

Original article

Assessment of Knowledge, Attitudes, and Practices Regarding Dental Waste Management among Dentists in Benghazi, Libya

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ABSTRACT

Dental clinics generate potentially hazardous wastes (e.g., sharps, blood-contaminated materials, chemicals, and amalgam residues) that pose infection and environmental risks, making it important to assess dentists' knowledge, attitudes, and everyday practices toward safe dental waste management in Benghazi, Libya. Aim: To evaluate knowledge, attitudes, and practices (KAP) related to dental waste management among dentists in Benghazi, Libya. A descriptive cross-sectional survey was administered to 118 registered dental practitioners using a structured, self-administered questionnaire. Associations between demographic variables (age, academic qualifications, employment type, and managerial role) and KAP scores were examined ($p < 0.05$). Higher knowledge was significantly associated with more favorable attitudes and better practices. Older age, lower academic qualifications, employment outside academia, and absence of managerial roles were linked with lower KAP scores ($p < 0.05$). Despite generally adequate knowledge and positive attitudes, gaps in routine waste-management practices persisted. Dentists in Benghazi show satisfactory knowledge and attitudes but suboptimal practical implementation. Targeted training and stronger policy enforcement are recommended to improve compliance and clinical safety.

Introduction

An increasing demand for dental care services has led to a significant rise in the generation of biomedical waste (BMW) [1]. These wastes, if not managed and disposed of in a scientifically sound manner, pose substantial risks to both human health and the environment [2]. Dental care facilities produce considerable amounts of BMW, and improper handling of this waste not only endangers patients and oral health professionals but also places the general public at heightened risk of health hazards [2]. Dental waste is categorized as a component of hospital waste and is broadly divided into two types: liquid waste and solid waste. These categories are further classified into two major groups—non-risk waste and risk waste. The latter includes both infectious and hazardous materials [3]. Infectious waste is known to contain a wide spectrum of pathogenic microorganisms, while hazardous waste consists of materials that include toxic metals such as silver, lead, and mercury. These substances are environmentally persistent and do not degrade after disposal. Common examples include dental amalgam, X-ray films, and chemical disinfectants used in clinical settings [4].

Mercury, particularly from dental amalgam, is recognized as a potent neurotoxin. It is the most toxic non-radioactive and among the most volatile heavy metals. Environmental contamination may occur through the release of mercury from dental facilities and industrial processes due to improper disposal practices. Additionally, other substances such as polystyrenes, barium, and strontium may also present toxic risks if not handled and discarded appropriately [5]. Improper disposal of dental waste can adversely affect dental professionals, ancillary staff involved in material handling, and ultimately, the general population—especially through the emission of toxins during incineration and other waste treatment methods [1].

In recent years, the surge in demand for dental care has resulted in the rapid expansion of dental clinics, which has consequently led to a marked increase in the volume of biomedical waste generated [6]. It is imperative that dental professionals possess comprehensive knowledge and adhere to proper dental waste management protocols to reduce the risk of cross-infection and mitigate the release of harmful toxins into the environment. To guide healthcare workers in this regard, the Ministry of Health's General Directorate for Infection Prevention and Control, in collaboration with the Directorate of Dentistry, has issued an Infection Prevention and Control Manual for Dental Settings. This manual outlines the official policies and procedures expected to be followed by dental healthcare personnel and clearly delineates their responsibilities concerning infection control and waste management [7].

Despite this, the rapid proliferation of dental healthcare facilities in response to public demand has led to a measurable increase in the generation of biomedical waste. Reports indicate that up to 80% of medical and

dental waste is mixed with general waste, thereby rendering otherwise non-hazardous waste toxic and more difficult to manage safely [8]. Although awareness of the health risks and environmental impacts of poor waste management practices is increasing globally among healthcare professionals, a significant number of dental clinics—particularly in countries such as India—remain insufficiently engaged in effective waste management strategies [9]. This study aimed to assess the knowledge, attitudes, and practices related to dental waste management among dental practitioners in Benghazi city, Libya.

Methods

Study design and setting

Cross-sectional questionnaire survey among registered dental practitioners in Benghazi, Libya.

Sample size and power

The minimum sample size for a single proportion was calculated *a priori* using OpenEpi (v.3) with the standard formula for proportions (two-sided 95% confidence level, margin of error = 9%). As the expected prevalence of adequate/acceptable waste-management practices in dentists varies at ~40–45% in recent surveys, we used a p-value of 0.42 (e.g., protocol-adherent behavior \approx is ~42% in a multicenter dental waste survey). This yielded $n = 116$; our achieved $n = 118$ met and slightly exceeded the requirement. Calculation approach and tool are documented by Sullivan et al. (<https://www.openepi.com/SampleSize/SSPropor.htm>) and in a didactic review by Charan & Biswas (2013) [10]. Prior proportion used: Boukhris et al. (2025) [11].

Worked example

$$n = Z^2 \times p(1-p)/d^2 = 1.96^2 \times 0.42 \times 0.58/0.09^2 \approx 115.5 \approx 116$$

Eligibility criteria

Inclusion

The inclusion criteria were licensed dentists aged ≥ 18 years practicing in Benghazi, able to provide informed consent, and available during data collection. While we had excluded individuals unable to participate, those concurrently enrolled in intensive waste-management trainings/interventions, likely to bias responses, or those declining participation.

Instrument

The questionnaire was adapted for this study through contextual edits to align with local regulations and relevant terminology. Its foundational structure, including item wording and topical coverage pertaining to waste segregation, storage, and amalgam handling, was derived from the KAP survey instrument developed by Divya and Nivedhitha in their study on dental waste management. To establish content validity, the adapted instrument was reviewed by an expert panel comprising five specialists in dental public health, infection prevention and control, and environmental dentistry. Furthermore, a pilot test was conducted with a cohort of twenty dentists, who were excluded from the final sample, to assess the clarity of the items and the approximate completion time. The instrument demonstrated acceptable internal consistency, with an overall Cronbach's alpha coefficient of 0.82, a reliability metric consistent with established reports for KAP tools within the allied oral-health literature.

Questionnaire structure

Section 1: demographics/professional data.

Section 2: knowledge (7 items).

Section 3: attitudes (5 items).

Section 4: practices (30 items).

Scoring and categorization

Knowledge was scored dichotomously, with correct responses assigned a value of 1 and incorrect responses a value of 0; a percentage score was calculated as the obtained score divided by the maximum possible score multiplied by 100. Knowledge was categorized as excellent for scores equal to or greater than 65%, average for scores ranging from 50% to less than 65%, and fair for scores below 50%. Attitude was measured on a three-point scale, with positive responses assigned a value of 2, neutral responses a value of 1, and negative responses a value of 0, from which a percentage score was similarly derived. Attitude was classified as positive for percentage scores of 65% or above, neutral for scores from 50% to less than 65%, and negative for scores below 50%. Practice was assessed using a three-level scale, where complete and correct performance received a score of 2, partial performance a score of 1, and incorrect performance a score of 0, with a parallel calculation of a percentage score. Practice was rated as good for scores at or above 65%, fair

for scores between 50% and less than 65%, and poor for scores below 50%. These classification thresholds align with the modified Bloom's taxonomy approach frequently employed in Knowledge, Attitude, and Practice (KAP) studies, which commonly utilize bands such as 60–79% for "moderate" and $\geq 80\%$ for "good" categorization. The a priori decision to establish a slightly stricter threshold of 65% for the middle category is supported by methodological precedents demonstrating acceptable variation in the application of modified Bloom cut-offs.

Data collection

A total of 130 paper questionnaires were hand-delivered to clinics during working hours. Data collection spanned three months. Each survey required ~10–15 minutes. Twelve forms were excluded for incompleteness; 118 complete responses were analyzed.

Data management, confidentiality, and ethics

Surveys were anonymous; no direct identifiers were collected. Each participant was assigned a study code. Completed forms were digitized and stored in a password-protected database accessible only to the research team. Ethical approval was obtained from the Benghazi University—Faculty of Dentistry Research Ethics Committee (approval no. BUFD-2023-021), and written informed consent was secured prior to participation. For infection-control standards referenced to participants, see CDC summary guidance for dental settings and the Saudi MOH dental IPC manual.

Statistical analysis

Data were organized in Microsoft Excel and analyzed in IBM SPSS Statistics v24. Descriptive statistics summarized demographics and KAP distributions. Group differences and associations were evaluated using Chi-square (χ^2) tests. Multivariate logistic regression identified predictors of higher KAP categories. Statistical significance was set at $p \leq 0.05$.

Results

Among the 118 respondents, 56.8% were male, and 43.2% were female, with ages ranging from 26 to 58 years. The study sample represented a wide spectrum of demographic and occupational characteristics. Regarding the level of knowledge on dental waste management, 57.6% of participants demonstrated excellent knowledge, 34.7% exhibited an average level of knowledge, and 7.6% showed only a fair understanding. In terms of attitude, 59.3% of respondents displayed a positive attitude, 35.6% were neutral, and 5.1% expressed a negative attitude. For practices related to dental waste management, 43.2% were classified as having good practice, 38.1% demonstrated fair practice, and 18.6% reported poor practice. The analysis revealed a statistically significant association between higher levels of knowledge and both positive attitudes and good practices regarding dental waste management.

Multivariate logistic regression analysis identified several factors influencing knowledge, attitude, and practice scores. Younger participants were significantly more likely to exhibit excellent knowledge, positive attitudes, and appropriate practices compared to older counterparts. Higher academic qualifications, particularly possession of a PhD, were significantly associated with increased levels of knowledge, more favorable attitudes, and improved practices. Employment in academic institutions was positively correlated with enhanced knowledge, attitude, and practice. Additionally, holding a managerial position was significantly associated with better knowledge and a more positive attitude, though it did not have a statistically significant effect on practice outcomes.

Among 118 respondents, 56.8% were male and 43.2% female; ages ranged from 26 to 58 years. Knowledge levels were excellent in 57.6%, average in 34.7%, and fair in 7.6%. Attitudes were positive in 59.3%, neutral in 35.6%, and negative in 5.1%. Practices were good in 43.2%, fair in 38.1%, and poor in 18.6%.

Higher knowledge was significantly associated with positive attitudes and better practices. Multivariate analyses indicated that younger age, higher academic qualifications (especially PhD), employment in academic institutions, and managerial roles predicted higher knowledge and more favorable attitudes; managerial roles showed limited direct association with practice after adjustment.

Table 1. Basic demographic and occupation characteristics data of the studied group

Demographics	Number	Percent
Age		
<30	32	27.1
30-40	28	23.7
40-50	33	28.0
>50	25	21.2
Sex		

Male	67	56.8
Female	51	43.2
Academic degree		
Bachelor's	47	39.8
Diploma	33	28.0
Master	30	25.4
PhD	8	6.8
Do you work in college?		
Yes	47	39.8
No	71	60.2
Is the clinic affiliated with a hospital?		
Yes	65	55.1
No	53	44.9
How long have you had experience working as a dentist?		
<5	40	33.9
5-10	42	35.6
>10	36	30.5
What are your average daily working hours?		
<8	81	68.6
8-10	37	31.4
Do you hold a management position?		
No	84	71.2
Yes	34	28.8
Total	118	100.0

Table 2. Distribution of the studied group regarding their Scoring of knowledge, attitude, and practice towards dental waste management

Dental waste management	Number	Percent
Knowledge		
Excellent	68	57.6
Average	41	34.7
Fair	9	7.6
Attitude		
Positive	70	59.3
Neutral	42	35.6
Negative	6	5.1
Practice		
Good	51	43.2
Fair	45	38.1
Poor	22	18.6
Total	118	100.0

Table 3. The relation between the level of knowledge and both attitude and practice towards dental waste management

Variables	Knowledge						Total	P value
	Excellent "n=68"		Average "n=41"		Fair "n=9"			
	No.	%	No.	%	No.	%		
Attitude								
Positive	63	92.6	7	17.1	0	0.0	70	0.0021*
Neutral	5	7.4	33	80.5	4	44.4	42	
Negative	0	0.0	1	2.4	5	55.6	6	
Practice								

Good	50	73.5	1	2.4	0	0.0	51	0.001*
Fair	16	23.5	28	68.3	1	11.1	45	
Poor	2	2.9	12	29.3	8	88.9	22	

Table 4. Multivariate analysis of different demographic factors affecting knowledge, attitude, and practice

Variables	Knowledge		Attitude		Practice	
	Odd's ratio	P value	Odd's ratio	P value	Odd's ratio	P value
Age						
<30	2.03	0.002*	2.41	0.001*	2.51	0.0016*
30-40	1.88	0.013*	2.11	0.004*	2.07	0.006*
40-50	1.07	0.65	2.33	0.001*	1.65	0.017*
>50 "Reference item."	1.0		1.0		1.0	
Sex						
Male "Reference item."	1.0		1.0		1.0	
Female	1.20	0.67	1.16	0.77	0.97	0.211
Academic degree						
Bachelor's "Reference item."	1.0		1.0		1.0	
Diploma	1.22	0.32	1.29	0.21	1.17	0.107
Master	1.82	0.38	1.69	0.046*	2.1	0.005*
PhD	2.35	0.001*	2.41	0.002*	2.66	0.001*
Do you work in college?						
Yes	2.16	0.005*	1.89	0.009*	1.75	0.011*
No "Reference item"	1.0		1.0		1.0	
Is the clinic affiliated with a hospital?						
Yes	1.25	0.233	1.30	0.133	1.11	0.399
No "Reference item"	1.0		1.0		1.0	
How long have you had experience working as a dentist?						
<5 "Reference item."	1.0		1.0		1.0	
5-10	1.42	0.116	1.22	0.29	1.03	0.58
>10	1.55	0.081	1.51	0.073	1.24	0.48
What are your average daily working hours?						
<8 "Reference item."	1.0		1.0		1.0	
8-10	1.06	0.51	1.09	0.48	1.1	0.44
Do you hold a management position?						
No "Reference item"	1.0		1.0		1.0	
Yes	1.84	0.014*	1.92	0.011*	1.21	0.255

Discussion

Workplace environments present a multitude of potential exposure risks. Occupational illnesses may result from chemical, physical, biological, and ergonomic hazards, while injuries may stem from structural deficiencies or procedural errors. Despite technological advancements such as LASER systems and electromagnetic sources, traditional occupational hazards, particularly biological agents, remain prevalent concerns in healthcare settings [13].

Healthcare institutions, including hospitals and dental clinics, carry a significant responsibility to uphold public health standards and environmental safety, particularly in the management of biomedical waste. Ironically, institutions that aim to improve health outcomes can themselves become sources of harm if waste is not managed correctly, endangering staff, patients, and surrounding communities. Effective and safe healthcare waste disposal is thus essential to safeguarding public and environmental health [14].

In the present study involving 118 dental practitioners, 57.6% demonstrated excellent knowledge concerning dental waste management, 34.7% exhibited average knowledge, and 7.6% showed fair knowledge. Regarding attitudes, 59.3% of respondents displayed a positive attitude, 35.6% were neutral, and 5.1% had a negative attitude. In terms of practice, 43.2% demonstrated good waste management practices, 38.1% were fair, and 18.6% reported poor practices.

Comparable results were observed in a study by Gautam et al. [15], where only 21.1% of participants had excellent knowledge, suggesting a significant opportunity to enhance awareness through academic and community-based education initiatives. They emphasized the necessity of incorporating practical waste management training into dental curricula and community outreach programs to reinforce the importance of this issue [15]. Gautam et al. [15] also reported that 57% of dental professionals had a positive attitude, with the remainder showing neutrality—findings echoed by Mugabi et al. [16], who observed a median score of 2.76 for attitude. Their study also noted that 75% strongly supported dental waste segregation, while 54% endorsed the treatment of waste prior to disposal, aligning with previous findings where 52.7% of dentists recommended autoclaving before disposal. Furthermore, 78.9% of participants strongly acknowledged the health risks associated with improper waste management. However, only 56.3% did not view waste management as an additional workload, and 66.9% strongly advocated for training from health authorities—underscoring the need for ongoing professional education [16, 17].

The current study demonstrated a statistically significant correlation between a high level of knowledge and both a positive attitude and good practice. In a related study by Abhishek et al. [18], involving 186 professionals (38% women, 62% men), a significant association was found between knowledge, practice, and waste management, with a p-value of 0.0001 indicating a strong relationship between knowledge and practice scores. However, their findings suggested an overall poor understanding of dental biomedical waste (BMW) disposal among the surveyed Indian dentists, contrasting with our findings [18]. Similarly, Sharma et al. [19] reported inadequate knowledge and awareness of BMW-related risks among healthcare personnel. The logistic regression analysis in our study identified age, academic degree, academic employment, and management roles as significant predictors of knowledge, attitude, and practice. Younger practitioners demonstrated superior knowledge and practices compared to older counterparts. A PhD degree, employment in academic settings, and holding managerial roles were associated with increased knowledge and more favorable attitudes, although managerial positions were not strongly linked to improved practices.

Supporting our findings, Cayo-Rojas et al. [20] observed that knowledge of dental waste management improved with age ($p = 0.001$) and experience ($p = 0.007$), likely due to repeated exposure to relevant training. Interestingly, dental hygienists and assistants exhibited higher knowledge scores than dentists themselves. Singh et al. [21] also reported that paramedical personnel possessed substantial theoretical knowledge in dental waste management. However, other studies noted inconsistencies and variability in the knowledge and practices among dental professionals [22]. These findings highlight the critical need for continuous education and targeted training at all levels of dental healthcare practice. Such measures are vital for reducing the risks posed by improper biomedical waste disposal and for promoting sustainable environmental and public health outcomes [23]. The present study concludes that while the level of knowledge and attitude regarding dental waste management among dental professionals in Benghazi was generally acceptable, the implementation in practice was suboptimal. Key determinants of knowledge, attitude, and practice included age, academic qualification, employment in educational institutions, and administrative roles.

Conclusion

Although knowledge and attitudes toward dental waste management were generally satisfactory, clear practice gaps persisted. Common shortcomings included incomplete color-coded segregation and improper disposal of hazardous materials such as lead foil and amalgam. These findings mirror patterns reported in Tripoli and internationally, where high awareness contrasts with inconsistent execution. Mercury exposure from amalgam remains a particular concern, underscoring the toxicological risks. Closing this knowledge-practice gap requires targeted staff training, clear SOPs, proper labeling of containers at the point of use, and regular audits with feedback to ensure sustained compliance.

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Conflicts of Interest

The authors declare no conflict of interest.

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