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SAFEGUARDING THE ENVIRONMENT: INSIGHTS INTO BIOMEDICAL WASTE MANAGEMENT PRACTICES AMONG SAUDI NURSING STUDENTS

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Abstract: Biomedical waste (BMW) is any waste generated during the diagnosis, treatment, or immunization of humans or animals. BMW can be classified into general waste, pathological, radioactive, chemical, infectious, sharps, and pharmaceuticals. BMW management is essential to protect human health and the environment. The proper BMW management process includes handling, segregation, mutilation, disinfection, storage, transportation, treatment, and disposal. BMW management is still in its infancy in many parts of the world. This is due to a number of factors, including lack of awareness, lack of resources, and lack of enforcement. The purpose of this review is to provide an overview of BMW management, including its importance, challenges, and best practices.

Keywords: biomedical waste, waste management, infection control, environmental protection, Attitude, Biomedical Waste Management, interns, Knowledge, Nursing Students, Practices,
Saudi Arabia

1. Introduction

Today, with tremendous advancement in global healthcare facilities, BioMedical Waste (BMW) becomes a universal issue (Mathur et al., 2012). The waste generated during healthcare related procedures carries a higher potential for infection and injury than any other type of waste. Biomedical Waste is defined as "any solid, fluid or liquid waste, including its container and any intermediate product, which is generated during its diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biological and the animal waste from slaughterhouses or any other like establishments" (WHO, 2009). Major sources of BioMedical Wastes (BMW) consist of hospitals, labs, medical research, blood banks, nursing homes, mortuaries, autopsy contemn, or sources include dental and medical clinics, cosmetic clinics, and paramedics (WHO, 2019). So, BMW can classify into General Waste, Pathological, Radioactive, Chemical, Infectious, Sharps, and Pharmaceuticals (Mathur et al., 2012).

The appropriate biomedical waste management (BMWM) process includes vital steps, including handling, segregation, mutilation, disinfection, storage, transportation, treatment, and disposal (Ajmera & Jayalkshmi, 2016; Singh et al., 2014). The purposes of BMWM are mainly to reduce waste generation, ensure its efficient collection, handling, and safe disposal in such a way that it controls infection and improves safety for employees

working in the system (Mirza et al., 2016). A strict adherence to biomedical waste rule is required by all those who are involved in dealing with BMWM in any manner and to every institution that generate BMW (Marla et al., 2018).

Biomedical waste management is nevertheless at the infancy stage and recently got attention (Babu et al., 2009) due to increased awareness about human immunodeficiency virus, hepatitis B virus, hepatitis C virus, and diverse potentially infectious diseases (Kumar et al., 2015). Hospital waste management has varied ramifications as it not merely affects the patients' health but also healthcare providers (doctors, nurses, technicians, and housekeeping staff. etc.) and public (Mathur et al., 2011). It is estimated that 80-85% of the BMW is noninfectious general waste, 10% is infectious and 5% is other hazardous waste.

Nonetheless, if the infectious components get mixed with the general waste, the entire bulk of hospital waste potentially becomes infectious (Haider et al., 2015). However, evidence from different kinds of literatures explained that the proportion of hazardous waste is varied from country to country ranging from 20% to 75% (Deress, 2018). The greatest risk of biomedical waste is from the contagious and sharp components as health care personnel and people associated with handling them are usually getting needle prick injuries and can acquire infections like HIV/AIDS, HBV, and HCV (Patil et al., 2013). Other hazards associated with poor waste management include risks related to hazardous chemicals or drugs and disposables being repacked and sold without being washed. Waste piles also attract variety of disease vectors, including mosquitoes and flies (Malini et al., 2015).

Among the health care team, *nurses* play a crucial role in proper disposal of hospital wastes. They come in a very early step in the chain of hospital waste management process (Haider et al., 2015). Nurses spend maximum time with patients in the ward than any other member of the healthcare team, which increases their exposure and risk to the hazards present in a hospital environment, mostly biomedical waste. Nurses frequently get needle injuries that increase chances of infections, mainly HIV and Hepatitis B and C (Patidar et al., 2014). A previous study found that there were around 700 injuries per 1000 nursing staff per week out of which 60% were because of needles occurred during recapping or handling but few were due to discarded sharps (Ahmed, 2012).

Therefore, health and safety of the nursing staff is cardinal feature of biomedical waste management. Although biomedical waste management cannot be obtained without the cooperation of each employee and patient, nursing personnel play a vital role in this whole process. They are also responsible for warding off risk owing to waste to the other members of health team, students, and community at large (James et al., 2016). Sound knowledge, positive attitude, and safe practices among all staff members need to be strengthened (Ahmed, 2012). They need to be adequately furnished with latest information, skills and practices in managing this waste besides reducing hospital-acquired infections to protect their own health (James et al., 2016).

More specifically, nursing students and intern nurses as future nursing work force should be provided with plenty knowledge of discrete steps of waste management for the success of any health care waste management program and to ensure safe practice. Nursing students during and after completing their studies are at potential risk for hazards owing to biomedical waste because of the contact with hospitals. Tomorrow, these students will be running to perform independently in distinct health facilities and be the health leaders (Mirza et al., 2016). Recently, importance has been placed on enhancing students' career development competencies, which comprise knowledge, attitudes, skills, and talent development which are vital for successful progression in work life (Abou Hashish, 2019)

Knowledge, Attitude, Practices (KAP) of nursing students are inevitable aspects in biomedical waste management (Mathur et al., 2011). If the knowledge, attitude and practice are not up to the point than hospital waste management, imparting of these aspects needs to be enhanced. Adequate nurses' knowledge about the health risk of hospital waste and appropriate methods of handling is fundamental to protect them, safeguard their patients

and the community from many adverse effects (Mirza et al., 2016). Thus, this study concerned with measuring these three aspects.

Operationally, "Knowledge" relates to the awareness, amount of information or understanding about biomedical waste management among nursing students and of a circumstance or fact, gained through association or experience. "Attitude" means a settled way of thinking or feeling about something. Attitude points out the ideas and views of students regarding biomedical waste management. "Practice" measures the actual application or use of an idea, belief or method as opposed to linked theories. It attributes to actions or behaviours of nursing students regarding biomedical waste management in wards and clinical setting (Sidhu & Kaur, 2016; Ahmed, 2012).

1.1 Problem statement

Although there is an increased global awareness among health care professionals about risks with appropriate management techniques, the degree of awareness has been found to be unsatisfactory (Hossain et al., 2011). Specifically, poor BMWM is a problem in most developing countries owing to lack of information and trained clinical staff in the waste management framework. In addition, the absence of BMWM guideline and suitable treatment and disposal methods could further curb the waste management efforts (Hossain et al., 2011). Poor knowledge and improper handling of healthcare waste management present a tremendous risk to the health of the patients, health care professionals specially nurses as well as to the public besides contributing to the serious health consequences and a significant impact on the environment as well (Mathur et al., 2011; Haider et al., 2015). Lack of awareness and inadequate knowledge can lead to the hospitals becoming a hub of spreading diseases rather than working toward eradicating those diseases (Chaudhari & Mahajan, 2018).

Most of related studies about the awareness of waste management among the nursing students were conducted in foreigner countries (Chaudhary & Mahajan, 2018; Ajmera & Jayalkshmi, 2016; James et al., 2016; Sidhu & Kaur, 2016; Haider et al., 2015; Ahmed, 2012). In Kingdom of Saudi Arabia (KSA), little was reported about the level of knowledge, attitude, practice scores, and linked factors among nursing students and intern nurses who have key future roles to ensure effective BMWM.

Considering all these aspects, the researchers felt the need to undertake this research. Measuring the level of knowledge, assessing the attitude, and determining the practice of nursing students and intern nurses and related factors on BMWM are the key objectives to consider for safe healthcare practice. Therefore, this study is aimed at filling this gap and recommending policymakers to design and implement appropriate intervention to improve safe BMWM and to initiate necessary adjustments if need be.

1.2 Aim of the Study

The primary aim of this study was to assess Knowledge, Attitude and Practice (KAP) of undergraduate and interns nursing students regarding Biomedical Waste Management. Further, to explore the factors influencing their KAP of Biomedical Waste Management.

2. Methodology

2.1 Study Design and Setting

A descriptive-cross-sectional research design was conducted at College of Nursing- Jeddah (CON-J), which is affiliated to King Saud bin Abdul-Aziz University for Health Sciences, National Guard Health Affairs, and Saudi Arabia. CON-J admits female Saudi national and awards a Bachelor of Science in nursing (BSN).

2.2 Study Subjects

The study comprised a convenient sample of 315 participants including all undergraduate nursing students enrolled in the academic levels 5 to 8 at CON-J (N=229) and, all intern nurses who enrolled in the internship period (N=86) per the academic year 2018/2019 and willing to participate in the study. *Exclusion criterion was nursing students who enrolled in the fourth academic level.*

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2.3 Instrument

Knowledge, Attitude and Practice of Biomedical Waste Management Questionnaire (KAP-BMWMQ). A structured questionnaire was developed by the researchers based on the relevant literature to achieve the aim of this study. It is a self-administered structured and anonymous questionnaire comprises three parts:

Part 1: Students' demographic characteristics. This part included five questions related to students' demographic characteristics and academic profile such as (age, academic level, previous information on BMWM, the source of this information and learning experience affects their KAP towards BMWM).

Part 2: Knowledge, Attitude and Practice Regarding Biomedical Waste Management: This part consists of 43 items to measure participants' responses on three domains: Knowledge, Attitude, and Practice:

A-Knowledge domain consists of 19 questions covering general information (7 items), waste management (7 items), colour coding (2 items), and risk associated (3 items). Responses on this domain used Yes (1) and NO (0) format. The overall score ranged from 0 to 19. Maximum score for knowledge question was 19. The knowledge score was divided into two categories, i.e., inadequate knowledge (<10), and adequate knowledge (11-19). Knowledge scores below and above or equal to the mean score were assigned for inadequate and adequate knowledge.

B-Attitude domain comprises 13 Likert items addressing four subscales: importance of biomedical waste management (4 items), self-responsibility and reporting (4 items), teamwork (2 items), and training and education (3 items). Responses were framed using a 3-point Likert scale range from (1) "Disagree (1), Undecided (2), and Agree (3)". The total score ranged from 1 to 39. The Attitude score was classified into two categories, i.e., unfavorable (<20), and favorable attitude (21–39). Attitude scores below the mean and above or equal to mean score were assigned for unfavorable and favorable attitude.

C-Practice domain includes 11 questions with four subscales: Role in Waste Management (3 items), Selfprotection measures (3 items), Needle stick injury (3 items), and Reporting (2 items). Responses were dichotomized by giving "1" or "0" point for Yes and No options, respectively. The total score ranged from 0 to 11. The practice scores were grouped into two categories, i.e., poor practice (<6), and good practice (6–11). Practice scores below the mean and above or equal to the mean score were assigned for inadequate and adequate practice.

Part 3: Factors influencing KAP of Biomedical Waste Management. This part comprises two open-ended questions that claimed the participants to point out what are the major facilitators and barriers that affect their KAP of Biomedical Waste Management from their point of view. Responses were presented by No and %

2.4 Validity and Reliability

The study instrument **(KAP-BMWMQ)** was tested for content validity by the first author and expert academic members in the field of study. Accordingly, the required modification made. Also, it was proved for internal reliability using Cronbach's alpha correlation coefficient and found reliable where alpha $\alpha = 0.89$. In addition, a pilot study was conducted on 5% of nursing students.

2.5 Data collection

After obtaining the needed approval, the KAP-BMWMQ was distributed in its English form for nursing students and intern students who agreed to participate in the study. Data were collected in participants' break time, which was identified from their academic and clinical (Rota) schedules.

2.6 Data analysis

Data coded by the researchers and statistically analysed using Statistical Package for the Social Science (SPSS) version 22. Frequency and proportions were utilized for describing demographic attributes and reported factors affecting KAP. Descriptive statistics such as mean, and standard deviation applied to summarize the data. For

comparison between numerical data, chi square χ^2, Student's t test, and Analysis of Variance (ANOVA) were employed. P value of ≤.05 considered as the level of significance.

2.7 Ethical considerations

Institutional Review Board (IRB) approval was obtained from King Abdullah International Medical Research Centre (KAIMRC) No (SP19/048/J). The researchers explained the aim of the study to all participants. The privacy and confidentiality of data were maintained and assured by having participants' informed consent. The researchers granted the anonymity of participants and the right to withdraw from the study at any time with no coercion.

3. Result

3.1 Demographic Characteristics

Table 1 illustrates that mean age for study participants was 22.34 ± 1.04 years old with the highest percentage (64.8%) belong to the age group ≤ 21 years. About one quarter (27.3%) of them represents intern nurses and the rest of the participants (undergraduate nursing students) were distributed across the different academic levels. The largest proportion (63.5%) had no previous information about Biomedical Waste Management. Lecture was the most addressed sources of information (48.70%) among those who have previous information followed by workshops (42.61%). About two-thirds (64.4%) perceived classroom and clinical together as learning experience affect their attitude toward BMW compared to each of classroom learning experience (27.3%) and clinical experiences (8.3%).

Table 1. Distribution of Saudi Nursing Students and intern nurses According to Demographic and Academic Characteristics (N =315)

Interns (n = 86)		Nursing Students (n = 229)		Total (N = 315)	
Part I: Demographic/ Academic Data.					
No.	**%**	**No.**	**%**	**No.**	**%**

*Many responses by one participant

3.2 Mean Score and Level of knowledge regarding biomedical waste management

Referring to knowledge of biomedical waste management, table 2 displays the overall mean percent score of knowledge represented by 49.52±23.62. Above one half of undergraduate nursing students and intern nurses (57.5%) had inadequate knowledge level. The highest knowledge mean was for risks associated dimension (74.39±29.39) followed by waste management (52.24±28.67), and colour coding (40.32 ± 43.46). While general information had the lowest mean score (38.78±30.87).

In addition, table 2 shows significant statistical differences between the two studied groups concerning their overall knowledge of biomedical waste management where (t= 7.983, P<0.001). Intern nurses had higher mean (64.20±18.77) compared to undergraduate nursing students (44.01± 22.92). The same trend of result was reflected in the related knowledge dimensions except for risks associated dimension which reveal no significant difference between the two groups (P=0.149).

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Table 2. Mean Score and Level of knowledge regarding biomedical waste management among nursing students and interns (N=315)

Knowledge of Biomedical Waste Management	Nursing Students (n = 86)		Interns (n = 229)		Total (N = 315)		Test of sig(P)
	No.	%	No.	%	No.	%	
Knowledge Level							
Inadequate knowledge(<10)	27	31.4	154	67.2	181	57.5	χ^2=32.880
Adequate knowledge (11-19)	59	68.6	75	32.8	134	42.5	(<0.001*)
	Mean ± SD		**Mean ± SD**		**Mean ± SD**		
Overall Knowledge	**64.20 ± 18.77**		**44.01 ± 22.92**		**49.52 ± 23.62**		t= 7.983(<0.001*)
General Information	53.65 ± 26.47		33.19 ± 33.19		38.78 ± 30.87		t= 5.851(<0.001*)
Waste Management	69.27 ± 21.97		45.85 ± 28.32		52.24 ± 28.67		t= 7.757(<0.001*)
Color Coding	62.21 ± 42.66		32.10 ± 40.91		40.32 ± 43.46		t= 5.752(<0.001*)
Risks associated	78.29 ± 30.15		72.93 ± 29.03		74.39 ± 29.39		t= 1.447(<0.149)

χ^2: Chi square test t: Student t-test

p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

3.3 Mean Score and attitude Level towards biomedical waste management

Table 3 reveals the participants' attitude towards biomedical waste management. Almost all undergraduate nursing students and intern nurses (99.7%) had a favorable attitude level represented by mean percent score 82.04±13. 63. Perceived importance of biomedical waste management has the highest mean (84.09±16.91) followed by self responsibility and reporting (82.54±18.52), and training and education (80.37±21.61) while teamwork was rated as the lowest mean scores (79.44±24.92). Also, Table 3 reveals no statistically significant differences between the two studied group regarding their overall attitude towards biomedical waste management (t= 0.941, *P*=0.347) as well as its related dimensions except for Training and Education where Nursing Students have higher mean than Interns (t= 2.229, *P*=0.027).

Table 3. Mean Score and Attitude Level towards biomedical waste management among nursing students and interns (N=315)

Attitude towards Biomedical Waste Management	Nursing Students (n = 86)		Interns (n = 229)		Total (n = 315)		Test of sig(P)
	No.	%	No.	%	No.	%	
Attitude Level							

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Unfavorable (<20)	0	0.0	1	0.4	1	0.3	$\chi^{2\,(FE}p)=$ 0.377 (1.000)
	86	100.0	228	99.6	314	99.7	
	Mean ± SD		**Mean ± SD**		**Mean ± SD**		
	80.86 ± 13.41		**82.48 ± 13.72**		**82.04 ± 13.63**		t=0.941(0.347)
	84.3 ± 16.18		84.01 ± 17.21		84.09 ± 16.91		t=0.138(0.890)
	82.56 ± 19.58		82.53 ± 18.15		82.54 ± 18.52		t=0.011(0.991)

Favorable attitude (21–39)

Overall attitude

Perceived Importance of BMW Self Responsibility and reporting

Teamwork 77.91 ± 27.5 80.02 ± 23.92 79.44 ± 24.92 t= 0.670(0.503)

Training and Education 75.97 ± 21.33 82.02 ± 21.53 80.37 ± 21.61 t= 2.229(0.027*)

□²: Chi square test FE: Fisher Exact t: Student t-test p: p value for comparing between the studied groups *: Statistically significant at p ≤ 0.05

3.4 Mean Score and practice Level of biomedical waste management

Table 4 reveals the overall mean percent score of practice level of biomedical waste management displayed by 51.0±25.5. The highest proportion of participants (58.1%) had a good practice of BMWM compared to (41.9%) who had poor practice level. Regarding the related practice dimensions, self-protection measures had the highest mean (69.31±36.53) followed by role in waste management (50.69±36.51), and needle stick injury (41.27±29.93) while reporting was scored as the lowest mean (38.57±41.23). Table 4 shows significant statistical differences between the two studied groups concerning their overall practice of biomedical waste management where (t= 9.347, *P*<0.001). Intern nurses had higher mean (68.29±18.01) compared to undergraduate nursing students (44.5±24.89). The same trend of result was reflected in the related practice dimensions where (*P*<0.001).

Table 4. Mean Score and Level of Practice regarding biomedical waste management among nursing students and interns (N=315)

Practice of Biomedical Waste Management	**Nursing Students (n = 86)**		**Interns (n = 229)**		**Total (N = 315)**		**Test of sig(P)**
	No.	**%**	**No.**	**%**	**No.**	**%**	
Practice Level							
Poor practice (<6)	11	12.8	121	52.8	132	41.9	□²=41.188
Good practice (6–11)	75	87.2	108	47.2	183	58.1	(<0.001*)
	Mean ± SD		**Mean ± SD**		**Mean ± SD**		
Overall practice	**68.29 ± 18.01**		**44.5 ± 24.89**		**51.0 ± 25.5**		t= 9.347(<0.001*)
Role in Waste Management	73.26 ± 26.97		42.21 ± 36.05		50.69 ± 36.51		t= 8.257(<0.001*)
Self-protection measures	90.31 ± 22.79		61.43 ± 37.62		69.31 ± 36.53		t= 8.263(<0.001*)
Needle stick injury	51.16 ± 27.86		37.55 ± 29.89		41.27 ± 29.93		t= 3.666(<0.001*)
Reporting	53.49 ± 43.24		32.97 ± 39.1		38.57 ± 41.23		t= 4.029(<0.001*)

□²: Chi square test t: Student t-test p: p value for comparing between the studied groups

*: Statistically significant at $p \leq 0.05$

3.5 Mean Score of Knowledge, Attitude and Practice Regarding Biomedical Waste Management by the Current undergraduate Academic Level

Table 5 displays a significant difference among undergraduate nursing students across the various academic levels regarding their overall mean score of Overall Knowledge (F=20.324, *P*<0.001) and Overall practice (F =52.024, *P*<0.001). Students at level seven had the highest knowledge mean (55.12±22.72) while undergraduates at level eight had the higher practice mean (60.73±21.45) contrasted to students at level five who possess the lowest knowledge and practice means. On the other hand, there is no significant difference among nursing students across the different academic levels regarding their overall attitude towards BMWM (F=0.406, *P*<0.805).

Table 5. Mean Score of Knowledge, Attitude and Practice Regarding Biomedical Waste Management by the Current undergraduate Academic Level (N=229)

	Academic level				
Mean ± SD.	**Fifth (n =66) Mean ±SD.**	**Six (n =75) Mean ± SD.**	**Seventh (n =38) Mean ± SD.**	**Eighth (n =50) Mean ±SD.**	**F(P) Mean % score**
Overall Knowledge	34.77±26.45	44.21±19.11	55.12±22.72	47.47±18.77	20.324(<0.001*)
Overall attitude	83.22±19.39	81.38±9.16	82.89±7.78	82.85±14.21	0.406(0.805)
Overall practice	23.14±27.49	48.85±15.66	51.67±11.4	60.73±21.45	52.024(<0.001*)

F: F for ANOVA test p: p value for association between different categories *: Statistically significant at $p \leq 0.05$

3.6 Barriers and Facilitators Factors affecting KAP of BMWM as reported by studied participants.

In response to the two open-ended questions asking about perceived factors affecting KAP to BMWM, the number of participants answered these questions was 150 (67.0%). Some of them identified more than one barrier or facilitator to BMWM. The most frequently mentioned barriers to BMWM are lack of adequate knowledge about BMW (100%), Inadequacy of resources like PPEs (86.67%), non-compliance to adhere to the safety rules and guidelines (80.0%), lake of supervision (66.67%), and fear of reporting any mistake, incident and injury (66.67%). On the contrary, participants reported that the most important facilitators that could help in the commitment to BMWM programs are; periodic mandatory education and training programs for BMW (100%), Strict policy, rules, regulation for compliance with BMW (100%), supervision and monitoring of healthcare professionals' practice (100%), availability of safety methods and resources such as sharp containers and PPE (80.0%), culture of error reporting and blame free environment (66.67%).

Table 6. Barriers and Facilitators Factors affecting KAP of BMWM as reported by studied participants (N=150)

Perceived Facilitators* (N=150)	No (%)	Perceived Barriers *	No (%)
Mandatory Periodic training programs for BMW program	150 (100%)	Lack of adequate knowledge about BMW	150 (100%)
Strict policy, rules, regulation for BMW	150 (100%)	Noncompliance to follow the rules	120 (80%)

Supervision and monitoring of healthcare professionals' practice	150 (100%)	Lake of supervision	100(66.67%)
Availability of safety methods and resources such as sharp containers, PPE	120 (80%)	Inadequacy of resources	130(86.67%)
Culture of error reporting blame free environment	100(66.67%)	Fear of reporting any mistake, incident, and injury	100(66.67%)

*****Multiple responses by one participant

4. Discussion

The primary aim of this study was to assess Knowledge, Attitude and Practice (KAP) of undergraduate and interns nursing students regarding biomedical waste management and explore the factors influencing their KAP of Biomedical Waste Management. There is a paucity of research conducted on nursing students to be compared with the current study's findings. Result will be explained in the light of similar studies conducted on health students and health care providers in the clinical setting.

In this study, **Saudi nursing students and interns are aware of Risks associated with biomedical waste, but they are lacking the general knowledge of BMWM, color-coded bags and the disposal methods per category.** Although students are lectured this topic in their undergraduate curriculum and oriented within their clinical training, the result presented participants' needs for more training, and scrutiny from the nurse educators and clinical teaching assistants towards strengthening this knowledge.

This continues in the same way with Begum et al., (2015) who declared that student nurses were lacking the knowledge in all features apparently because of their unfamiliarity with BMWM topic in the syllabus and they never had trainings about it. The result also congruent with the findings of Sidhu & Kaur (2016) who mentioned about 40% of the students have below average knowledge regarding biomedical waste management. Together with Hashemi et al., (2010) they pointed out, there is a call for generating awareness among students concerning biomedical waste as they are presumed to be the boosters of public health in the society soon. In contrast, Rao et al., (2016) found the medical students have good knowledge about the variables related to waste management and high positive attitude regarding all variables of biomedical waste management.

The findings are also parallel with many studies conducted among nurses/healthcare providers. For instance, Mane et al., (2016) detected that majority of the nurses were unaware about the risks linked with biomedical waste which comply to the findings of Sharma et al., (2013) who showed a lack of knowledge and awareness towards BMW among the participants. Similarly, Rajput et al., (2016) reported, most nurses did not know the exact number of color-coded containers needed for biomedical waste management.

It was determined that this curtailed knowledge among nursing students and nurses attribute to insufficient training and educational level of staff which entail higher attention and awareness on Biomedical waste segregation as the most critical step for good waste management, and it should be conducted at the point of generation using color-coded bins (Deress et al., 2018; Begum et al., 2015; Mathur et al., 2011, 2012).

Therefore, attention should be directed toward teaching and training nursing students and nurses for BMWM. Many studies pointed to the obligation of providing regular educational intervention and awareness or all health care personnel as a mean strategy for practical BMWM (Rao et al., 2018; Mane et al., 2016; Mathur, 2011, 2012). Training could inspire motivation and change in mindset of all the healthcare personnel, specifically those in the junior level. Also, displaying Information about BMW risks and offering instructions on waste segregation on posters insides hospitals and clinics near waste bins could be helpful. The present study admitted that **Interns nurses and undergraduate nursing students had a significant and pleasant attitude towards BMWM** most for perceived importance of biomedical waste management and self responsibility while their attitude toward

teamwork requiring to be enhanced. Having a positive attitude might be considered as a prerequisite part of building up knowledge and skills in nursing practice and developing attitude can shape behaviors. Similarly, Pinto et al., (2014) asserted on that positive attitude could play an important role in motivating good practice.
In the same study setting, Abou Hashish et al., (2020) explained that Saudi nursing students had a high attitude level towards general patient safety which pointed out as a crucial and integral part in students' teaching learning process. They attributed also their result to students' enrollment in the clinical experience and exposure, which could make them more confident. This goes in the same line with Tella et al., (2014) who highlighted that the patient is the focal point of safe care, and nursing students can have an influential role through their attitudes and behaviors by having a searching approach and the confidence to work differently.
However, the result proved students' need to be positive in supporting each other and working as a team with others. Working within the team enhances communication and improve learning from other experiences, reduce error and improve performance. Corresponding with this speculation, Wami et al., (2016) found students relate teamwork and participation dimensions to enhanced safety measures. Also, Abou Hashish et al., (2020) revealed that some interviewed nursing students acknowledged that teamwork, communication, and collaboration among students and staff in the unit can boost their overall attitude towards safe practices. In this line, Petty et al., (2016) affirmed that embedding an inter-professional teamwork experience into the undergraduate nursing and medical students curriculum allow students to practice team skills, including collaboration, communication, situational monitoring, mutual support, and leadership, and to enforce team strategies such as briefs, debriefs and huddles.
The result displayed that participants had a moderate good practice level of BMWM especially for Self-protection measures and they require more practice in the area of reporting. Students and Interns even when assigned to practice by themselves yet they are under training and supervision. So, it is an expected result. This conforms to Sidhu and Kaur (2016) who demonstrated that despite having knowledge, there is still a lack in the day-to-day practice of BMWM; this could be because of the no formal training or no strict laws regarding the BMWM.

Reporting incidents, injuries and errors has been cited in many studies as a challenge for nursing students and staff. The low score of reporting in this study might be interpreted by what indicated by nursing students in the qualitative findings, that they nevertheless lack the experience and skills in the area of error disclosure and management besides the fear of reporting system and punishment as barriers (Abou Hashish et al., 2020). Likewise, Safarpour et al., (2017) delineated that students reported barriers such as fear of punishment and negative attitude and pressure by other staff after errors and lack of enough knowledge affect their attitude toward error reporting. Equally, the practice of reporting of injuries arising from improperly disposed biomedical waste found to be miserably low among nursing staff. Abou Hashish and El-Bialy (2013) reported, nurses afraid of reporting errors because of the unpredictable responses of their administrators and fear of being blamed for causing errors.
Hence, nursing students require working in a secure environment allows a blame-free culture where error reporting could promote mindfulness and sensitivity to their own role and responsibility regarding safety practices. In this instance, El-Jardali et al., (2011) signifying the reality that error reporting systems provide valuable data to address a drawback in work systems and processes, in turn, allow nurses to learn from errors and presents an opportunity to improve safety. Furthermore, Langari et al., (2017) concluded that the prevention of incidents and acting after errors are important experiences for students to have during their education, as they can learn from events in which safety is jeopardized.
On comparison between the two studied groups, the present study reported that Interns nurses showed higher knowledge and practice means compared to undergraduate nursing students. Also, knowledge and

practice of BMWM affected by nursing students' academic level. The higher the level, the higher knowledge and practice. This could be attributed to the fact that intern nurses and higher academic level students had more experience and familiarity with hospital infection control practice and procedures application as a part of their training/or nursing duties while caring for patients. Similarly, Abou Hashish & Bajbeir (2018) stated that, with students' enrollment in clinical settings and with their developed years of study, professional knowledge, experiences, and skills expected to increase compared to students at lower levels who has little clinical exposure and experience. Clinical exposure can help nursing students to learn from practice, grasp why errors happen and learn from them (Tella et al., 2014; Langari et al., 2017).

Therefore, Mohapatra et al., (2012) suggested the necessity of getting a balance between effective practical training and theoretical aptitude building which requires a supportive teacher. Also, Tella et al., (2014) recommended for embedding safety topics into nursing education through various teaching and learning strategies. Integrated learning system, clinical safety reporting system, and incidents root cause analysis and Problem Based Learning (PBL),reflective learning experiences are learning methods help to bridge theory-practice gap (Abou Hashish et al., 2020; Abou Hashish & Bajbeir, 2018; Kavitha, 2014).

Barriers and Facilitators of BMWM

Nursing students and intern nurses reported many barriers to BMWM including inadequacy of knowledge and resources like PPEs, noncompliance to adopt the safety rules and guidelines, and lake of supervision. This fit the findings of previous studies which conceded that nursing students reported that noncompliance of staff with infection control measures and standard precautions particularly physicians, workload on nurses and lack of adequate supplies and equipment as barriers hinder safety and make the hospital/work environment unsafe (Abou Hashish et al., 2020). Evenly, Wami et al., (2016) and Pazokian and Borhani, (2017) revealed a lack of proper hospital facilities and working equipment can endanger patient safety and contribute toward an environment in which errors can occur and cause harm to patients.

On the contrary, Nursing students and interns pointed to several facilitators that could support the proper commitment to BMWM such as periodic essential education and training programs for BMW, compliance to strict policy, rules, regulation for BMW, adequate supervision and monitoring of healthcare professionals' practice and students and cultivate a culture of error reporting and blame free environment with adequate concern from hospital manager of providing the staff with adequate safety methods and resources such as sharp containers and PPEs. Clear safety regulations and policies and infection control guidelines in the work/ clinical environment to integrate their knowledge, attitude, practice, and commitment towards safety. This finding is logical and aligns with respondents' perceived barriers.

In this respect, certain recommendations had been highlighted. Al- Momani and Al Momania (2013) asserted on conformity with standard precautions minimizes the risk of hospital infection, and a collaborative effort including the academics and hospital administrators to implement a multidisciplinary hospital-based programs coupled with regular practice audits and performance feedback is needed. In the same line, Ridelberg et al., (2014) and Wami et al., (2016) concluded that participating in the hospital's safety training programs increment the safety culture as the staff spend more times on safety reporting program, this situation favours them to deal more with safety issues.

Moreover, Pazokian and Borhani (2017) advocated for improving facilities and equipment and providing sufficient and efficient personnel are needed to achieve a significant level of effectiveness in clinical services. Likewise, Reid-Searl et al., (2010) pointed out that a supportive learning environment had a crucial role in the students teaching of safety practice as the potential for making mistakes or errors reduced when nursing students adequately supervised by their educators and the danger of errors expanded when nursing students lacked enough

supervision. In such vein, Abou Hashish (2019) concluded that nursing education can play a great role in fostering students' development of the information and skills required in the practice of nursing, and those capabilities that may offer students the potential throughout their careers to conform to and have an impact on changing scopes of practice, health care needs, and a dynamic health care system.

5. Study Strengths and Limitations

This study considered being the first one that led toward measuring Saudi nursing students KAP Level of BMWM and factors influencing with a newly developed and valid questionnaire which could contribute to the existing body of knowledge and might be a suitable point for future researches. However, this current study has some limitations that must be considered. Using a convenience sample of nursing students from one educational institution limits the generalizability of KAP level to all students. Also, data based on students' self-reports which may introduce bias. This warrants the replication of the studies in other nursing colleges using other tools. This study focused on nursing students' perceptions, including nurses and other professional groups may echo another angle to enhance KAP of BMWM. Many prospective investigations are proposed to conquer these limitations.

6. Conclusion

Today's students will be tomorrow's healthcare professionals and it is imperative to make them knowledgeable, competent and prudent for patients and future generations. To safeguard their own health, patients and of the environment, students must have adequate knowledge and a positive attitude toward hospital waste management to work safely. Hence, knowledge, attitude and practice studies are particularly important as they are expected to recognize the current awareness and practice levels and to establish educational programs to resolve the gap between current level and the target.

To sum up, the present study showed varied levels of knowledge, practice and attitudes amongst nursing students and intern nurses showing a KAP significant gap and a need for the continuing education and training for effective BMWM. Participants had inadequate general knowledge of BMWM and color coding. However, they showed up a positive attitude and moderate practice level of BMWM. Intern nurses had the higher knowledge and practice means compared to undergraduate nursing students.

Also, participants identified many barriers and facilitators that influence their KAP. The areas of general knowledge, attitude toward teamwork and practice of incident reporting showing a KAP gap that need to be bridged and enhanced.

7. Implications of the study

The management of biomedical wastages poses a substantial challenge to the nursing manager, nurse educators and staff nurses. *Hence, certain implications are introduced as the study's recommendations:*

7.1 Implications for the Nursing Practice:

- A good-designed periodic comprehensive training and In-service programs about the causes, risk factors, hazards, handling, segregation, transportation and storage of waste in colored bins until final disposal and treatment BMW management should proposed for all staff categories to build up the understanding and information. Lectures, seminars, workshops, journal clubs for Evidence-based practice and research papers, attending various conferences and resource persons are examples of effective teaching- learning strategies.
- The right practices and other activities of BMW management and its ramifications in the form of avoiding injuries, importance of vaccinations and following of universal precautions can be achieved when supported by information, education and communication strategies like handouts, stickers, charts, celebrations of various health events like hand hygiene day and other days etc.

-Error reporting and blame-free culture should be a norm on health care/clinical environment. Therefore, nurses, interns and students must take part in the process of injuries, incidents and errors reporting, analysis and management to enhancing learning.

7.2 Implications for Nursing Administration:

-Written policies, standards and protocol must be clearly set by the Nursing Administrator regarding the Infection control and the waste management techniques.

- Nursing Administrators may facilitate and support the participation personnel in various continuing education programs through adjusting their shift schedules and work assignments.
- Nursing colleges Administrators and Nursing managers should work together to ensure that nursing students and intern nurses provided with adequate professional orientation and supervision during their clinical and internship period. Clinical supervision by Teaching Assistants (TAs) and nurse educators is expected to ensure that students adequately supported and guided in the clinical setting. As well, collaboration and coordination between preceptors, nurse managers and nurse educators should be promoted to provide intern nurses with adequate monitoring and follow up for safe practice.

-The KAP of all persons who are involved in BMWM should be assessed periodically to identify learning needs and fill any gap in their KAP.

7.3 Implications for Nursing Education:

-The topic of biomedical waste management should be more included in the undergraduate academic nursing and medical curricula to understand the importance of BMWM and to manage it efficiently. Seminars should be conducted to refresh the knowledge of the students on each academic level.

7.4 Implications for nursing research:

-Further studies should be replicated on a larger sample and involving all concerned healthcare personals as this would give more significant results and may provide a better assessment tool to test the level of KAP and the ways of improvement.

-Multidisciplinary intervention study can be planned as a longitudinal to assess its impact along with various personnel. All health care professionals regardless of their designation, experience and qualifications must be included in this intervention, so it can avoid cross infections among the professionals and patients in the health care sector.

-A comparative interventional study for nursing students can be conducted be giving one group structured teaching and another group by issuing information booklet to determine its effectiveness and the retention of knowledge.

Conflict of Interest

The authors declare no conflict of interest.

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