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Risk of infection associated with dental unit water: a cross-sectional descriptive observational study

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Abstract

Aim: The objective of this study was to evaluate the infectious risk associated with dental unit water by assessing microbial contamination, identifying contributing factors, and proposing preventive measures to ensure the safety of patients and staff. Material and Methods: A cross-sectional descriptive observational study was conducted in Tunisia utilizing an online questionnaire. Distributed to dentists and dental students, the survey assessed their knowledge, training, and practices concerning water-related infection risks in dental chair units. Results: Among the 82 participants, most demonstrated a lack of awareness regarding waterborne infection risks and failed to implement recommended disinfection protocols. Only 29% were aware of the Ministry of Health's circular 31bis-2023. Water quality testing (both chemical and microbiological) was infrequent, and vital practices such as flushing, disinfection, and traceability of maintenance actions were inconsistently applied. Discussion: The findings reveal substantial gaps in infection control awareness and adherence within the dental sector. Limited training and inadequate enforcement of existing guidelines necessitate urgent reforms, including enhanced professional education, standardized hygiene protocols, and more stringent regulatory oversight to ensure the safety of both patients and providers. Conclusion: Further studies involving a larger sample of dentists, complemented by field visits, are required.

Keywords: water, infection prevention, dentistry.

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Introduction

Water is a fundamental element in dental procedures, playing a crucial role in cooling rotary instruments, rinsing the oral cavity, and filling patient cups. However, the waterlines in dental units offer a favorable environment for the development of microbial biofilms, attributable to water stagnation within narrow conduits with limited continuous flow. These biofilms may harbor opportunistic microorganisms, some of which could pose a pathogenic threat to immunocompromised patients and healthcare personnel [1,2].

Although waterborne infections in dental settings are seldom documented in the scholarly literature, this risk remains underestimated owing to the challenges of establishing a direct correlation between waterline contamination and patient infection rates [3]. Nevertheless, underreporting should not diminish the importance of implementing stringent control measures for the microbiological quality of water used, particularly because research has shown that contamination levels in dental unit waterlines significantly exceed the standards deemed acceptable for potable water [4,5].

Furthermore, the quality of water is influenced not only by its physicochemical properties—specifically its hardness and pH—but also by the maintenance and disinfection procedures implemented on the equipment [6]. Consequently, both national and international guidelines endorse routine flushing, the employment of suitable disinfectants, and the periodic assessment of the microbiological quality of the water [7,8].

Nevertheless, the application of these practices varies among different facilities. This dissertation aims to evaluate dentists' knowledge and practices regarding the management of dental unit waterlines and to emphasize the importance of proper maintenance and adherence to safety protocols.

Materials and Methods

1. Type of study:

This was a cross-sectional, descriptive, observational study conducted on a sample of dental practitioners operating within Tunisia.

2. Sample and inclusion criteria:

Participants included dental students or practicing dentists in Tunisia, whether in private practice, hospitals, or university hospitals, and encompassing general practitioners as well as specialists.

3. Data collection:

Data were collected using a questionnaire designed through Google Forms. It consisted of three sections and 21 questions:

3.1. General information:

Age, sex, years of professional experience, sector of practice, etc.

3.2. Knowledge and training:

- Training in hygiene,
- Knowledge of the infectious risk related to dental unit water,
- Risk factors,
- Knowledge of Circular 31bis-2023 issued by the Ministry of Health regarding the prevention of infectious risk in dental units.

3.3. Professional practices :

- Source of the dental unit water supply
- Water sampling from the network to determine water hardness
- Bacteriological sampling of dental unit water
- Frequency of bacteriological sampling of dental unit water
- Flushing of dental unit water outlets (rotary instruments, air–water syringe, cup filler, etc.)
- Availability of standard-compliant filters and water softeners
- Regular monthly replacement of sand and particle filters
- Availability of a functional internal disinfection system for the dental unit, activated daily
- Product used for internal disinfection of the dental unit and its concentration
- Traceability of maintenance and disinfection procedures of the dental unit
- elf-assessment of knowledge on the infectious risk related to dental unit water
- The questionnaire was disseminated exclusively to dentists. Each participant was allowed to submit the form only once and was not permitted to modify their responses after submission. This questionnaire was developed based on

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the recommendations of Circular 31bis-2023 issued by the Ministry of Health.

4. Ethical Considerations:

4.1. Confidentiality and Anonymity:

All information provided was strictly confidential and used solely for research purposes. The option to collect respondents' email addresses was disabled to ensure the anonymity of the responses.

4.2. Voluntary Participation:

Participation was entirely voluntary. Participants retained the right to withdraw from the questionnaire or refuse participation at any point without the obligation to provide any justification.

5. Statistical Analysis:

The results were collected and analyzed using Microsoft Excel, version 2016.

Results

1. General Characteristics:

1.1. Age and Sex:

The distribution of dentists who responded to the questionnaire according to age range and sex is shown in Table I:

Table I: Distribution of dentists responding to the questionnaire by age range and sex

Age	Count	Percentage
< 30 ans	16	19.5%
between 30 and 40 old	50	61%
between 41 and 50 old	16	19.5%
Sex	**Count**	**Percentage**
Man	12	14.6%
Woman	70	85.4%
Total	82	100%

1.2. Years of Professional Experience, Practice Sector, and Governorate:

The distribution of dentists who responded to the questionnaire according to years of professional experience and practice sector is shown in the following table:

Table II: Distribution of dentists responding to the questionnaire by years of professional experience and practice sector.

Years of Experience	Frequency	Percentage
Less than 5 years	31	37.8%
5–10 years	28	34.1%
11–20 years	22	26.8%
21–30 years	1	1.2%
Practice Sector	**Frequency**	**Percentage**
Private practice	37	45.1%
Hospital facility	32	39%
University hospital facility	13	15.9%
Total	82	100%

The distribution of dentists responding to the questionnaire by governorate of practice is shown in the figure below:

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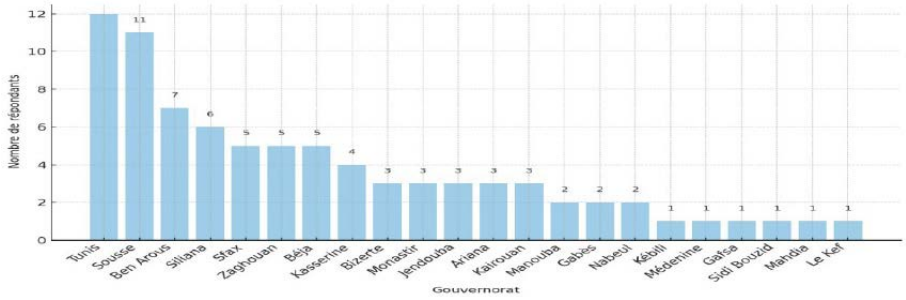
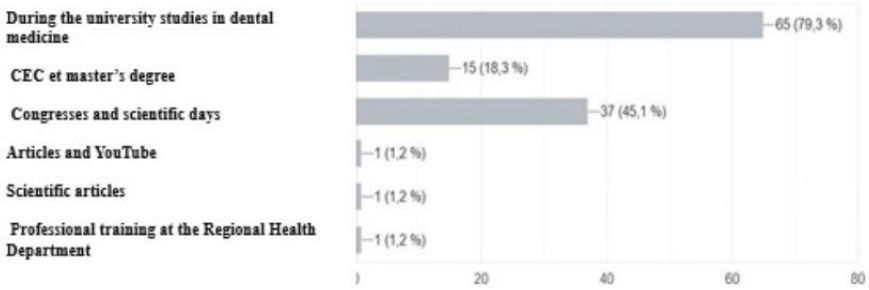


Figure 1: Distribution of dentists responding to the questionnaire by governorate of practice 02 were students, 68 were general dentists, and 12 were specialists.

2. Knowledge and Training:

2.1. Hygiene Training:

Figure 2: Distribution of dentists responding to the questionnaire according to their hygiene training.



2.2. Knowledge of Infection Risk Associated with Dental Unit Waterlines:

As illustrated in Figure 3 below, 20.7% of the participating dentists were not aware of the infection risks linked to dental unit waterlines.

Figure 3: Distribution of dentists responding to the questionnaire according to their knowledge of infection risk associated with dental unit waterlines.

2.3 Knowledge of Risk Factors:

The risk factors identified in the questionnaire (including water hardness, bacteriological quality of the network water, and water stagnation in dental chair tubing) were all correctly reported. The distribution of dentists responding to the questionnaire, based on their responses concerning risk factors associated with water-related infections in dental units, is depicted in the following figure.

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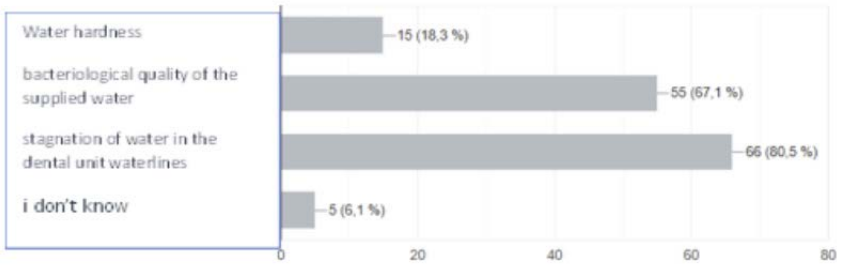
Figure 4: Distribution of dentists responding to the questionnaire based on their responses concerning the risk factors of water-related infections in dental units.

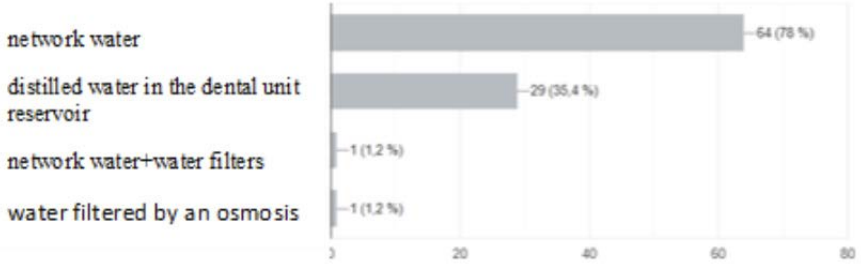


2.4. Knowledge of Circular 31bis-2023 of the Ministry of Health concerning the prevention of infection risk in dental units.

3. Professional Practices:

3.1. Source of the dental chair water supply:

Figure 5: Distribution of the 82 dentists responding to the questionnaire according to the source of the dental chair water supply.



3.2. Testing of mains water to assess water hardness

Figure 6: Distribution of the 82 dentists responding to the questionnaire according to the frequency of testing the hardness of mains water.

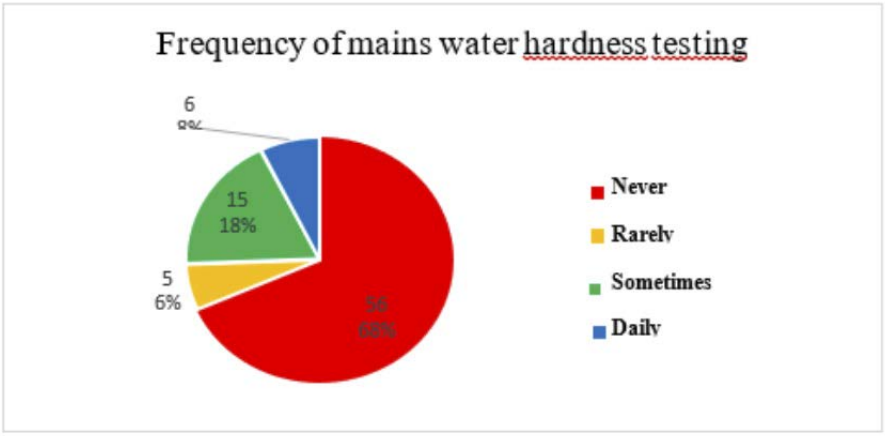


Table III: Distribution of the 82 dentists according to the adopted flushing protocol.

Response Category	Number
Daily in the morning before starting activity for 5 minutes	7
Daily after the end of activity for 20 seconds	15
Daily morning + after activity + between patients	9
Daily morning + between patients	5
Daily after activity + between patients	3
Daily morning + after activity	2
Sometimes, randomly	23
Never	10

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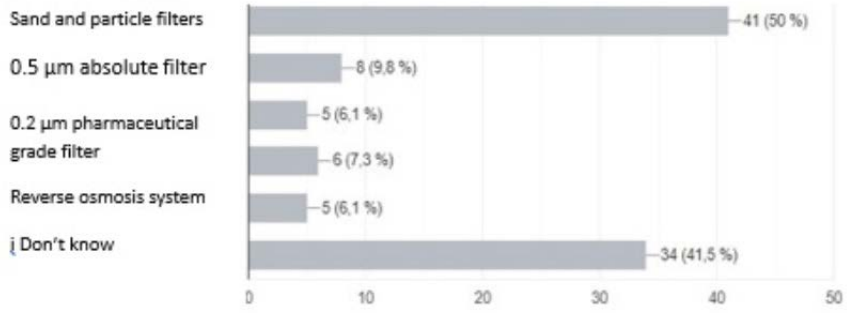
Response Category	Number
End of the day: one 10-minute cycle	1
I do not take care of flushing	1

Only 9 out of the 82 dentists surveyed reported performing flushing in accordance with the recommendations of Circular 31 bis-2023 from the Ministry of Health.
10 out of 82 dentists never perform flushing.

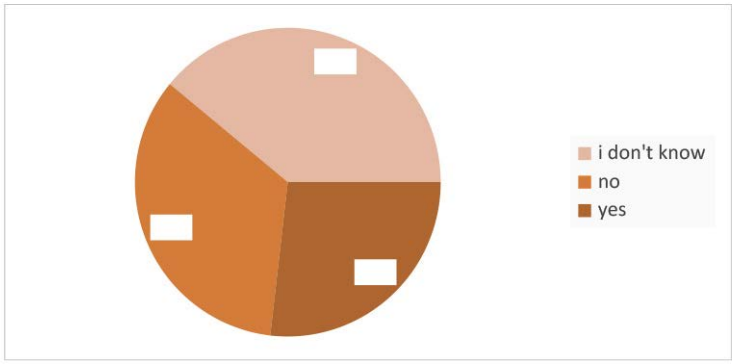
3.3. Availability of standard-compliant filters and water softeners

Figure 7: Distribution of the 82 dentists who responded to the questionnaire according to the availability of standard-compliant filters and water softener.



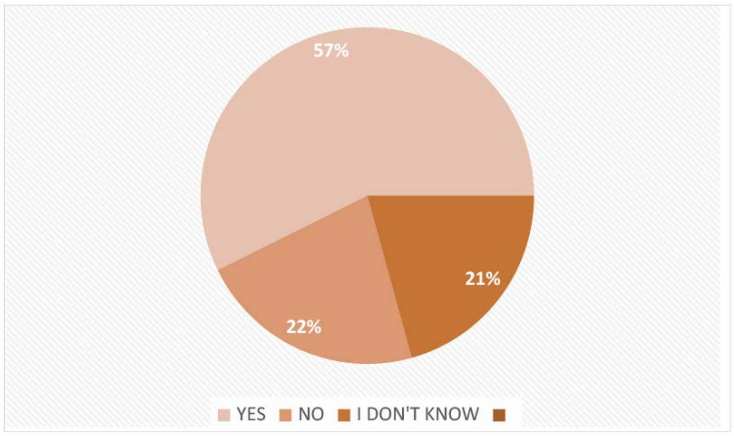
3.4. Monthly Regular Replacement of Sand and Particle Filters

Figure 8: Distribution of the 82 dentists who responded to the survey according to the monthly regular replacement of sand and particle filters.



3.5. Availability of a Functional Internal Chair Disinfection System, Operated Daily

Figure 9: Distribution of the 82 dentists who responded to the survey according to the availability of a functional internal chair disinfection system that is operated daily.



3.6. Product Used for Internal Chair Disinfection and Its Concentration

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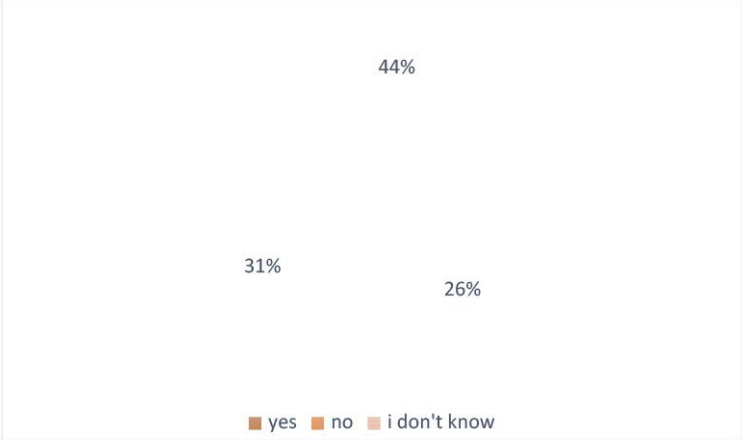
Product or Category	Number of Responses
Hydrogen peroxide (3%)	28
Hydrogen peroxide (5%)	3
Hydrogen peroxide (concentration not specified)	7
Bactinyl (concentration not specified)	9
Bactinyl 2%	1
Bactinyl 5%	1
Bactinyl 0.2%	1
Septanil	7
Bactione 1%	2
Bactinol	1
Bleach	1
Vinegar (for suction only)	1
Bactinyl or Hydrogen peroxide	1
Bactinyl or Chlorine	1
3% Disinfectant (no brand)	1
Nothing / Never done	4
I don't know / Not my responsibility	14

Table IV: Distribution of the 82 dentists according to the product used for internal chair disinfection and its concentration

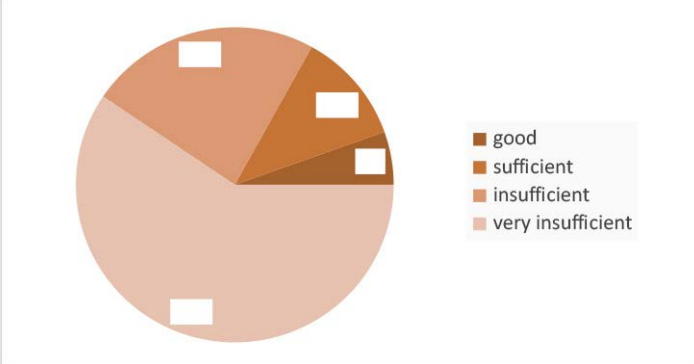
3.7. Traceability of Chair Maintenance and Disinfection Measures

Figure 10: Distribution of the 82 dentists who responded to the survey according to the traceability of chair maintenance and disinfection measures.



3.8. Self-Assessment of Knowledge on the Infectious Risk Related to Water in Dental Units

Figure 11: Distribution of the 82 dentists who responded to the survey according to their self-assessment of knowledge on the infectious risk related to water in dental units.



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Discussion

1. Dentistry and Infection Risk:

The French Technical Committee on Nosocomial and Healthcare-Associated Infections (CTINILS) defines a healthcare-associated infection as one that appears during or after a medical procedure (diagnostic, therapeutic, preventive, or educational) and was neither present nor incubating beforehand.

Dental care carries a risk of infection transmission because it involves complex, hard-to-sterilize instruments and invasive procedures performed in a contaminated environment, promoting cross-transmission between patients and dental staff[7,9]

2. Waterborne Infection Risk in Dentistry:

Beyond this risk, the dental care environment may serve as a reservoir for microorganisms. Dental units incorporate multiple systems (air, water, electricity) and devices essential for treatment procedures. Water is utilized to cool instruments (e.g., high-speed handpieces, contra-angles) and to rinse the patient's mouth [1,2].

Therefore, ensuring optimal microbiological water quality is imperative. Pathogens including *Legionella, Pseudomonas aeruginosa, Flavobacterium*, atypical mycobacteria, *Aeromonas*, and *Acinetobacter* have the capacity to proliferate under conducive conditions. Contamination at the point of use presents health hazards to both dental personnel and patients, particularly those with respiratory conditions or compromised immune systems. [9,10,11]

Three exposure routes are possible: direct ingestion, mucocutaneous contact, and inhalation of contaminated aerosols generated by dental instruments.

Although waterborne infections in dental units are rarely reported, their incidence is likely underestimated due to the difficulty of linking them to water system contamination. This risk, however, should not be overlooked. [11 ,12] .Among the respondents, 21% were unaware of this risk, and only 16% had received related training. Greater emphasis on this topic is recommended in both undergraduate and postgraduate dental education.

3. Water-Related Infection Risk Factors in Dentistry:

Among the 82 surveyed dentists, 5 were unaware of any waterborne infection risk factors, highlighting the need for greater awareness.

3.1. Water Stagnation and Biofilm Formation:

According to the FDI, a biofilm constitutes a colony of microorganisms adhering to a surface and is encased within an extracellular polymeric matrix, rendering it highly resistant to disinfectants.

In dental unit waterlines, several factors facilitate the proliferation of biofilms: backflow contamination in the absence of anti-retraction valves, ambient temperatures conducive to microbial growth, variations in laminar flow, periods of inactivity such as weekends and holidays, the type of pipe material, and low or irregular water flow, particularly in Tunisia. [13]

Dental unit water systems comprise elongated, slender conduits measuring 1 to 2 millimeters in diameter, typically fabricated from nylon or polyvinyl chloride (PVC) materials that are conducive to bacterial proliferation. In instances of prolonged water stagnation, biofilms develop on the internal surfaces of these conduits. [12,14]

Microbial cells may detach from these biofilms and enter the water flow supplied to the patient [12]. This constitutes one of the primary risk factors, as identified by 80.5% of the surveyed dental practitioners.

3.2. Water Hardness:

The quality of water utilized in dental units is of paramount importance for managing microbial contamination. Water hardness—assessed by the concentrations of calcium and magnesium—can indirectly facilitate the formation of mineral deposits (scale) within the piping systems. Such deposits foster the development of bacterial biofilms, thereby establishing a resilient microbial reservoir that cannot be readily eradicated through routine flushing or chemical disinfection [1].

Research indicates that elevated water hardness levels enhance bacterial adhesion to the internal surfaces of waterlines, notably for opportunistic species such as *Pseudomonas aeruginosa* and *Legionella pneumophila*, which are associated with nosocomial and community-acquired infections. [15,16].

It is advisable to utilize softened or treated water in order to minimize mineral deposits and sustain disinfection efficacy. Consistent monitoring of the physicochemical and microbiological quality of the water is imperative to prevent infection risks associated with dental unit water systems [17, 18].

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Seventy percent of surveyed dentists have never conducted water hardness testing. It is recommended that water hardness analysis be mandated prior to the establishment of a dental practice and, within the public sector, before the installation of dental units. Only five of the eighty-two respondents reported possessing a water softener.

4. Preventive Measures for Water-Related Infection Risk in Dentistry:

4.1. Tunisian Regulations and Recommendations:

The INEAS (2018) and the Ministry of Health's Directorate of Environmental Hygiene and Protection (2023) have issued guidelines aimed at preventing waterline-related infections in dental units. Following each patient, the water should be aspirated thoroughly, followed by the application of an appropriate disinfectant for the suction systems.

Furthermore, dental unit waterlines, including handpiece hoses, air/water syringes, and cup fillers, are mandated to be systematically flushed—initially for five minutes at the commencement and conclusion of each day, and for a duration of 20 to 30 seconds between patients. Flushing procedures may be performed either with the instruments remaining connected after use or prior to installing new equipment. [9,19]

Detachable components must be disinfected separately. Dental unit maintenance should include the air/water syringe, waterlines, and the entire water circuit. The air/water syringe carries external (splashes) and internal (backflow) contamination risks, so anti-retraction valves are recommended. Tips—disposable or sterilizable—should be replaced between patients.

Waterlines must use potable water, with regular microbiological testing to ensure safety. Manufacturer protocols for use and maintenance must be followed, regardless of the disinfectant used.

Maintaining water distribution equipment is essential, including checking system function, monitoring water temperatures, flushing outlets, and cleaning, descaling, and disinfecting removable parts, sinks, traps, and other fixtures.

Microbiological and physicochemical tests (e.g., free chlorine, pH, turbidity) should be done at set intervals. Noncompliant results, technical changes, shutdowns, or waterline-related infections require targeted corrective actions, with effectiveness verified by follow-up microbiological testing. [7,9,17]

Additional Guidelines (Circular 31 bis–2023, Ministry of Health):

- Install absolute pharmaceutical-grade filters (0.5 μm then 0.2 μm), plus sand and particle filters. In our sample, only 4 of 82 dentists had all three, while 41.5% were unaware of their filter types.
- Replace sand and particle filters monthly or as needed; only 26.8% of dentists did so monthly.
- Install anti-retraction valves at dead ends (water tanks, rotary handpiece lines).
- Use water softeners when necessary; 68% of dentists never tested water hardness.
- Conduct regular physicochemical (hardness, free chlorine) and microbiological tests with traceability; recommended at least once per year. [19]
- Periodically maintain wastewater circuits.
- Report any non-compliance to the Ministry of Health for corrective action.

The analysis shows that only 29% of surveyed dentists were aware of Ministry Circular 31 bis–2023 on infection prevention in dental units. This low awareness highlights poor communication or insufficient dissemination and underscores the need to strengthen institutional communication and include these regulations in continuing education for dental professionals.

4.2. Other Recommendations:

Several methods are available for disinfecting dental unit waterlines, including the use of hydrogen peroxide, chlorine dioxide, and chlorhexidine. Recent reviews advise employing independent reservoirs with distilled water for circuit disinfection. Routine flushing should invariably be supplemented with chemical disinfection. Most disinfectants—such as chlorine, chlorhexidine, hydrogen peroxide, certain mouthwashes, and citrus extracts—are effective; however, alkaline peroxide may cause pipe clogging. Regularly alternating disinfectants aids in preventing the development of resistant microbial strains [10,12].

Each dental unit manufacturer provides specific disinfection protocols, which practitioners should follow. In our sample, 28 of 82 dentists used 3% hydrogen peroxide, while others used non-compliant products or did not disinfect the internal water circuit.

US FDA Recommendations (2018) for Dentists:

- Implement documented standard operating procedures to guide staff in waterline infection prevention.
- Use appropriate equipment and methods, including independent water reservoirs, chemical treatment protocols, filtration

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systems, and sterile water delivery devices.
- For units with independent reservoirs, flush waterlines every evening and after periods of inactivity to prevent stagnation.
- After each patient, run water and air for 20–30 seconds to remove potential residues.
- Inspect waterlines regularly for deterioration or visible contamination, replacing them as needed or per manufacturer guidelines.
- Watch for signs of biofilm, such as musty odors, cloudy water, particles, or pipe clogging. [20]

- ***Recommendations:***

Given the observed gaps in dentists' knowledge and practices regarding water-related infection risks in dental units, the following are recommended:
- Strengthen dentists' education on hygiene and waterborne infection risks during university studies and through continuing education (CEC, conferences, training days).
- Include hospital hygiene in mandatory Continuing Professional Development for dental license renewal.
- Require bacteriological and physicochemical water analyses for practice authorization.
- Emphasize traceability of hygiene measures.
- Establish agreements with public or private labs to reduce testing costs.
- Conduct regular inspections of private and public dental units by hygiene authorities.
- Centralize analysis results and deficiencies in a national registry to enable more effective action.

Conclusion

The objective of this research was to elucidate dentists' knowledge and practices concerning water-related infection hazards. Several deficiencies were identified. It is recommended that larger-scale studies and in-person inspections be conducted.

Waterborne infections in dental units are seldom documented in scientific literature; however, they are plausibly underreported. This underestimation stems from the challenge of directly associating an infection with contamination of the dental unit water system. Nonetheless, the potential risk persists and warrants diligent oversight. Additionally, the economic implications of this risk have yet to be evaluated.

Author Contributions

Conceptualization: [Jemli Safa]; **Methodology:** [Baccar Marwa]; **Validation:** [Jemli Safa]; **Data Curation:** [Baccar Marwa]; **Writing – Original Draft Preparation:** [Rejeb Wissal]; **Writing – Review and Supervision:** [Jemli Safa].

All authors have read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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