

Original article

Occupational Risk of Tuberculosis Among Dental Healthcare Workers and Potential Transmission Risk to Dental Patients: A Cross-Sectional Study in Tripoli, Libya

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Tuberculosis; Dental Healthcare Workers; Occupational Exposure; Infection Control; Aerosol Transmission; Dental Patients; Libya.

Abstract

Tuberculosis (TB) remains a global health challenge and occupational hazard for dental healthcare workers (DHCWs) due to airborne transmission and aerosol-generating procedures. In Libya, evidence on occupational TB risk and infection control in dental settings is scarce. This descriptive cross-sectional study assessed occupational TB risk among DHCWs and potential transmission to patients in Tripoli, Libya. A total of 172 participants were recruited: 95 DHCWs and 77 TB patients. Structured questionnaires collected demographic, knowledge, exposure, and practice data. Data were analysed using SPSS 25 with descriptive statistics and chi-square tests. Among DHCWs, 66.3% were female, 51.6% aged 25–34, 88.8% were dentists, and 50.5% worked in private clinics. Only 15.8% had received TB training in the last three years, yet 87.4% correctly identified airborne transmission, and 84.2% were aware of dental aerosol risks. Exposure to TB patients was reported by 7.4%, while 42.1% were unsure and 35.8% reported accidental exposure. Adherence to infection-control protocols was high (70.5% always), but PPE use varied: gloves/masks 100% always, eye protection 22.1%, gowns 50.5%, N95 5.3%. Daily aerosol-generating procedures were performed by 62.1%, but high-volume suction was always used by only 45.3%. Chi-square tests showed significant associations between PPE training ($p=0.046$) and TB training ($p=0.009$) with eye protection use. The findings reveal a knowledge–practice gap: despite high theoretical knowledge, critical gaps remain in eye protection, N95 respirator use, and high-volume suction. TB-specific training was infrequent but linked to better eye protection. Addressing these gaps requires recurring, disease-specific education alongside structural and institutional support.

Introduction

In Libya, tuberculosis (TB) continues to be a significant public health concern, and studies have assessed infection-control measures and biosafety procedures in dental settings [1,2]. Globally, TB remains a major public health challenge and an important occupational hazard for healthcare workers because of its airborne transmission [3]. The risk of TB transmission in dental settings is increased by delayed identification of infectious patients, inadequate ventilation, inconsistent use of personal protective equipment, and suboptimal infection-control practices [4]. The American Dental Association emphasises that dental office risk assessment and training should be integral to infection-control planning [5]. Awareness of droplet and airborne isolation precautions among general dental practitioners in Libya has been evaluated, revealing knowledge gaps [6]. Similarly, a study among dental students and interns in Benghazi, Libya, found limited orientation to infection-control guidelines [7]. The World Health Organisation provides guidelines on TB infection prevention and control that can inform practice [8]. The CDC summary of infection prevention practices in dental settings outlines basic expectations for safe care [9]. Dental healthcare workers are particularly vulnerable due to their close contact with patients and frequent exposure to aerosols generated during routine dental procedures; high-volume evacuation and other evacuation devices have been shown to reduce aerosol and splatter [10,11,12]. Therefore, this study aimed to assess the occupational risk of tuberculosis among dental healthcare workers and evaluate the potential risk of TB transmission to patients in dental clinics in Tripoli, Libya.

Methods**Study Design and Setting**

A descriptive cross-sectional study was conducted to evaluate the occupational risk of tuberculosis (TB) among dental healthcare workers (DHCWs) and to assess the potential risk of TB transmission to dental patients attending healthcare facilities in Tripoli, Libya. The study employed structured questionnaires to obtain information on participants' demographic characteristics, tuberculosis-related knowledge, occupational exposure, infection-control practices, and patient

experiences related to dental care. The study was carried out in selected public and private dental clinics, academic dental training institutions of Al-Tahadi University, and the Tripoli Tuberculosis Centre, Tripoli, Libya. Data collection was performed following approval from the relevant academic and health authorities, from December 2025 to March 2026.

Study Population and Eligibility Criteria

The study consisted of two independent participant groups. The first group included dental healthcare workers involved in direct patient care, comprising dentists, dental assistants, dental hygienists, dental students engaged in clinical training, and dental radiology personnel. The second group included patients diagnosed with tuberculosis who attended the Tripoli Tuberculosis Centre during the study period. Dental healthcare workers were eligible if they were dentists or allied dental personnel actively involved in clinical practice, dental students undertaking clinical training, or participants willing to provide informed consent. Tuberculosis patients were eligible if they were adults with confirmed active pulmonary TB, active extrapulmonary TB, latent TB infection, or had completed TB treatment, attended the Tripoli Tuberculosis Centre during the study period, and were able and willing to provide informed consent. Exclusion criteria were unwillingness to participate, incomplete questionnaires, dental personnel not involved in clinical patient care, and patients younger than 18 years of age.

Sample Size and Sampling Technique

A convenience sampling technique was used. A total of 172 participants were recruited, including 95 dental healthcare workers and 77 patients diagnosed with tuberculosis. Eligible participants were approached consecutively during the data collection period until the required sample size was achieved.

Data Collection Instrument

Data were collected using two structured questionnaires developed after reviewing current World Health Organisation (WHO) and Centres for Disease Control and Prevention (CDC) recommendations regarding tuberculosis prevention and infection control in healthcare settings [3,4,8,9]. The questionnaire administered to dental healthcare workers comprised sections on sociodemographic characteristics, awareness and knowledge of tuberculosis, previous occupational exposure to TB, infection-prevention and control practices, use of personal protective equipment (PPE), frequency of aerosol-generating dental procedures, and tuberculosis screening and Bacillus Calmette–Guérin (BCG) vaccination history. The questionnaire administered to patients with tuberculosis collected information on demographic characteristics, tuberculosis history and treatment status, oral health needs, utilisation of dental services during TB illness, disclosure of TB status to dental professionals, infection-control measures observed during dental visits, and patient satisfaction, including waiting time for dental care. Both questionnaires consisted primarily of closed-ended questions with predefined response categories to facilitate standardised data collection.

Study Variables

The primary outcome variables included the level of tuberculosis knowledge among dental healthcare workers, occupational exposure to suspected or confirmed TB cases, compliance with infection-control practices, utilisation of personal protective equipment (PPE), frequency of aerosol-generating procedures, dental attendance among patients with tuberculosis, and disclosure of tuberculosis status during dental visits. The independent variables included participants' age, sex, professional category, years of clinical experience, workplace setting, and tuberculosis disease status.

Data Collection Procedure

Eligible participants were informed about the objectives of the study before enrollment. After obtaining written informed consent, questionnaires were distributed and completed anonymously. Investigators remained available throughout the process to clarify questions without influencing participants' responses. Completed questionnaires were reviewed for completeness before data entry.

Statistical Analysis

Data were analysed using SPSS version 25. Descriptive statistics, including frequencies, percentages, tables, and graphs, were used to summarise participant characteristics and study variables. The chi-square test was used to examine associations between training status (PPE training and TB training) and self-reported adherence to key infection-control practices, such as eye protection use, gown use, mask change frequency, and high-volume suction use. A p-value of less than 0.05 was considered statistically significant.

Results

Participant Characteristics

(Table 1) summarises the demographic and professional characteristics of the study population. The majority of participants were female ($n = 63$, 66.3%) and aged 25–34 years ($n = 49$, 51.6%). Dentists represented 88.8% ($n = 84$) of the sample, followed by dental assistants ($n = 8$, 8.6%), RPS ($n = 2$, 1.6%), and FPD specialists ($n = 1$, 1.1%). Half of the participants worked in private dental clinics ($n = 48$, 50.5%), while 21.1% ($n = 20$) worked in public clinics, 17.9% ($n = 17$) in academic/training institutions, and 10.5% ($n = 10$) in combined public-private settings. Regarding professional experience, 31.7% ($n = 30$) had 1–5 years, 24.8% ($n = 24$) had less than 1 year, 21.2% ($n = 20$) had 6–10 years, 12.2% ($n = 12$) had 11–20 years, and 10.1% ($n = 10$) had more than 20 years.

Table 1. Demographic and professional characteristics (N = 95)

Variable	Category	n (%)
Gender	Female	63 (66.3)
	Male	32 (33.7)
Age (years)	<25	11 (11.6)
	25–34	49 (51.6)
	35–44	24 (25.3)
	45–54	10 (10.5)
	45–55	1 (1.1)
Profession	Dentist	84 (88.8)
	Dental assistant	8 (8.6)
	FPD specialist	1 (1.1)
	RPS	2 (1.6)
Workplace	Private dental clinic	48 (50.5)
	Public dental clinic	20 (21.1)
	Academic/training institution	17 (17.9)
	Public-private clinics	10 (10.5)
Experience	<1 year	24 (24.8)
	1–5 years	30 (31.7)
	6–10 years	20 (21.2)
	11–20 years	12 (12.2)
	>20 years	10 (10.1)

TB Training and Knowledge

(Table 2) presents TB-related training and knowledge. Only 15.8% ($n = 15$) had received TB training in the last 3 years, while 84.2% ($n = 80$) had not. However, 60.0% ($n = 57$) had received training on personal protective equipment (PPE). Regarding TB transmission knowledge, 87.4% ($n = 83$) correctly identified airborne droplets as a mode of transmission, while 4.2% ($n = 4$) were unsure, and 8.4% ($n = 8$) selected other modes (blood exposure, contaminated surfaces, or combinations). Awareness of dental aerosols and TB was reported by 84.2% ($n = 80$) of participants.

Table 2. TB training and knowledge (N = 95)

Variable	Category	n (%)
TB training in last 3 years	No	80 (84.2)
	Yes	15 (15.8)
PPE training	Yes	57 (60.0)
	No	38 (40.0)
TB transmission knowledge	Airborne droplets	83 (87.4)
	Unsure	4 (4.2)
	Other (blood, surface, combined)	8 (8.4)
Awareness of dental aerosols & TB	Yes	80 (84.2)
	No	15 (15.8)

TB Exposure and Infection Control Practices

(Table 3) Details TB exposure and infection control practices. Half of the participants (50.5%, $n = 48$) reported no exposure to a TB patient, 42.1% ($n = 40$) were unsure, and 7.4% ($n = 7$) reported exposure. Accidental exposure (e.g., needlestick, aerosol, droplet) was reported by 35.8% ($n = 34$). Adherence to infection-control protocols was high: 70.5% ($n = 67$) always followed protocols, 21.1% ($n = 20$) often, 7.4% ($n = 7$) sometimes, and 1.1% ($n = 1$) rarely. When asked about deferring

treatment for patients with TB symptoms, 37.9% (n = 36) said yes, 31.6% (n = 30) said no, and 30.5% (n = 29) found it not applicable.

Table 3. TB exposure and infection control practices (N = 95)

Variable	Category	n (%)
Exposure to TB patient	No	48 (50.5)
	Not sure	40 (42.1)
	Yes	7 (7.4)
Accidental exposure.	Yes	34 (35.8)
	No	61 (64.2)
Follow infection-control protocols	Always	67 (70.5)
	Often	20 (21.1)
	Sometimes	7 (7.4)
	Rarely	1 (1.1)
Defer treatment for TB symptoms.	Yes	36 (37.9)
	No	30 (31.6)
	Not applicable	29 (30.5)

PPE Usage

(Table 4) summarises PPE usage. Gloves and masks were always used by 100% of participants. However, eye protection was used always by only 22.1% (n = 21), often by 13.7% (n = 13), sometimes by 50.5% (n = 48), and never by 13.7% (n = 13). Gown use was always by 50.5% (n = 48), often by 16.8% (n = 16), sometimes by 26.3% (n = 25), and never by 7.4% (n = 7). Surgical masks were the most common type (80.0%, n = 76), followed by cloth masks (14.7%, n = 14) and N95/FFP2 (5.3%, n = 5). Mask change between patients was reported by 77.9% (n = 74), while 14.7% (n = 14) changed only when soiled, and 7.4% (n = 7) did not change.

Table 4. PPE usage (N = 95)

PPE type	Always n (%)	Often n (%)	Sometimes n (%)	Never n (%)
Gloves	95 (100)	0 (0)	0 (0)	0 (0)
Mask	95 (100)	0 (0)	0 (0)	0 (0)
Eye protection/face shield	21 (22.1)	13 (13.7)	48 (50.5)	13 (13.7)
Gown	48 (50.5)	16 (16.8)	25 (26.3)	7 (7.4)
Mask type	Surgical: 76 (80.0)	Cloth: 14 (14.7)	N95/FFP2: 5 (5.3)	/
Mask change between patients	Yes: 74 (77.9)	Only when soiled: 14 (14.7)	No: 7 (7.4)	/

Aerosol-Generating Procedures and Suction Use

(Table 5) shows the frequency of aerosol-generating procedures and high-volume suction use. Daily aerosol procedures were performed by 62.1% (n = 59) of participants, several times weekly by 24.2% (n = 23), weekly by 8.4% (n = 8), and rarely by 5.3% (n = 5). High-volume suction was used always by 45.3% (n = 43), often by 15.8% (n = 15), sometimes by 21.1% (n = 20), and never by 17.9% (n = 17). Notably, among those performing aerosol procedures daily, only 29.5% (n = 28) always used high-volume suction, and 9.5% (n = 9) never used it (Figure 1).

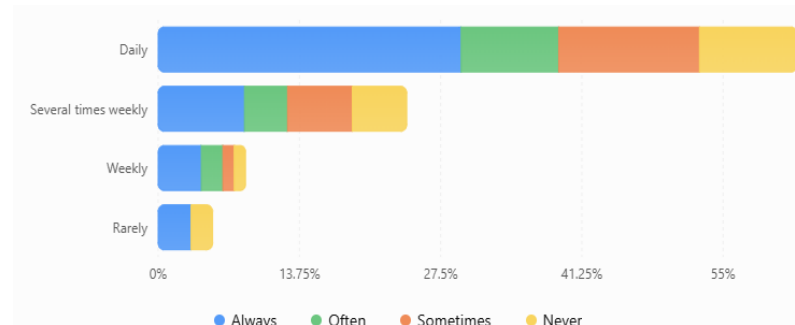


Figure 1. Frequency of high-volume suction use stratified by frequency of aerosol-generating procedures.

Among participants performing aerosol procedures daily, only 29.5% always used high-volume suction, while 9.5% never used it.

Associations Between Training and Practices

Chi-square tests were performed to examine the association between training status (PPE training and TB training) and self-reported adherence to key infection-control practices. A statistically significant association was observed between PPE training and eye protection use ($\chi^2 = 7.99$, $df = 3$, $p = 0.046$), with trained participants more likely to report “always” using eye protection (18/57, 31.6%) compared to untrained participants (3/38, 7.9%). Similarly, TB training in the last 3 years was significantly associated with eye protection use ($\chi^2 = 11.49$, $df = 3$, $p = 0.009$), where 8 of 15 trained participants (53.3%) reported “always” using eye protection, versus 13 of 80 untrained participants (16.3%). No significant associations were found between training status and gown use (PPE training: $\chi^2 = 1.02$, $df = 3$, $p = 0.797$; TB training: $\chi^2 = 4.64$, $df = 3$, $p = 0.200$), nor with mask change frequency or high-volume suction use (all $p > 0.05$; data not shown). These findings suggest that both PPE-specific and TB-specific training may improve adherence to eye protection, but broader infection-control practices may require additional targeted interventions.

Table 6. Chi-square tests for associations between training and eye protection use (N = 95)

Training variable	Eye protection use	n (%)	χ^2	df	p-value
PPE training			7.99	3	0.046*
Yes (n = 57)	Always	18 (31.6)			
	Often	8 (14.0)			
	Sometimes	23 (40.4)			
	Never	8 (14.0)			
No (n = 38)	Always	3 (7.9)			
	Often	5 (13.2)			
	Sometimes	23 (60.5)			
	Never	7 (18.4)			
TB training (last 3 years)			11.49	3	0.009
Yes (n = 15)	Always	8 (53.3)			
	Often	2 (13.3)			
	Sometimes	5 (33.3)			
	Never	0 (0.0)			
No (n = 80)	Always	13 (16.3)			
	Often	11 (13.8)			
	Sometimes	41 (51.3)			
	Never	15 (18.8)			

* P-value statistically significant at less than 0.05.

Discussion

Demographic and Professional Characteristics

The present study provides a comprehensive assessment of tuberculosis (TB) awareness, infection-control practices, and PPE utilisation among dental healthcare personnel in a resource-limited setting. The sample was predominantly female (66.3%) and aged 25–34 years (51.6%), with dentists comprising the vast majority of respondents (88.8%). Approximately half of the participants (50.5%) worked in private dental clinics, and a similar proportion (56.5%) had five or fewer years of professional experience. These findings are broadly consistent with the demographic profile of the Libyan dental workforce reported in previous national studies. For example, a study of 123 dentists in Tripoli found that 60.1% were female and 68.3% were general practitioners, reflecting a similar gender distribution and professional composition to the present sample [1]. The predominance of private-sector employment in the current study (50.5%) is also notable, as infection-control infrastructure and oversight may be less standardised in private settings compared with academic or public institutions, a concern that has been raised in the Libyan context [2].

TB Training and Knowledge

A critical finding of this study was the low uptake of TB-specific training, with only 15.8% of participants having received any TB training in the preceding three years. This is considerably lower than what would be expected given the occupational risk posed by aerosol-generating dental procedures. The World Health Organisation and the Centres for Disease Control and Prevention recommend that all dental healthcare personnel receive routine education on TB transmission, risk assessment, and infection-control protocols as part of a comprehensive written infection-control programme [3,4]. A Libyan study conducted in Misurata similarly identified a significant gap in systematic training, with many participants reporting the absence of structured training or periodic assessments within their institutions [2]. The American Dental

Association further emphasises that dental office risk assessment and training should be integral to TB infection-control planning [5]. The gap identified in this study suggests that TB education may be systematically neglected in both undergraduate dental curricula and continuing professional development in the study setting. Encouragingly, knowledge of the primary mode of TB transmission was high, with 87.4% of participants correctly identifying airborne droplets as the primary route. Similarly, 84.2% reported awareness of the association between dental aerosols and TB. This level of knowledge is comparable to findings from earlier studies conducted in high-burden settings; for example, a Libyan study reported that 90% of surveyed dentists had knowledge of TB transmission routes in the dental clinic [6]. However, the discordance between theoretical knowledge and reported training participation (87.4% transmission knowledge vs. 15.8% recent training) suggests that knowledge may be acquired through informal channels or undergraduate education rather than structured, up-to-date TB-specific training. This pattern has been described in the Libyan literature, where static knowledge acquired during initial professional education may not be reinforced through continuing education, potentially leading to outdated practices [6].

Exposure and Infection-Control Practices

The finding that only 7.4% of participants reported confirmed exposure to a TB patient, while 42.1% were unsure, is clinically significant. The high proportion of uncertainty likely reflects inadequate TB risk assessment during patient history-taking. The CDC recommends that dental healthcare personnel routinely ask all patients whether they have a history of TB disease or symptoms indicative of TB during initial and periodic medical history updates [4]. A Libyan study conducted in Zawia found that while general dental practitioners had high levels of knowledge about droplet and airborne isolation precautions, their practice was comparatively lower, a pattern that mirrors the knowledge–practice gap observed in the present study [6]. The lack of systematic risk assessment is a critical gap that may expose both clinical staff and subsequent patients to undiagnosed active TB. This concern is amplified by the finding that 35.8% of participants reported accidental exposure (e.g., needlestick, aerosol, or droplet), underscoring the tangible occupational risk faced by this population. Adherence to infection-control protocols was generally high, with 70.5% of participants reporting that they “always” followed protocols. However, this self-reported adherence must be interpreted with caution, as social desirability bias may inflate reported compliance. A Libyan study conducted in Tripoli similarly found that while hand hygiene compliance was widely practised, other infection-control measures were inconsistently applied [1]. The deferral of treatment for patients with TB symptoms was practised by only 37.9% of participants, with 31.6% indicating they would not defer treatment. This is at variance with standard recommendations, which advise that elective dental treatment for patients with suspected or confirmed active TB should be deferred until a physician confirms non-infectivity [3,4]. A Libyan study found that 90% of dentists had never treated a patient with TB, and 70% did not know how to detect the disease during consultation, suggesting that the reluctance to defer treatment may reflect a combination of limited awareness of referral pathways and a lack of institutional policies mandating deferral [6].

PPE Usage

The universal reported use of gloves and masks (100% “always”) is an encouraging finding that reflects the near-universal adoption of these basic PPE items in contemporary dental practice. This is consistent with the high compliance rates reported in Libyan studies. A study conducted in Misurata found high adherence to glove and mask use among dental healthcare workers [2], and a study in Tripoli reported similar findings [1]. However, the picture is markedly different for eye protection and gowns. Only 22.1% of participants reported “always” using eye protection, with 50.5% using it only “sometimes” and 13.7% never using it. This is a substantial concern, as ocular exposure to aerosolised pathogens—including *Mycobacterium tuberculosis*—during aerosol-generating procedures poses a direct risk of transmission. A Libyan study of dental students and interns in Benghazi found that the vast majority of third-year students reported never wearing eyewear (73.2%) or a face shield (81.1%), indicating that this is a persistent and widespread problem across different regions of Libya and different levels of professional experience [7]. The predominance of surgical masks (80.0%) over N95/FFP2 respirators (5.3%) is another area of concern. During aerosol-generating procedures, surgical masks provide inadequate protection against airborne droplet nuclei of the size that carry *M. tuberculosis*. The use of N95 respirators or high-efficiency particulate air (HEPA) filtration is specifically recommended for dental staff performing aerosol-generating procedures when TB status is unknown [4,8]. The low adoption of N95 respirators in this sample may reflect cost, availability, or lack of awareness of the specific TB-related indication. Additionally, the finding that 14.7% of participants changed masks only when soiled and 7.4% did not change masks between patients indicates that mask change practices fall short of the recommended standard of changing masks between patient encounters [9].

Aerosol-Generating Procedures and High-Volume Suction

The frequency of aerosol-generating procedures was high, with 62.1% of participants performing such procedures daily. Despite this, high-volume suction (HVS) was used “always” by only 45.3% of participants, and among those performing aerosol procedures daily, only 29.5% always used HVS while 9.5% never used it. This is a critical finding, as HVS has been

shown to effectively reduce aerosol and splatter generation during dental procedures. One study reported that the use of HVS effectively reduced 37.5–96% of splatter generation and 82–93% of aerosol and droplet particles at 1.2 m for ultrasonic scaler and air polisher procedures [10]. Another study found that dynamic high-volume suction devices that follow the path of the aerosol-generating device effectively eliminate aerosol particles escaping from the oral cavity [11]. The underutilisation of HVS in the present sample represents a significant missed opportunity for aerosol mitigation and, by extension, for TB transmission risk reduction. This finding aligns with the broader literature indicating that even when dental professionals are aware of aerosol risks, translating that awareness into consistent HVS use remains a challenge [12]. The low uptake of HVS in Libya may also reflect equipment availability and cost constraints, particularly in private clinics, as well as a lack of institutional protocols mandating its use [2].

Associations Between Training and Practices

The chi-square analyses revealed statistically significant associations between both PPE training ($\chi^2 = 7.99$, $p = 0.046$) and TB training in the last three years ($\chi^2 = 11.49$, $p = 0.009$) with eye protection use. Participants who had received TB training were substantially more likely to report “always” using eye protection (53.3%) compared with untrained participants (16.3%). This finding provides empirical support for the role of targeted training in improving specific infection-control behaviours. It is notable that the effect size was larger for TB training than for general PPE training, suggesting that disease-specific education may be particularly effective in driving behaviour change. A Libyan study conducted in Zawia similarly concluded that general dental practitioners had high levels of knowledge and good practice towards infection control after the COVID-19 outbreak, suggesting that disease-specific education campaigns can have a measurable impact on practice [6]. However, no significant associations were found between training status and gown use, mask change frequency, or HVS use. This dissociation suggests that while training can improve discrete, readily modifiable behaviours such as eye protection use, more complex or resource-dependent practices—such as consistent HVS use and appropriate gown utilisation—may require additional structural interventions, including equipment availability, workflow redesign, and institutional enforcement [3,4,9].

Implications and Recommendations

The study points to three priority actions: first, mandatory and recurring tuberculosis education for all dental personnel, since training was linked to improved eye protection use and may strengthen broader infection-control adherence; second, addressing structural barriers such as PPE availability, ergonomic high-volume suction use, and institutional policies to close the knowledge–practice gap, particularly as Libyan studies reveal poor awareness of written biosafety protocols; and third, establishing clear protocols for TB risk assessment, referral, and treatment deferral, supported by training and monitoring.

Limitations

The cross-sectional design prevents causal inference, and self-reported data may be inflated by social desirability bias. The modest sample ($N = 95$), composed mainly of dentists (88.8%), limits generalisability to other dental team members. PPE and HVS availability were not assessed, and the single geographic setting restricts broader applicability.

Conclusion

In conclusion, dental healthcare personnel showed high theoretical knowledge of TB infection control but inconsistent application in practice. TB-specific training was uncommon, though it was significantly associated with better eye protection use. Major gaps remained in eye protection, N95 respirator use, and high-volume suction during aerosol-generating procedures, consistent with moderate compliance reported across Libyan dental settings. Closing these gaps requires recurring, disease-specific education alongside structural and institutional support. Structural interventions that support and enforce evidence-based infection-control practices in dental settings.

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