD
Age (Year)	Min-Max (24-39)			29.26 ± 3.437
Sex	Male	13	11.6	
	Female	99	88.4	
Educational qualification	Diploma	37	33.0	
	Basic B.Sc. & Post Basic B.Sc.	67	59.8	
Working Experience (Year)	Min-Max (2-15)			4.58 ± 2.556
Working place	Medicine	28	25.0	
	Surgery	27	24.1	
	ICU	37	33.0	
	Gynecology	20	17.9	

Table 2 shows the knowledge level of nurses based on the Nurse's Knowledge on Biomedical Waste Management Questionnaire (NKBWMQ). For the question on biomedical waste management, 48.2% (54 participants) answered correctly, while 51.8% (58 participants) answered incorrectly, with a mean score of .48 and a standard deviation (SD) of .502. Regarding biomedical waste management schedules, 81.3% (91 participants) answered correctly, and 18.8% (21 participants) answered incorrectly, yielding a mean of .81 (SD=0.392). Only 10.7% (12 participants) correctly identified the types of biomedical waste, while 89.3% (100 participants) did not, resulting in a mean of 0.11 (SD=0.311).

The basic principles of segregation of biomedical waste were correctly identified by 81.3% (91 participants), with 18.8% (21 participants) incorrect (mean=0.81, SD=0.392). For color coding of biomedical waste management, 71.4% (80 participants) answered correctly, and 28.6% (32 participants) answered incorrectly (mean=0.71, SD=0.454). Universal

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precautions that should be used were correctly answered by 47.3% (53 participants) and incorrectly by 52.7% (59 participants), with a mean of 0.47 (SD=0.502).

Regarding the use of disposal bags, 70.5% (79 participants) answered correctly, and 29.5% (33 participants) answered incorrectly (mean=0.71, SD=0.458). Wearing gloves was correctly answered by 86.6% (97 participants) and incorrectly by 13.4% (15 participants) (mean=0.87, SD= 0.342). For putting biomedical waste in the wrong bin, 60.7% (68 participants) answered correctly, and 39.3% (44 participants) answered incorrectly (mean=0.61, SD=0.491).

When asked about bin usage, 49.1% (55 participants) answered correctly and 50.9% (57 participants) incorrectly (mean=0.49, SD=0.502). The correct statement about the separation of infectious and non-infectious materials was answered correctly by 47.3% (53 participants) and incorrectly by 52.7% (59 participants), with a mean of 0.47 (SD=0.502). For sources of biomedical waste management, 90.2% (101 participants) answered correctly, and 9.8% (11 participants) answered incorrectly (mean=0.90, SD=0.299).

The doses of the hepatitis B vaccine were known by 93.8% (105 participants), while 6.3% (7 participants) were incorrect (mean=0.94, SD=0.243). Finally, the benefits of post-prophylaxis were equally known and unknown, with 50.0% (56 participants) correct and 50.0% (56 participants) incorrect (mean=0.50, SD=0.502).

The total knowledge mean score was 8.88, with a standard deviation of 2.20, ranging from a minimum of 2 to a maximum of 12. The participants were categorized into three knowledge levels: 36.6% (42 participants) had a low level of knowledge, 39.3% (44 participants) had a moderate level, and 24.1% (27 participants) had a high level of knowledge.

Table 2. Distribution of Participants' Knowledge Level about Biomedical Waste Management (n=112)

Variables	Correct Answer		Incorrect Answer		Mean (SD)
	N	%	N	%	
Biomedical waste management	54	48.2	58	51.8	0.48 (0.502)
Biomedical waste management schedules	91	81.3	21	18.8	0.81(0.392)
Types of biomedical waste	12	10.7	100	89.3	0.11 (0.311)
Basic principles of segregation of bio medical waste management	91	81.3	21	18.8	0.81 (0.392)
Choose the correct statement about color coding of biomedical waste management	80	71.4	32	28.6	0.71 (0.454)
Universal precaution should be used on	53	47.3	59	52.7	0.47 (0.502)
Disposal bag must be used	79	70.5	33	29.5	0.71 (0.458)
Wearing gloves during	97	86.6	15	13.4	0.87 (0.342)
Reason of putting biomedical waste in wrong bin	68	60.7	44	39.3	0.61 (0.491)
Bin should be	55	49.1	57	50.9	0.49 (0.502)
Correct statement about separation of infectious and non-infectious materials in different	53	47.3	59	52.7	0.47 (0.502)
Sources of biomedical waste management	101	90.2	11	9.8	0.90 (0.299)
Doses of hepatitis B vaccine	105	93.8	7	6.3	0.94 (0.243)
Benefits of post prophylaxis	56	50.0	56	50.0	0.50 (0.502)
Total Knowledge	Min - Max (2- 12)				8.88 ± 2.20
Level of Knowledge					
Low level of knowledge	42		36.6 %		
Moderate level of knowledge	44		39.3%		
High level of knowledge	27		24.1%		

Table 3 presents the distribution of participants' practice levels regarding biomedical waste management (n=112). Participants' responses varied across different aspects of waste management practices.

Regarding applying rules for biomedical waste management, a majority reported frequently (Often: 23.2%, Always: 43.8%), resulting in a mean score of 2.09 (SD = 0.906). Similarly, principles of segregation were often followed (Often: 25.9%, Always: 50.0%), yielding a mean of 2.23 (SD = 0.880). Participants demonstrated high adherence to correctly identifying color coding for waste segregation (Often: 25.0%, Always: 64.3%), with a mean score of 2.51 (SD = 0.759).

Regarding universal precautions, a significant proportion consistently followed these practices (Often: 21.4%, Always: 56.3%), resulting in a mean of 2.32 (SD = 0.862). Usage of disposal bags before segregation also showed frequent adherence (Often: 25.0%, Always: 45.5%), with a mean of 2.13 (SD = 0.921). Gloves were regularly used during patient care and waste management (Often: 16.1%, Always: 69.6%), with a mean score of 2.54 (SD = 0.782).

Conversely, a notable proportion admitted to occasionally putting biomedical waste in the wrong bins (Sometimes: 24.1%, Always: 9.8%), resulting in a lower mean score of 0.73 (SD = 0.995). Preventative practices such as not recapping

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needles to avoid injury showed mixed adherence (Never: 45.5%, Sometimes: 15.2%, Always: 31.3%), yielding a mean of 1.25 (SD = 1.319).

Overall, the total mean score for practice was 25.63 (SD = 5.86), ranging from a minimum of 7 to a maximum of 37. Participants' practice levels were categorized as follows: 41.1% (46 participants) exhibited a low level of practice, 25.9% (29 participants) showed a moderate level, and 33.0% (37 participants) demonstrated a high level of practice in biomedical waste management.

Table 3. Distribution of Participants' Practice Level about Biomedical Waste Management (n=112)

Variables	Correct Answer		Incorrect Answer		Mean (SD)
	N	%	N	%	
I apply the rules of bio medical waste management	2 (1.8)	35 (31.3)	26 23.2)	49 (43.8)	2.09±.906
I follow the principles of segregation of bio medical waste management	3 (2.7)	24 (21.4)	29 (25.9)	56 (50.0)	2.23±.880
I correctly identify color coding of the segregation for biomedical waste	3 (2.7)	9 (8.0)	28 (25.0)	72 (64.3)	2.51±.759
I follow the universal precautions while caring patients and dealing biomedical waste	2 (1.8)	23 (20.5)	24 (21.4)	63 (56.3)	2.32±.862
I used disposal bag before the segregation of biomedical waste	4 (3.6)	29 (25.9)	28 (25.0)	51 (45.5)	2.13±.921
I used gloves while touching patients and segregation of biomedical waste	2 (1.8)	14 (12.5)	18 (16.1)	78 (69.6)	2.54±.782
I put biomedical waste in wrong bin	63 (56.3)	27(24.1)	11 (9.8)	11 (9.8)	.73±.995
I did not recap needle to prevent needle stick injury	51 (45.5)	17 (15.2)	9 (8.0)	35 (31.3)	1.25±1.319
I separately discard of infectious and non-infectious materials	4 (3.6)	22 (19.6)	24 (21.4)	62 (55.4)	2.29±.905
I immediately report any incident, hazard or injury related to biomedical waste	7 (6.3)	25 (22.3)	27 (24.1)	53 (47.3)	2.13±.969
I complete the vaccination course against for hepatitis B	9 (8.0)	4 (3.6)	10 (8.9)	89 (79.5)	2.60±.895
I maintain the post prophylaxis is management	28 (25.0)	22 (19.6)	26 (23.2)	36 (32.1)	1.63±1.179
I attend on training program regarding biomedical waste management	39 (34.8)	34 (30.4)	16 (14.3)	23 (20.5)	1.21±1.132
Total Practice			Min -Max (7-37)		25.63±5.86
Level of Practice					
Low level of practice		46		41.1%	
Moderate level of practice		29		25.9%	
High level of practice		37		33.0%	

Table 4 provides insights into the relationship between knowledge, practice on biomedical waste management, and socio-demographic characteristics among the participants (n=112). Age did not correlate significantly with either knowledge (r=0.090, p=0.347) or practice (r=-0.121, p=0.203) related to biomedical waste management. Similarly, there were no significant differences between males and females in terms of their knowledge (t/r/F = -2.251, p=0.782) or practice (t/r/F=0.439, p=0.551) regarding biomedical waste management. However, higher education levels showed a significant association with both knowledge (t/r/F=3.871, p=0.024) and practice (t/r/F=2.473, p=0.049) in biomedical waste management, indicating that participants with Basic & Post Basic B.Sc., and MPH/MSS qualifications tended to exhibit higher levels of knowledge and practice compared to those with a diploma. Years of experience and the specific ward where nurses worked did not significantly influence their knowledge or practice in biomedical waste management (experience: knowledge r=0.153, p=0.107; practice r=0.077, p=0.417; ward type: knowledge t/r/F=1.499, p=0.219; practice t/r/F=1.330, p=0.269). Overall, neither the total knowledge score (r=0.037, p=.697) nor the level of knowledge (low, moderate, high) (r=-0.023, p=0.808) showed significant associations with practice in biomedical waste management among the participants.

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Table 4. Relationship Between Practice on Biomedical Waste Management, Knowledge, and Socio-Demographic Characteristics among Participants (N=112)

Variables	Category	Knowledge			Practice		
		Mean ± SD	t/r/F	p	Mean ± SD	t/r/F	p
Age			0.090	0.347		-0.121	0.203
Sex			-2.251	0.782		0.439	0.551
	Male	7.62±2.39			26.30±5.55		
	Female	9.05±2.13			25.54±5.92		
Education			3.871	0.024		2.473	0.049
	Diploma	8.11±2.54			26.00±4.87		
	Basic & Post Basic	9.33±1.91			25.95±5.45		
	MPH/MSS	8.75±1.98			21.25±10.89		
Experience			0.153	0.107		0.077	0.417
Working Place			1.499	0.219		1.330	0.269
	Medicine Ward	8.25±2.17			27.10±6.99		
	Surgery ward	9.19±2.00			25.66±4.19		
	ICU	8.81±2.31			25.54±5.86		
	Gynaecology Ward	9.50±1.79			23.70±5.90		
Total Knowledge						0.037	0.697
Total Knowledge Level						-0.023	0.808

DISCUSSION

This section highlights nurses' knowledge and practice level about biomedical waste management and its relationship with their socio-demographic profile in a structured way.

The findings from this study reveal varying levels of knowledge among nurses regarding biomedical waste management. Specifically, 24% of participants demonstrated a high level of knowledge, 39.3% had a moderate level, and 36.6% showed a low level of knowledge on this crucial aspect of healthcare practice. These results differ notably from previous studies, which reported higher average levels (66%) and a significant proportion (32%) with good knowledge among nurses (Olaifa et al., 2018; Ranu et al.,2016), highlighting inconsistencies in knowledge levels across different contexts.

Regarding specific aspects of biomedical waste management, a substantial majority (81.3%) of participants in this study were well-informed about biomedical waste management schedules, aligning closely with findings from a prior study (Al Balushi et al., 2018). In contrast, Muthoni, Nyerere, and Nagui (2016) reported that only 54.5% of respondents knew these schedules, indicating discrepancies in awareness levels across studies. Similarly, while only 10.7% of participants correctly identified types of biomedical waste in this study, other research reported higher recognition rates (72.7% and 82.5%, respectively) (Anand et al., 2016; Naidana and Surapaneni, 2013), underscoring inconsistencies in knowledge across different settings. Moreover, the study found that 81.2% of participants understood the basic principles of segregating biomedical waste, comparable to findings from previous studies which reported similar levels of awareness (70.6% and 82%, respectively) (Soyam et al., 2017; Mir et al., 2013). However, discrepancies were noted in identifying color coding and universal precautions, where findings from other studies either aligned closely or differed significantly from the current study's results (Vishal et al., 2012; Sharma et al., 2013). These variations emphasize the need for targeted interventions to improve uniformity in biomedical waste management knowledge and practices among healthcare professionals.

In the case of practice level, this study reveals varied levels of practice among nurses regarding biomedical waste management, with 41.1% demonstrating a low level, 25.9% a moderate level, and 33.0% a high level of practice. These results differ notably from previous study (Olaifa et al., 2018) reported a higher percentage of nurses exhibiting moderate (54.5%) and high (0.6%) levels of practice, highlighting inconsistencies in practice levels across different contexts. Similarly, an earlier study found that a substantial proportion of nurses exhibited good (36%) and average (59%) levels of practice (Ranu et al.,2016), further underscoring discrepancies compared to the current study.

In examining specific practices related to biomedical waste management, this study found that a significant majority (43.8%) of participants always applied the rules of biomedical waste management, contrasting with findings from other study where a higher percentage (59%) adhered to these rules (Ranu et al.,2016). Regarding the segregation of biomedical waste, 50.0% of participants in this study always maintained the principles, which differs from the higher compliance rates

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(81.25%) reported by a researcher team in their study (Mor et al., 2017). Moreover, while 64.3% of participants always used the correct disposal bins in this study, a study found a higher percentage (92.7%) among nurses in Bangladesh (Bhattacharjee and Saha, 2015), indicating regional variations in practice standards.

Regarding universal precautions, 56.3% of participants in this study always followed these precautions, which is consistent with findings by some prior studies where approximately 50% of nurses adhered to universal precautions (Chaudhuri et al., 2016; Sharma and George, 2014). However, discrepancies were noted in the use of disposal bags, with 45.5% of participants always using them in this study compared to 92.6% reported by a study in India (Anozie et al., 2017). Regarding hepatitis B vaccination, 79.5% of participants in this study completed the vaccination course, aligning closely with other findings that reported similar high vaccination coverage rates (Al Balushi et al., 2018; Anand et al., 2016). Lastly, only 34.8% of participants attended training sessions on biomedical waste management, contrasting sharply with higher attendance rates (61.6%) reported by Uddin et al. (2014), indicating a potential gap in training opportunities for healthcare professionals in this study's context.

The present study explored the relationship between knowledge and practice related to biomedical waste management among participants, finding no significant associations with sociodemographic variables such as age, sex, education, years of working experience, and specific working departments. Despite the lack of statistical significance in these relationships, notable differences were observed in mean scores and standard deviations between knowledge and practice groups. For instance, while age did not significantly correlate with practice, Khan et al. (2017) also noted a non-significant relationship in their study, suggesting age may not be a determining factor in adopting biomedical waste management practices.

Similarly, the study found that although the relationship with sex was not statistically significant, female respondents had a higher mean knowledge score (9.05 ± 2.13) than males, whereas males exhibited a higher mean score in practice (26.30 ± 5.55). This aligns with previous findings indicating potential gender differences in knowledge acquisition versus practical application in healthcare settings (Khan et al., 2017).

Regarding education, while a statistically significant association was found between education level and both knowledge ($F = 3.871$, $p = 0.024$) and practice ($F = 2.473$, $p = 0.089$) in this study, the mean knowledge score was highest among participants with Basic & Post Basic qualifications (9.33 ± 1.91), whereas those with Diploma qualifications demonstrated the highest mean practice score (26.00 ± 4.87). These findings suggest that while higher education may enhance knowledge levels, practical application may vary across educational backgrounds, echoing the nuanced relationship highlighted by a previous study (Vishal et al., 2012).

In contrast, the study found no significant association between years of working experience and knowledge, although this relationship showed a higher correlation than age with practice. This finding mirrors observations by other study suggesting that while experience may contribute to knowledge accumulation, its impact on practice may not always be straightforward (Khan et al., 2017). These insights underscore the complex interplay between knowledge acquisition, educational background, and practical implementation of biomedical waste management practices among healthcare professionals.

CONCLUSION

This study revealed varying levels of knowledge among senior nurses regarding biomedical waste management (BMW), with 24.1% demonstrating high knowledge, 39.3% moderate knowledge, and 36.6% low knowledge. This distribution underscores the need for targeted educational interventions to enhance understanding across all aspects of BMW, including waste types, segregation principles, and infection control measures.

Regarding practices, the study found that 33.0% of nurses exhibited high levels, 25.9% moderate levels, and 41.1% low levels of practice in BMW management. This indicates significant gaps in translating knowledge into consistent, effective practices, emphasizing the importance of educational initiatives to bridge these gaps and ensure comprehensive BMW management practices.

On the other hand, higher educational qualifications were significantly associated with both higher knowledge and practice levels in BMW management, highlighting the importance of educational initiatives tailored to different nursing demographics. However, factors such as age, gender, years of experience, and specific ward assignment did not show significant correlations with knowledge or practice levels, suggesting a need for uniform educational interventions across all nursing demographics.

Regarding policy and training implications, the study underscores the urgent need for standardized training programs and policies tailored to BMW management, especially targeting nurses with lower knowledge and practice.

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Implementing comprehensive policies, regular refresher courses and certification programs could help bridge existing gaps and ensure adherence to BMW guidelines.

While the study's findings are valuable, they are limited to a single tertiary hospital in Bangladesh. Future research could expand the scope to include multiple hospitals across different regions to capture broader trends in BMW management practices. Longitudinal studies could also assess the effectiveness of educational interventions over time in improving knowledge retention and practice sustainability among healthcare providers.

In a nutshell, enhancing the knowledge and practice of BMW management among nurses is crucial for mitigating health risks associated with biomedical waste. Healthcare facilities can contribute significantly to creating a safer and healthier environment for healthcare workers and the broader community by addressing these challenges through targeted educational initiatives and policy reforms.

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