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St. Paul's Hospital Millennium Medical College**

School of Public Health

August, 2025

Addis Ababa, Ethiopia



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St. Paul's Hospital Millennium Medical College

Graduate Study Program

School of Public Health

**Solid waste management practice and associated factors among private dental
clinics in Addis Ababa, Ethiopia**

By: Jenberu Workeye (BSc, MLT)

**A Thesis submitted to the Department of Public Health, St. Paul's Hospital
Millennium Medical College in Partial Fulfillment of the Requirements for
the Degree of Master of Science in Epidemiology.**

August, 2025

Addis Ababa, Ethiopia

**St. Paul's Hospital Millennium Medical
College
Graduate Study Program
School of Public Health**

Title: Assessment of solid waste management practice and associated factors among private dental clinics in Addis Ababa, Ethiopia

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Acronyms

- BMW-Biomedical waste
- FDA- Food, Medicine, Healthcare Administration, And Control Authority
- FMOH- federal ministry of health
- HCWM- Healthcare waste management
- IP-Infection prevention
- PPE-Personal protective equipment
- SPHMMC-St. Paul's Hospital Millennium Medical College
- UNICEF- United Nations Children's Fund
- WHO -world health organization

Abstract

Background: Effective solid waste management in dental clinics is essential to protect public health and the environment, as dental waste can pose significant risks to patients, professionals, and ecosystems. Despite global concerns about dental waste management, there is limited evidence on the issue in Ethiopia, highlighting the need for local studies.

Objective: To assess practices of solid dental waste management practice and associated factors among private dental clinics in Addis Ababa, Ethiopia

Method: A facility-based cross-sectional study was conducted from June 2024 to August 2024 in 222 randomly selected private dental clinics across four sub-cities of Addis Ababa. A total of 222 Dental Licensed Holder (Licensed Officer) participated, and their knowledge of SWM practices was assessed. Both observation checklists and structured interviewer-administered questionnaires were used to collect data on SWM practices and knowledge levels based on the 2021 Ethiopian Healthcare Waste Management Guideline. Trained professionals gathered the data, which were analyzed using SPSS Version 26. Binary logistic regression was used to identify factors associated with SWM practices, with variables from bivariable analysis ($p \leq 0.25$) included in the multivariable model; significance was set at $p < 0.05$.

Results: Of the 222 clinics, 124 (55.9%, 95% CI: 49.5–62.8%) demonstrated good SWM practices, with 156 (70.3%) segregating waste at the point of generation and 130 (58.6%) having functional incinerators. However, only 76 (34.2%) documented waste disposal, and 83 (37.4%) had a waste management plan. Dental Licensed Holders (Licensed Officers) in 148 (66.7%) clinics had poor knowledge scores (<60%). Multivariable logistic regression showed that clinics in one of the sub-cities (AOR = 0.001, 95% CI: 0.000–0.107, $p = 0.003$) and those with Dental Licensed Holders (Licensed Officers) having 16–20 years of experience (AOR = 0.014, 95% CI: 0.000–0.802, $p = 0.039$) had lower odds of good practices compared to Yeka sub-city and holders with >20 years of experience, respectively. Non-segregation of waste streams reduced odds of good practices (AOR = 0.021, 95% CI: 0.001–0.752, $p = 0.034$), while without labeling waste containers (AOR = 10.198, 95% CI: 3.25–39.76, $p = 0.008$) and safe transportation with spills/leaks (AOR = 11.530, 95% CI: 3.50–47.12, $p = 0.013$) increased odds.

Conclusion: The level of solid waste management practice among private dental clinics in Addis Ababa was below the expected national standard (55.9%), rated “yellow” by Ethiopian Food

and Drug Authority criteria. **Limited documentation, poor knowledge, and weak segregation systems** were the main challenges. Strengthening regulatory supervision, **regular staff training**, and enforcing written waste management plans are essential to improve dental waste management and protect community health.

1. Introduction

1.1. Background

The World Health Organization defines healthcare waste as "discarded (and untreated) materials from healthcare activities on humans or animals that have the potential of transmitting infectious agents to humans" (1). Dental healthcare service units generate a variety of wastes that can be classified into hazardous, non-hazardous, biohazards, pharmaceutical, and sharp wastes (2). These wastes include blood-soaked dressings and bloody tissues; sharp objects; heavy metals; paper; cardboard; glass; gloves; needles; X-ray films; and dental Mercury use is being reduced in health care and other applications around the world because of its toxicity and pollution potential (3).

Wastewater from dental clinics typically contains raised levels of heavy metals such as mercury, silver, copper, and zinc which arise mainly from the placement and removal of amalgam restorations and the discarding of used radiographic fixer solutions (4). Amalgam is the main hazardous solid waste used in dental clinics and its mercury content is recognized as a toxic element, and it is the most volatile heavy metal known in nature (4, 5).

Several studies have revealed that dental management is encircled with many problems. A systematic review in Asian countries found that dentists' knowledge and practice of dental waste management and disposal were inadequate and poor (6). Problems including the incorrect segregation system, a lack of a standard method for sharps disposal, and improper disposal of amalgam products were indicated (7). Financial burden, lack of availability of service facilities, poor attitude, poor knowledge, and the standard of clinics were outlined as significant determinants for solid dental waste management practice (8).

Although there are several studies conducted all over the world to assess solid dental waste management, no published article on dental waste management in Ethiopia. Hence, the main

objective of this study is to assess practices of solid waste management and associated factors among private dental clinics in Addis Ababa, Ethiopia.

1.2. Statement of the problem

Worldwide, an estimated 16 billion injections are administered every year. Not all needles and syringes are disposed of safely, creating a risk of injury and infection and opportunities for reuse (9). In 2015, a joint WHO/UNICEF assessment found that just over half (58%) of sampled facilities from 24 countries had adequate systems in place for the safe disposal of healthcare waste (10). Healthcare waste management activities can directly affect the environment, human health, and society in a variety of different ways. The potential adverse impacts of inadequate HCWM include disease transmission, physical injury, air pollution, soil pollution, water pollution, climate change, and social impacts. These impacts can result from the improper management and handling of healthcare waste during generation, transportation, storage, treatment, and disposal (11). The biomedical waste generated in the dental clinics includes sharps, used disposable items, infectious waste (blood-soaked cotton, gauze, etc.), hazardous waste (mercury, lead), and chemical waste (such as spent film developers, fixers, and disinfectants) (5). Dentists and dental personnel have been directly and indirectly exposed to Hg emissions from incinerators and Hg in wastewater from different sources, which could be either households or dental clinics (12). The release of amalgam particles into dental office wastewater or solid waste is an important concern as these particles could then be released into the environment (13). A systematic review of 24 articles in Asian countries revealed that most of the studies reported low-level practice regarding the segregation of dental biomedical waste. In this study, in Karnataka, approximately one-third of dentists were not following the BMW guidelines for sharps management, and most of them were disposing of sharps in general waste bins (14). In a study in southern Iran, 89.1% of dental offices and clinics disposed of their infectious waste with domestic waste. Only 60% of centers used the standard method for sharps disposal. None of the dental centers disposed of their pharmaceutical waste and x-ray fixer waste by standard methods. Less than 10% of centers recycled the amalgam and lead foil pockets and sent the waste to the manufacturer (15).

Though evidence shows that various problems are posed by dental waste management, there is no study conducted among private dental clinics in Ethiopia. Thus, the current study is aimed at assessing the practices of solid waste management and associated factors among private dental clinics in Addis Ababa, Ethiopia.

1.3. Significance of the study

In general, assessing practices of solid waste management practice and associated factors among private dental clinics helps countries to identify the gaps and determinants and establish a potential strategic plan to enhance dental HCWM and ultimately lessen its negative impacts on human health and the environment. The evidence generated from this study can be used to improve private dental waste management, including the management of toxic and hazardous materials such as dental amalgam. It also helps regulatory bodies ensure the safety of dental care practices related to waste management. Furthermore, it is used to provide input for future research.

2. Literature review

2.1. Dental Solid waste management practice

A systematic review of 24 articles in Asian countries revealed that most of the studies reported low-level practice regarding the segregation of dental biomedical waste. In this study, in Karnataka, approximately one-third of dentists were not following the BMW guidelines for sharps management, and most of them were disposing of sharps in general waste bins (16).

A study in southern Iran revealed that 89.1% of dental offices and clinics disposed of their infectious waste with domestic waste. Only 60% of centers used the standard method for sharps disposal. None of the dental centers disposed of their pharmaceutical waste and x-ray fixer waste by standard methods. Less than 10% of centers recycled the amalgam and lead foil pockets and sent the waste to the manufacturer (17).

In a study in India, 46.2% said they break the needle and dispose of it and only 21.9% use a needle burner to destroy it. About 40.6% of dentists dispose of excess silver amalgam by throwing it into a common bin (18).

A study in Senegal showed that all practitioners stated that their offices had waste bins, 81.2% using plastic bags; 73.2% reported that the bins were washed and disinfected an average of once a day. Only 7.2% of the offices or facilities had an autoclave, and 5.8% had an incinerator (19).

In a study in Nigeria Two hundred and twenty-eight (52.2%) respondents segregate the BMW in the clinic and (86%) dispose of sharp disposables inside sharp boxes. A greater proportion of respondents, 216 (49.4%), dispose of amalgam-contaminated gloves/ gauze in the regular dustbin and 185 (42.3%) dispose of hazardous liquid waste in the regular drain. Only 7.3% of respondents strictly adhered to the manufacturer's recommendations when discarding the developer and fixer solutions in the clinic (4).

Another study in Nigeria revealed that 68.6% of the dentists stated that there were no special disposal facilities for the different kinds of waste materials generated in their clinics: 52.9% disposed of sharp items, and waste bins; and 77.7% said there was no special treatment/disposal

of needles and other items used on patients with infectious diseases. Most practices burned their waste in the hospital area and 73.6% said they were not aware of any rules or body to regulate dental waste disposal in Nigeria (20).

2.2. Determinants of dental Solid waste management practice

A study in northern India revealed that the majority of private practitioners were not practicing it due to various reasons, such as financial burden, lack of availability of service facilities, and poor attitude toward its management (21).

A study conducted in Pekanbaru City, Indonesia showed that the overall dental waste management practices were associated with knowledge, training attainment, availability of facilities, and the use of personal protective equipment (22).

A study conducted in Ilu Aba Bor Zone, Oromia region, south-west Ethiopia, showed that the presence of the HCWM committee and designated healthcare waste storage site, reading the HCWM manual, and having good knowledge of HCWM were factors associated with good HCWM practice (23).

A study conducted in Dire Dawa, Eastern Ethiopia showed that adequate knowledge on healthcare waste management, trained on waste management, the presence of guidelines, instructive posters on healthcare waste segregation and availability of color-coded waste bins were factors significantly associated with healthcare waste segregation practices (24).

A study conducted in Private Clinics in Addis Ababa, Ethiopia showed that Healthcare waste management practice in the surveyed clinics was significantly associated with presence of guidelines, budget allocation and inspection by the regulatory bodies (25).

2.3. Conceptual framework

The conceptual framework illustrates how various factors influence **solid dental waste management practice** among private dental clinics in Addis Ababa, Ethiopia. **In this study, the dependent variable is solid dental waste management practice (good or poor)**, while **independent variables** include regulatory, institutional, and human resource factors. **Knowledge of dental clinic license holders toward dental waste management** serves as both an **independent and intermediate (mediating)** variable that directly affects the level of waste management practice.

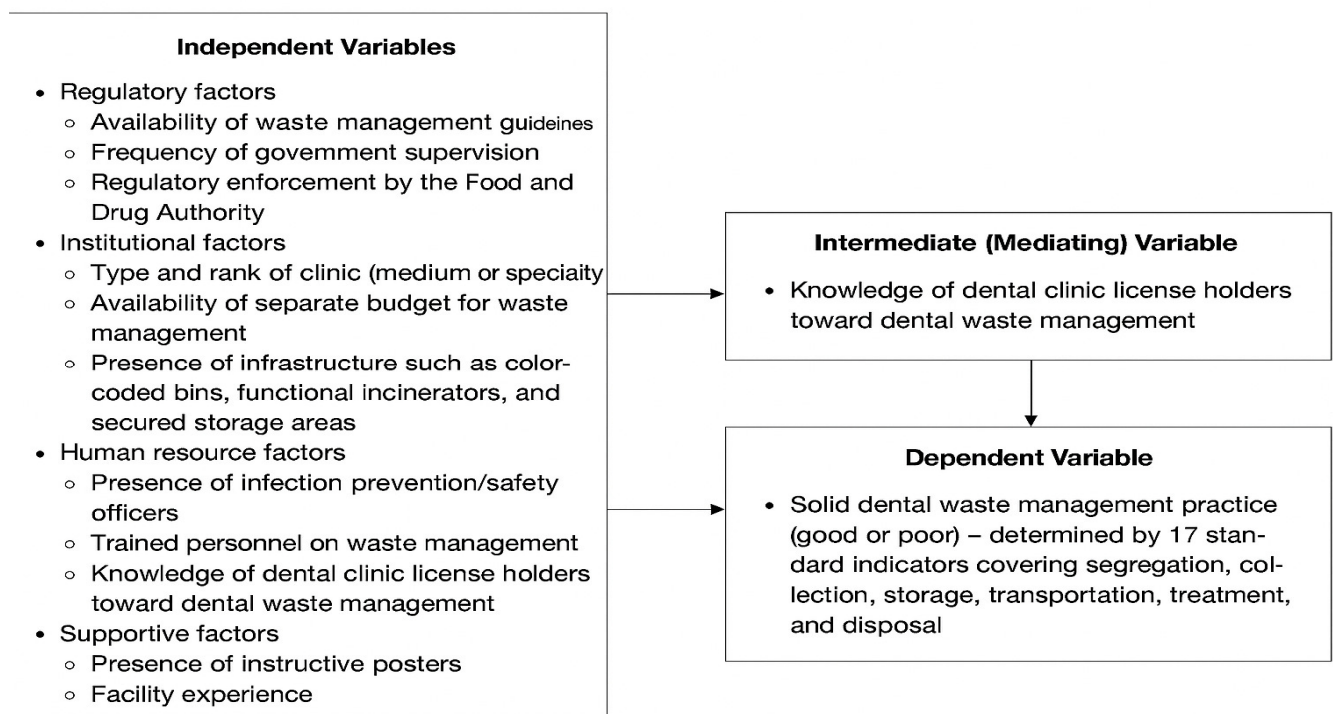


Figure 1: Conceptual framework of solid waste management practices among private dental clinics in Addis Ababa, Ethiopia, in 2024(adapted from (12-14, 25-30).

3. Research questions

- What is the status of solid waste management practices in private dental clinics in Addis Ababa, Ethiopia, in 2024?

- What factors are associated with solid waste management practices among private dental clinics in Addis Ababa, Ethiopia, in 2024?

4. Objectives

4.1. General Objective

- To assess practices of solid waste management and associated factors among private dental clinics in Addis Ababa, Ethiopia, 2024.

4.2. Specific Objectives

- To determine the solid waste management practice of the private dental clinics in Addis Ababa, Ethiopia, 2024.
- To identify factors associated with the practice of solid waste management among private dental clinics in Addis Ababa, Ethiopia, 2024.

5. Methods

5.1. Study area, setting, and period

According to the Addis Ababa city administration food and drug authority report in April 2024, there are a total of 412 dental clinics, of which 272 (66%) are medium dental clinics and the rest, 140 (44%) are specialty dental clinics in 11 sub-cities. According to the standard minimum requirements, 371 (90%) received a green license (> 74% score), 25 (6%) received a yellow license (between 50% and 74% score), and the remaining 16 (4%) received a red license (50% score). The study was conducted among randomly selected private dental clinics in four randomly selected sub-cities in Addis Ababa, Ethiopia, from June 2024 to August 2024.

5.2. Study design

Facility based; Cross-sectional study was conducted through structured questionnaires.

5.3. Source population

The source population were all private dental clinics in Addis Ababa, Ethiopia.

5.4. Study population

Selected Private dental clinics found in selected four sub-cities in Addis Ababa, Ethiopia, during the study period.

5.5. Inclusion and exclusion criteria

Include:

All **private dental clinics and professionals** actively providing dental services during the study period were eligible.

Dental Licensed Holders (Licensed Officers) with a valid license, actively managing or supervising their clinic, and willing to participate in the study.

Exclude:

Clinics **under administrative suspension**, those **without waste disposal services**, or **closed for renovation** during the data collection period.

Dental Licensed Holders (Licensed Officers) who are unavailable refuse consent, or whose clinics are closed, non-operational, or unlicensed.

5.6. Sample Size Determination

The study employed **simple random sampling**. Since there was **no previous research** on dental clinic waste management practices in Addis Ababa, an estimated prevalence of **50%** was used to maximize the sample size and ensure adequate precision. The initial sample size was calculated using the single population proportion formula with a 95% confidence level ($Z=1.96$) and a 5% margin of error ($d=0.05$), yielding 384. Because the total population of dental clinics was less than 10,000 ($N=412$), a **finite population correction** was applied, reducing the sample size to 199. To account for an expected **non-response rate of 12%**, the final sample size was increased to **222 clinics**.

Sample size calculation

$$n = \frac{z^2 p(1-p)}{e^2}$$

$$= \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2}$$

$$n = 384$$

for population size less than 10,000

$$n' = \frac{n_0}{1 + \frac{n_0 - 1}{N}} \text{ -----correction formula}$$

$$n' = \frac{384}{1 + \frac{383}{412}} = 199$$

$$199 + 23 \text{ including non-response rate 12\%}$$

$$= \underline{\underline{222}}$$

5.7. Sampling procedure

A random sampling technique was used to select four sub cities in Addis Ababa, Ethiopia. Then the study unites were determined by random selection procedure

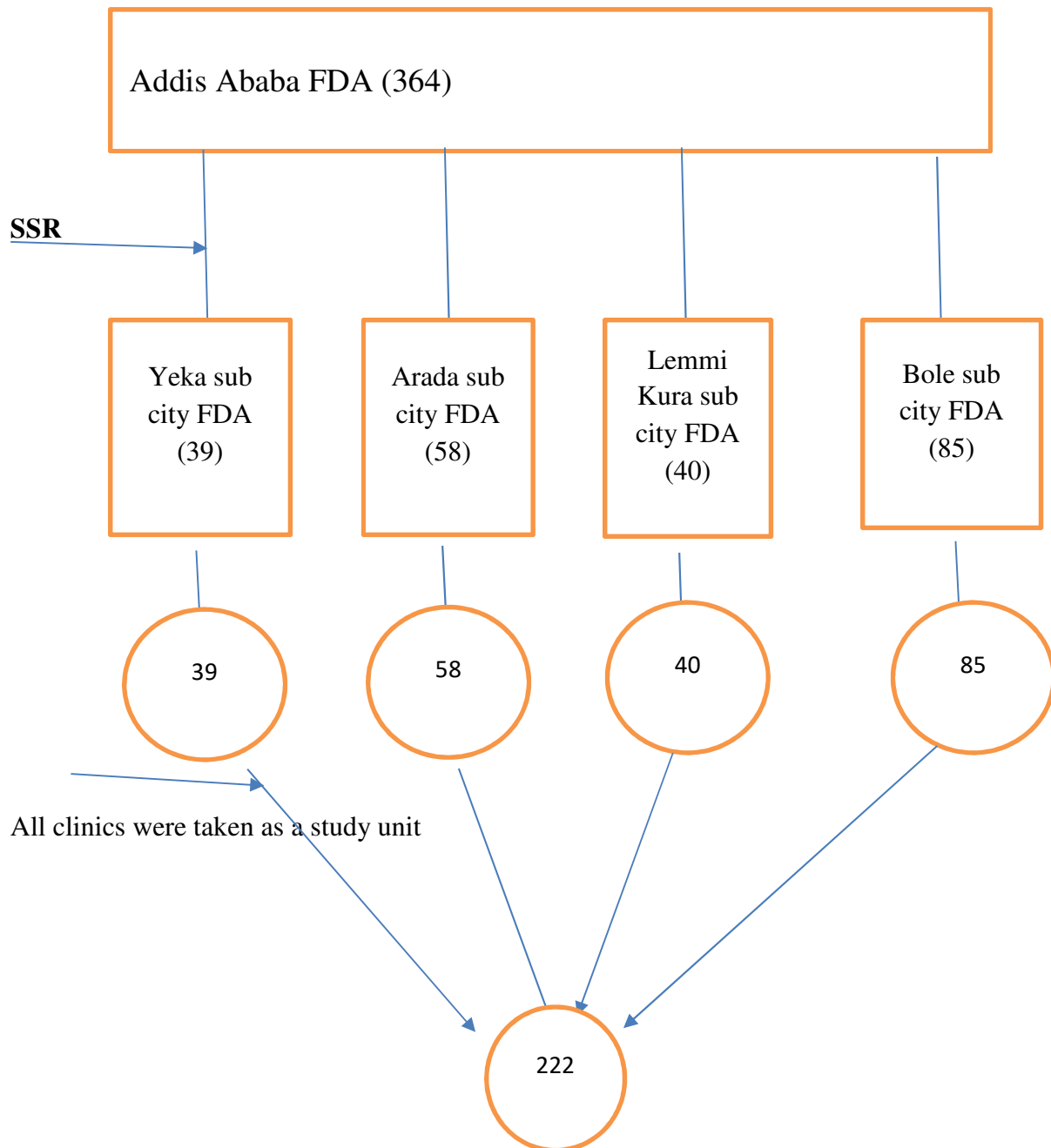


Figure 2: Schematic presentations of sampling technique of private dental clinics in Addis Ababa, Ethiopia, 2024.

5.8. Data collection

A structured data abstraction tool was developed in English after reviewing relevant literature and the 2021 Ethiopian Healthcare Waste Management Guideline. The tool comprised six sections: background variables, knowledge variables on solid dental waste management, and observational findings. Eight data collectors (four BSc nurses and four environmental health professionals) and four supervisors (public health officers) were recruited. The principal investigator conducted a two-day training session for both data collectors and supervisors.

The 17 practice questions were categorized into two components: **observable** (11 items verified through observation or document review) and **interview-based** (6 items obtained from licensed officers or responsible staff). Observable items included segregation of waste streams, labeling of containers, secure storage, prevention of spills, leaks, and pest infestation, safe transportation, functional incinerator availability, proper waste treatment, visibility of instructive posters, documentation of waste disposal, and presence of a written waste management plan. Interview-based items included availability of trained professionals, waste management guidelines, infection prevention officer, compliance with regulations, frequency of plan review, and separate budget allocation.

Knowledge of Private Dental Clinic Licensed Holders regarding solid dental waste management was measured using a self-administered checklist containing 10 questions. These questions were developed based on a thorough review of relevant literature and the 2021 Ethiopian Healthcare Waste Management Guideline. The checklist assessed participants' understanding of proper waste segregation, storage, handling, and disposal practices. Each correct response was scored, and the total score reflected the overall knowledge level of the license holders.

5.9. Variables of the study

5.9.1. Dependent variables

- The level of waste management practice adherence to a standardized checklist.

5.9.2. Independent variables

Background characteristics

Facility experience, and Licensed officer experience, and Location on building, Clinics rank, and Clinics status

Predictor variables

- Availability of regular supervision by government organs
- Availability of waste management guideline
- Knowledge of license owner towards solid dental waste management
- Availability of trained professionals on waste management
- Availability of IP /safety officer
- Presence of instructive poster
- Availability of separate budget for waste management practices

5.10. Operational definitions

Private dental clinics: are dental clinics owned by private or non-governmental organizations with a legal working license from appropriate regulatory bodies (FDA).

Dental Licensed Holder (Licensed Officer):

A licensed dental professional and facility head who holds the clinic's operational license and is responsible for overseeing and ensuring proper solid dental waste management practices.

Good solid dental waste management practice: means clinics scored 60 % or more for 17 selected questions on waste segregation, collection, transport, treatment, and disposal.

Poor solid dental waste management practice: mean clinics score less than 60% on 17 selected questions on waste segregation, collection, transport, treatment, and disposal.

Good knowledge on solid dental practice: means a knowledge score by dental clinic licensed officers of 60% or more on 10 selected questions on solid waste management practice.

Poor knowledge on solid dental practice: means a knowledge score by dental clinic licensed officers of less than 60% on 10 selected questions on solid waste management practice.

Instructive posters: are lists of instructions that show how to manage solid dental waste and are posted in a visible place where solid dental waste is managed.

Solid waste: health care waste generated from dental clinics with physical form of solid texture.

Waste management practice: the processes and actions required to manage waste from its inception to its final disposal this includes the collection, transport, treatment and disposal of waste.

Medium dental clinics: legally licensed and has taken license for medium clinic standard by sub city FDA.

Specialty dental clinics: legally licensed and has taken license for specialty clinic standard by sub city FDA.

Clinics rank: clinic rank from national minimum standard perspective given by sub city FDA.

5.11. Data processing, quality assurance and analysis

Training was provided to the recruited supervisors and data collectors on the objectives and relevance of the study, procedures for data collection, and the importance of maintaining confidentiality. After data collection, the principal investigator reviewed all questionnaires to ensure completeness and consistency before data entry. Additionally, approximately 10% of randomly selected completed questionnaires were cross-checked against the corresponding original patient data by the supervisors.

A pre-test was conducted on 10 private dental clinics (5% of the total sample) in Yeka sub-city to assess the clarity and flow of the questions before the main data collection. Based on the pre-test findings, necessary modifications were made to improve question clarity and logical sequence.

Data were coded and entered into Epi Info version 7.2.4 and then exported to SPSS Version 26 for further processing and analysis. Descriptive statistics were computed to determine means, standard deviations, frequencies, and percentages.

Bivariable logistic regression analysis was performed to identify candidate variables for multivariable logistic regression. Variables with a $p\text{-value} \leq 0.25$ in the bivariable analysis were considered as candidates for inclusion in the multivariable model. Multicollinearity among independent variables was assessed using the variance inflation factor (VIF), and variables with high collinearity were excluded. The goodness-of-fit of the final model was tested using the Hosmer–Lemeshow test.

Multivariable logistic regression was then conducted to identify independent predictors of the outcome variable. Variables with a $p\text{-value} < 0.05$ and a 95% confidence interval were considered statistically significant.

5.12. Ethical consideration

Ethical clearance was obtained from the Institutional Review Board of St. Paul's Hospital Millennium Medical College. An official letter was submitted to the Addis Ababa City Administration Food, Medicine, and Healthcare Administration and Control Authority. The authority issued permission and collaboration letters to the respective dental clinics.

The data collection tools did not include any personal identifiers, and collected data were reported to the supervisors and investigators promptly. Information confidentiality was maintained by training both supervisors and data collectors on its importance. Each data collector was provided with a sealed envelope for storing completed questionnaires, while supervisors were given larger envelopes to collect data without accessing individual responses. Separate sheets were used to differentiate between clinics that were observed and those that were not.

In a few selected instances, data were reviewed jointly with the investigator for the purpose of ensuring data quality.

5.13. Dissemination of findings

Results of this study will be communicated to the concerned officials of the clinics studied. Again, feedback to Addis Ababa Food and Drug Authority will be given. The study finding will be sent to national and international conference and it will be published in peer reviewed journal.

6. Results

6.1. Background information of private dental clinics

In a 2024 survey of 222 private dental clinics in Addis Ababa, Ethiopia, 91 (41.0%) were located in Bole sub-city, 66 (29.7%) had facility experience of 6-10 years, and 77 (34.7%) had licensed officers with over 20 years of experience. Additionally, 74 (33.3%) were situated on the 2nd floor of buildings, 126 (56.8%) were specialty dental clinics, and 181 (81.5%) were ranked green.

Table 1: Background factors of solid waste management practices among private dental clinics in Addis Ababa, Ethiopia, in 2024. (n=222)

Variables	Categories	Frequency	Percent
Sub-city	Arada	21	9.5
	Bole	91	41.0
	Lemmi Kura	69	31.1
	Yeka	41	18.5
Facility experience	0-5 years	9	4.1
	6-10 years	66	29.7
	11-15 years	55	24.8
	16-20 years	29	13.1
	>20years	63	28.4
Licensed officer experience	0-5 years	9	4.1
	6-10 years	49	22.1
	11-15 years	63	28.4
	16-20 years	24	10.8
	>20years	77	34.7
Facility location on the building	Ground floor	23	10.4
	1st floor	55	24.8
	2nd floor	74	33.3
	3rd floor	60	27.0
	>4th floor	10	4.5
Type of dental clinic	Medium dental	96	43.2
	Specialty dental	126	56.8
Clinics rank	Green	181	81.5
	Yellow	41	18.5

6.2. Solid waste management practices among private dental clinics

In a 2024 survey of 222 private dental clinics in Addis Ababa, Ethiopia, 124 (55.9%) demonstrated good solid waste management practices (95% CI, 49.5–62.8%). Notable practices included 156

(70.3%) clinics segregating waste streams at the point of generation and 130 (58.6%) having functional incinerators. However, only 76 (34.2%) documented waste disposal, and 83 (37.4%) had a waste management plan in place. Additionally, licensed officers in 148 (66.7%) clinics exhibited poor knowledge scores regarding waste management.

Table 2: Solid waste management practices among private dental clinics in Addis Ababa, Ethiopia, in 2024. (n=222)

Variables	Categories	Frequency	Percent
IP officer delegated with written authorization	No	125	56.3
	Yes	97	43.7
Frequency of government supervision (Hamle 2015 – hamle 2016)	0 times per a year 1 time /year	6	2.7
	2 times per year	98	44.1
	> two time per a year	118	53.2
Separate budget allocated for waste management (in birr)	No separate budget allocated	5	2.3
	1000-4999	3	1.4
	5000-9999	1	.5
	10000-15000	2	.9
	> 15, 0000	211	95.0
Availability of waste management guideline	No	115	51.8
	Yes	107	48.2
Presence of instructional posters	No	147	66.2
	Yes	75	33.8
Availability of trained professionals on waste management	No	126	56.8
	Yes	96	43.2
Waste streams segregated at point of generation	No	66	29.7
	Yes	156	70.3
Waste containers labeled by waste stream	No	97	43.7
	Yes	125	56.3
Waste storage areas secure from unauthorized access	No	122	55.0
	Yes	100	45.0
Storage prevents spills and leaks	No	121	54.5
	Yes	101	45.5
Storage prevents pest infestation	No	137	61.7
	Yes	85	38.3
Containers transported safely (no spills/leaks)	No	122	55.0
	Yes	100	45.0
Waste disposed of in line with regulations	No	119	53.6
	Yes	103	46.4
Presence of functional incinerator	No	92	41.4

Variables	Categories	Frequency	Percent
	Yes	130	58.6
Documentation and tracking of waste disposal	No	146	65.8
	Yes	76	34.2
Waste management plan in place	No	139	62.6
	Yes	83	37.4
Waste management plan regularly reviewed	No	163	73.4
	Yes	58	26.1
Knowledge score of the licensed officer	Poor (Knowledge score less than 60%)	148	66.7
	Good (Knowledge score greater than or equal to 60%)	74	33.3
Overall facility assessment	Poor (Score less than 60%)	98	44.1
	Good waste management practice (Score greater than or equal to 60%)	124	55.9
Solid Waste management Practice	55.9%	(95% CI, 49.5 – 62.8)	

6.3 Knowledge Level of Dental Licensed Holders toward Solid Waste Management

Knowledge assessment was conducted using ten structured questions. Each correct response was given one point, and the total score was converted into a percentage. Licensed officers scoring $\geq 60\%$ were classified as having “good knowledge,” while those scoring $< 60\%$ were considered to have “poor knowledge.”

Among the 222 clinics, 74 (33.3%) licensed officers demonstrated good knowledge, whereas 148 (66.7%) showed poor knowledge regarding solid dental waste management. Knowledge gaps were particularly observed in areas such as proper segregation techniques, labeling of hazardous waste containers, and amalgam waste handling. Clinics with trained personnel and visible instructional posters showed relatively higher knowledge scores compared to those without.

Table 3: Knowledge of Solid Dental Waste Management among Private Dental Clinic Licensed Holders in Addis Ababa, Ethiopia, 2024 (n = 222):

Question	Frequency Correct (n)	Percentage Correct (%)
Types of dental waste	95	42.8
Proper disposal of amalgam waste	88	39.6
Health & environmental risks	102	45.9
Regulations & guidelines	80	36.0
Purpose of labeling waste containers	92	41.4
Best practices to reduce waste	75	33.8
Proper handling & storage of waste	98	44.1
Purpose of staff training	85	38.3
Types of waste containers and uses	100	45.0
Reporting & documenting waste management	90	40.5
Overall knowledge ($\geq 60\%$)	74	33.3
Overall knowledge ($< 60\%$)	148	66.7

6.3. Binary logistic regression analysis

6.3.1. Bivariable logistic regression analysis

Bivariable logistic regression was conducted to assess factors associated with solid waste management practices among private dental clinics in Addis Ababa, Ethiopia, in 2024. Variables with a p-value less than 0.25 were considered candidates for multivariable logistic regression analysis. The analysis revealed that facility experience (0-5 years: $p=0.009$, 11-15 years: $p=0.184$, 16-20 years: $p=0.000$), licensed officer experience (11-15 years: $p=0.248$, 16-20 years: $p=0.027$), facility location (1st floor: $p=0.248$), sub-city (Lemmi Kura: $p=0.167$), type of dental clinic ($p=0.023$), clinic rank ($p=0.000$), IP officer authorization ($p=0.000$), government supervision frequency (0 times: $p=0.243$, 2 times: $p=0.000$), and several waste management practices (e.g., availability of guidelines: $p=0.000$, instructional posters: $p=0.000$, trained professionals: $p=0.000$, waste segregation: $p=0.000$, labeled containers: $p=0.000$, secure storage: $p=0.000$, spill/leak prevention: $p=0.000$, pest prevention: $p=0.000$, safe transport: $p=0.000$, regulatory disposal: $p=0.000$, incinerator presence: $p=0.000$, documentation: $p=0.000$, waste management plan: $p=0.000$, plan review: $p=0.000$, and knowledge score: $p=0.000$) met the criterion. These variables are candidates for multivariable logistic regression to further explore their associations with solid waste management practices.

Table 4: Bivariable logistic regression analysis of factors associated with solid waste management practices among private dental clinics in Addis Ababa, Ethiopia, in 2024. (n=222)

Variables	Categories	Frequency		COR (95% CI)	P-Value
		Poor	Good		
Sub-city	Arada	12	9	0.79 (0.27, 2.27)	0.658
	Bole	39	52	1.40 (0.67, 2.93)	0.373
	Lemmi Kura	26	43	1.74 (.79, 3.80)	0.167
	Yeka	21	20	Ref	-
Facility experience	0-5 years	8	1	0.06 (0.01, 0.50)	0.009
	6-10 years	24	42	0.81 (0.39, 1.69)	0.580
	11-15 years	24	31	0.60 (0.28, 1.27)	0.184
	16-20 years	22	7	0.15 (0.05, 0.40)	0.000
	>20years	20	43	Ref	-
Licensed officer experience	0-5 years	9	0	0.00 (NE)*	0.999
	6-10 years	17	32	1.08 (0.51, 2.28)	0.849
	11-15 years	29	34	0.67 (0.34, 1.32)	0.248
	16-20 years	15	9	0.34 (0.13, 0.89)	0.027
	>20years	28	49	Ref	-
Facility location on the building	Ground floor	12	11	0.92 (0.21, 4.05)	0.909
	1st floor	17	38	2.24 (0.57, 8.75)	0.248
	2nd floor	37	37	1.00 (0.27, 3.75)	1.000
	3rd floor	27	33	1.22 (0.32, 4.67)	0.769
	>4th floor	5	5	Ref	-
Type of dental clinic	Medium dental	34	62	1.88 (1.09, 3.25)	0.023
	Specialty dental	64	62	Ref	-
Clinics rank	Green	91	90	0.20 (0.09, 0.48)	0.000
	Yellow	7	34	Ref	-
IP officer delegated with written authorization	No	73	24	12.17 (6.44, 22.99)	0.000
	Yes	25	100	Ref	-
Frequency of government supervision (Hamle 2014 – Sene 2015)	0 times per a year	2	4	2.816 (0.496, 15.988)	0.243
	1 time /year				
	2 times per year	27	71	3.703 (2.084, 6.580)	0.000
	> two time per a year	69	49	Ref	–
Separate budget allocated for waste management (in birr)	No separate budget allocated	3	1	0.000 (0.000, –)	0.999
	1000-4999	2	1	0.365 (0.033, 4.085)	0.413
	5000-9999	1	0	0.000 (0.000, –)	1.000
	10000-15000	2	0	0.730 (0.045, 11.821)	0.824
	> 15, 0000	89	122	Ref	–

Variables	Categories	Frequency		COR (95% CI)	P-Value
		Poor	Good		
Availability of waste management guideline	No	14	101	26.348 (12.765, 54.384)	0.000
	Yes	84	23	Ref	–
Presence of instructional posters	No	34	113	19.337 (9.172, 40.765)	0.000
	Yes	64	11	Ref	–
Availability of trained professionals on waste management	No	15	111	47.246 (21.329, 104.654)	0.000
	Yes	83	13	Ref	–
Waste streams segregated at point of generation	No	7	59	11.800 (5.065, 27.489)	0.000
	Yes	91	65	Ref	–
Waste containers labeled by waste stream	No	6	91	42.283 (16.904, 105.767)	0.000
	Yes	92	33	Ref	–
Waste storage areas secure from unauthorized access	No	19	103	20.393 (10.267, 40.509)	0.000
	Yes	79	21	Ref	–
Storage prevents spills and leaks	No	15	106	32.585 (15.500, 68.501)	0.000
	Yes	83	18	Ref	–
Storage prevents pest infestation	No	24	113	31.674 (14.644, 68.511)	0.000
	Yes	74	11	Ref	–
Containers transported safely (no spills/leaks)	No	10	112	82.133 (33.917, 198.895)	0.000
	Yes	88	12	Ref	–
Waste disposed of in line with regulations	No	10	109	63.947 (27.386, 149.317)	0.000
	Yes	88	15	Ref	–
Presence of functional incinerator	No	7	85	28.333 (12.024, 66.765)	0.000
	Yes	91	39	Ref	–
Documentation and tracking of waste disposal	No	29	117	39.768 (16.539, 95.624)	0.000
	Yes	69	7	Ref	–
Waste management plan in place	No	29	110	18.695 (9.234, 37.846)	0.000
	Yes	69	14	Ref	–
Waste management plan regularly reviewed	No	46	117	22.043 (8.862, 54.834)	0.000
	Yes	52	6	Ref	–
Knowledge score of the licensed officer	Poor (Knowledge score less than 60%)	78	70	0.332 (0.181, 0.609)	0.000
	Good (Knowledge score greater than or equal to 60%)	20	54	Ref	–

6.3.2. Multi-variable logistic regression analysis

Based on the multivariable logistic regression analysis, several factors were significantly associated with the likelihood of private dental clinics in Addis Ababa, Ethiopia, exhibiting good solid waste management practices. Clinics in the Arada sub-city had significantly lower odds of good practices compared to those in Yeka sub-city (AOR = 0.001, 95% CI: 0.000–0.107, $p = 0.003$). Similarly, clinics with licensed officers having 16–20 years of experience showed reduced odds of good practices relative to those with officers having over 20 years of experience (AOR = 0.014, 95% CI: 0.000–0.802, $p = 0.039$). Clinics that did not segregate waste streams at the point of generation were also less likely to demonstrate good practices (AOR = 0.021, 95% CI: 0.001–0.752, $p = 0.034$). Clinics that label waste containers by waste stream (AOR = 100.198, 95% CI: 3.245–3093.757, $p = 0.008$) and those that transport containers safely without spills or leaks (AOR = 11.530, 95% CI: 3.500–47.12, $p = 0.013$) had significantly higher odds of good practices.

Table 5: Multivariable logistic regression analysis of factors associated with solid waste management practices among private dental clinics in Addis Ababa, Ethiopia, in 2024. (n=222)

Variables	Categories	Frequency		AOR (95% CI)	COR (95% CI)	P-Value
		Poor	Good			
Sub-city	Arada	12	9	0.001 (0.000, 0.107)	0.79 (0.27, 2.27)	0.003
	Bole	39	52	0.228 (0.021, 2.429)	-	0.221
	Lemmi Kura	26	43	0.075 (0.003, 1.708)	-	0.104
	Yeka	21	20	–	-	–
Licensed officer experience	0-5 years	9	0	0.000 (0.000, –)	-	0.998
	6-10 years	17	32	0.108 (0.05, 2.546)	-	0.167
	11-15 years	29	34	1.8 (0.141, 23.030)	-	0.651
	16-20 years	15	9	0.014 (0.00, 0.802)	0.34 (0.13, 0.89)	0.039
	>20years	28	49	–	-	–
Waste streams segregated at point of generation	No	7	59	0.021 (0.001, 0.752)	11.800(5.065, 27.489)	0.034
	Yes	91	65	–	-	–
	No	6	91	10.198 (3.25, 39.76)	42.283(16.904, 105.767)	0.008

Waste containers non labeled by waste stream	Yes	92	33	—	-	—
Containers transported with spills/leaks	No	10	112	11.53 (3.50, 47.12)	82.133(33.917, 198.895)	0.013
	Yes	88	12	—	-	—

7. Discussion

The findings of this study should be interpreted in light of both global and national policy frameworks on healthcare waste management. The World Health Organization (WHO) emphasizes that effective management of healthcare waste, including dental waste, is essential to prevent environmental pollution, occupational hazards, and community health risks (1–3, 9). Ethiopia has national proclamations and directives that reflect these WHO recommendations; however, gaps in enforcement and implementation remain, as also reported in previous studies (7, 10, 11, 28). For example, the WHO's *Safe Management of Wastes from Health-care Activities* recommends segregation at the point of generation, color-coded containers, and proper documentation (2, 3), but in this study only 34.2% of private dental clinics documented waste disposal and 29.7% did not practice segregation. This inconsistency highlights the difficulty of translating international standards into local practice, a concern echoed in Ethiopian systematic reviews and qualitative studies (10, 13, 25). Strengthening adherence to WHO guidelines and reinforcing national policy implementation in private dental facilities are therefore critical to achieving safe and sustainable solid waste management in Ethiopia.

This study assessed solid waste management (SWM) practices among 222 private dental clinics in Addis Ababa, Ethiopia, in 2024, revealing that 124 (55.9%, 95% CI: 49.5–62.8%) exhibited good SWM practices. This proportion is lower than that reported in Nairobi, Kenya, where 68% of dental clinics adhered to proper waste management protocols(19), but higher than in Lagos, Nigeria, where only 42% of healthcare facilities, including dental clinics, demonstrated adequate practices (31). These variations likely stem from differences in regulatory enforcement, resource availability, and awareness levels across regions. In Morocco, a study found that only 27.3% of waste managers in dental clinics had received training, with 71.5% disposing of office waste directly into public bins, indicating widespread knowledge and practice gaps(32). Similarly, a Nigerian study reported high levels of toxic metals (e.g., lead, mercury) in soil and water near dental waste disposal sites, indicating the environmental risks of improper waste management (5). These findings align with the Ethiopian study, where 66.7% of licensed officers had poor knowledge scores, and only 34.2% of clinics documented waste disposal, underscoring a critical need for improved training and compliance.

Multivariable logistic regression analysis identified several factors significantly associated with SWM practices. Clinics in the Arada sub-city had significantly lower odds of good practices

compared to those in Yeka sub-city (AOR = 0.001, 95% CI: 0.000–0.107, $p = 0.003$). This geographical disparity may reflect inadequate infrastructure, weaker regulatory oversight, or socio-economic challenges in Arada, a less affluent area. A similar pattern was observed in India, where urban healthcare facilities in certain districts lagged due to limited municipal support (33). Clinics with licensed officers having 16–20 years of experience showed reduced odds of good practices compared to those with over 20 years (AOR = 0.014, 95% CI: 0.000–0.802, $p = 0.039$). This suggests that mid-career officers may lack updated training or face competing responsibilities, contrasting with a South African study where more experienced healthcare workers excelled due to accumulated expertise(22). The need for continuous professional development is evident to bridge this gap.

Waste segregation at the point of generation was a critical determinant, with clinics not segregating waste streams showing lower odds of good practices (AOR = 0.021, 95% CI: 0.001–0.752, $p = 0.034$). This aligns with global standards, as segregation minimizes infection risks and environmental harm(3). Conversely, labeling waste containers (AOR = 10.198, 95% CI: 3.245–393.757, $p = 0.008$) and safe transportation without spills or leaks (AOR = 31.530, 95% CI: 3.500–417.119, $p = 0.013$) were strongly associated with good practices. These practices are emphasized in global guidelines, which recommend color-coded bins and secure transport to mitigate occupational and environmental risks (34, 35). For instance, mercury-containing wastes must be stored in sealed containers and handed over to certified waste carriers (CWCs), while sharps require puncture-resistant containers labeled with biohazard symbols (35).

Significant deficiencies were noted in documentation and planning, with only 76 (34.2%) clinics documenting waste disposal and 83 (37.4%) having a waste management plan. These gaps contrast with findings from a global review indicating that facilities with formal plans achieve better outcomes (36). The low documentation rate in Addis Ababa differs from high-income settings, where regulatory compliance mandates detailed records (37). Additionally, 148 (66.7%) licensed officers exhibited poor knowledge scores, highlighting a critical training need. Locally, a study in Ethiopia's Amhara region identified improper segregation as a major barrier, consistent with the current findings (14). In Saudi Arabia, private dental clinics and independent labs showed lower knowledge and practice levels compared to teaching institutes, with only 25% of private clinics using color-specified containers (38). These comparisons suggest that resource constraints and lack of training are common challenges in developing countries.

The environmental and public health implications of poor SWM are significant. The Nigerian study's findings of toxic metal contamination near disposal sites underscore the potential for environmental pollution if waste is not properly managed (39). In Addis Ababa, while 130 (58.6%) clinics had functional incinerators, the effectiveness of their use remains unclear, and the lack of segregation in 29.7% of clinics could exacerbate risks. Global standards emphasize the need for proper handling of hazardous materials like mercury and sharps to prevent occupational exposure and environmental contamination(3, 34). The Ethiopian clinics with good practices likely adhered to these standards, but those with poor practices require targeted interventions to align with international benchmarks.

The study's findings also revealed systemic issues, such as the lack of government supervision in some clinics (2.7% reported no supervision) and the absence of instructional posters in 66.2% of facilities. These factors likely contribute to the observed knowledge and practice gaps. The high proportion of clinics (95.0%) allocating budgets over 15,000 ETB for waste management suggests financial commitment, but the lack of corresponding improvements in documentation and planning indicates a need for better resource allocation and oversight.

8. Conclusion

This study revealed that the overall practice of solid dental waste management among private dental clinics in Addis Ababa, Ethiopia, in 2024 was suboptimal, with only 55.9% of clinics demonstrating proper practices, corresponding to a "yellow" compliance rating. Knowledge among licensed officers was also limited, with only 33.3% showing adequate understanding of waste management protocols. The study identified several factors significantly associated with solid waste management practices, including clinic location, licensed officers' work experience, waste segregation, labeling of waste containers, and safe transportation practices.

These findings highlight the need for targeted interventions to strengthen adherence to national and international guidelines. Specifically, enhancing regulatory oversight, providing continuous professional training for licensed officers, and improving infrastructure for waste segregation, labeling, and safe disposal are essential to ensure effective and sustainable solid dental waste management in private clinics across Addis Ababa.

Strengths and Limitations

Strengths

This study, conducted in 2024 among private dental clinics in Addis Ababa, Ethiopia, has several notable strengths.

- First, it employed a comprehensive sample size, covering a significant proportion of private dental clinics across multiple sub-cities, ensuring representativeness of the dental sector.

Limitations

Despite its strengths, the study has limitations.

- Cross-Sectional Design: Limits the ability to establish causal relationships between factors and patient satisfaction.
- Second, the reliance on self-reported data for SWM practices and knowledge scores may introduce response bias, as participants might overstate compliance or knowledge.

9. Recommendations

1. Addis Ababa Food and Drug Authority (AAFDA)

Strengthen Regulatory Oversight:

- The study found that clinics in Arada sub-city had significantly lower odds of good SWM practices compared to Yeka (AOR = 0.001, 95% CI: 0.000–0.107, $p = 0.003$), indicating sub-city-specific disparities. AAFDA should prioritize targeted inspections and support in underperforming areas to address infrastructural gaps and non-compliance.

Promote Documentation and Planning:

- Only 34.2% of clinics documented waste disposal and 37.4% had a waste management plan. To improve compliance, AAFDA should mandate written SWM plans with periodic audits to ensure traceability and adherence to WHO guidelines (2, 3, 36).

2. Private Dental Clinics

Enhance Capacity Building:

- With 66.7% of licensed officers demonstrating poor knowledge and clinics staffed by officers with 16–20 years of experience showing reduced SWM performance (AOR = 0.014, 95% CI: 0.000–0.802, $p = 0.039$), mandatory annual training programs should target mid-career staff to update knowledge on segregation, labeling, and handling hazardous waste.
- Integrating SWM education into dental curricula will prepare future professionals to comply with international standards and reduce knowledge gaps noted in Ethiopia and other developing countries (10, 14, 38).

Improve Infrastructure:

- The study reported that 29.7% of clinics did not segregate waste and 58.6% had functional incinerators, but their effectiveness was unclear. Clinics should invest in color-coded bins, puncture-resistant sharps containers, secure storage, and ensure access to functional incinerators or certified waste carriers (CWCs) for safe disposal of hazardous materials such as mercury (3, 34, 35).

3. Recommendations for Future Research

- Explore the socio-economic and regulatory factors contributing to geographical disparities, as observed between Arada and Yeka sub-cities (AOR differences), to inform targeted interventions.

- Assess the environmental impact of dental waste disposal, including heavy metals contamination, as highlighted in Nigeria and Ethiopian studies (5, 39), to guide evidence-based policies.
- Conduct longitudinal studies to evaluate the effectiveness of SWM interventions and identify emerging challenges in private dental clinics.

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8. Annex

Questionnaire

Instruction

Mark the following questions with a sign on the cell based on facility observations.

Background factors

Variables	0-5 years	6-10 years	11-15 years	16-20 years	>20years
Facility experience					
Licenced officer experience					

Facility location on the building	Ground floor	1 st floor	2 floors	3 rd floor	>4 th floor

1. Clinics type

Medium dental ☐ specialty dental ☐

2. Clinics rank

Green ☐ yellow ☐ red ☐

Observational Checklist (11 items)

To be completed by the data collector through direct observation and document review.

1. Waste Segregation

1. Are healthcare waste streams segregated at the point of generation?
☐ Yes ☐ No
2. Are waste containers labeled with the appropriate waste stream?
☐ Yes ☐ No

2. Waste Storage

3. Are waste storage areas secure and inaccessible to unauthorized personnel?
☐ Yes ☐ No
4. Are waste containers stored in a manner that prevents spills and leaks?
☐ Yes ☐ No
5. Are waste containers stored in a manner that prevents pest infestation?
☐ Yes ☐ No

3. Waste Transportation

6. Are waste containers transported in a manner that prevents spills and leaks?
☐ Yes ☐ No
7. Are waste containers transported in compliance with local, state, and federal regulations?
☐ Yes ☐ No

4. Waste Treatment and Disposal

8. Is waste treated and disposed of in compliance with local, state, and federal regulations?
☐ Yes ☐ No
9. Is there a functional incinerator?
☐ Yes ☐ No
10. Is waste treatment and disposal documented and tracked?
☐ Yes ☐ No
11. Is there a written waste management plan available for review?
☐ Yes ☐ No

Interview-Based Questions (6 items)

(To be obtained from the licensed officer or responsible staff)

1. Institutional and Regulatory Factors

1. Is there an IP/safety officer formally delegated with written authorization?
☐ Yes ☐ No
2. How often does government supervision occur?
☐ 0 times/year ☐ 1 time/year ☐ 2 times/year ☐ >2 times/year
3. Is a separate budget allocated for waste management?
☐ No ☐ 1,000–4,999 ☐ 5,000–9,999 ☐ 10,000–15,000 ☐ >15,000
4. Is a waste management guideline available at the facility?
☐ Yes ☐ No
5. Are staffs trained on waste management?
☐ Yes ☐ No
6. Is a **waste management plan** in place?
☐ Yes ☐ No

Multiple-choice questionnaire for a knowledge assessment checklist for health professionals regarding dental waste management:

Instruction.

Select the best response and circle it.

1. What are the different types of dental waste?
 - a. General waste, hazardous waste, and infectious waste
 - b. General waste, recyclable waste, and organic waste
 - c. General waste, hazardous waste, and radioactive waste
 - d. General waste, infectious waste, and radioactive waste
2. What is the proper way to dispose of dental amalgam waste?
 - a. In the regular trash
 - b. In a sharps container
 - c. In a designated amalgam waste container
 - d. In a biohazard waste container
3. What are the potential health and environmental risks associated with improper dental waste management?
 - a. Exposure to infectious diseases and pollution of water sources
 - b. Exposure to hazardous chemicals and air pollution
 - c. Exposure to radioactive materials and soil contamination
 - d. Exposure to allergens and ozone depletion
4. What are the regulations and guidelines for dental waste management in your area?
 - a. There are no regulations or guidelines
 - b. They vary by state or province
 - c. They are the same across all regions
 - d. They only apply to large dental practices

5. What is the purpose of labeling dental waste containers?
 - a. To identify the contents of the container
 - b. To indicate the date of disposal
 - c. To indicate the type of waste
 - d. All of the above
6. What are the best practices for reducing dental waste and promoting sustainability in your practice?
 - a. Use digital radiography instead of traditional film
 - b. Use reusable or biodegradable materials when possible
 - c. Implement a recycling program for paper, plastic, and other materials
 - d. All of the above
7. What is the proper way to handle and store dental waste before disposal?
 - a. In a regular trash can
 - b. In a designated dental waste container
 - c. In a sharp's container
 - d. In a biohazard waste container
8. What is the purpose of training and educating staff on dental waste management practices?
 - a. To ensure compliance with regulations and guidelines
 - b. To promote sustainable practices in the dental office
 - c. To reduce the risk of exposure to hazardous materials
 - d. All of the above
9. What are the different types of dental waste containers and their uses?
 - a. Sharps containers for needles and other sharp objects, biohazard waste containers for infectious waste, and amalgam waste containers for dental amalgam waste
 - b. General waste containers for all types of waste, hazardous waste containers for chemicals and other hazardous materials, and radioactive waste containers for radioactive materials

c. Recyclable waste containers for paper, plastic, and other materials, organic waste containers for food and other organic materials, and general waste containers for all other waste

d. None of the above

10. What is the procedure for reporting and documenting dental waste management activities?

a. There is no need to report or document dental waste management activities

b. Keep a log of all waste disposal activities and report any incidents or violations to the appropriate authorities

c. Report waste disposal activities to the dental board or regulatory agency on a monthly basis

d. Report waste disposal activities to the local waste management authority on a quarterly basis.

DECLARATION

I the undersigned agree to accept all responsibilities for the scientific and ethical conduct off the research project. I will provide timely progress report to my advisor and seek the necessary advice and approval from my primary advisors in the course of the research. I will communicate timely to my advisors all stakeholders involved in the study including any source of funding for this research.

Name of the student: _____

Signature: _____

Date: _____

Approval of the Primary Advisor

Name of the primary advisor: _____

Signature: _____

Date: _____

Approval of the Co-Advisor

Name of the primary advisor: _____

Signature: _____

Date: _____