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Research article

The effect of different types of water sources on dental unit waterline contamination: A systematic review and meta analysis

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ABSTRACT

To systematically review the effect of different types of water sources on dental unit waterline (DUWL) contamination. 5 databases were searched from their inception to December 23, 2023. Two reviewers independently extracted the data and assessed the quality of the literature. The risk ratio (RR) was used as measure of effect size in meta-analysis. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) was used for evaluating quality of the evidence. Meta-analysis was completed by RevMan 5.4.5 studies involving 561 water samples were quantified for meta-analysis. The results indicated that no significant differences were found in view of contamination rate (RR = 1.01; 95 % CI, 0.72–1.41; $P = 0.96$, $I^2 = 62$ %; GRADE low) and detection rate of *Pseudomonas aeruginosa* (RR = 0.78; 95 % CI, 0.15–4.13; $P = 0.77$; $I^2 = 83$ %; GRADE very low) between using purified water and tap water as water sources of DUWL. The available evidence suggests that there is no significant difference between purified water and tap water in controlling DUWL contamination. However, the conclusions need to be further validated through more randomized controlled trials with robust design and a large sample size.

1. Introduction

Following the Corona Virus Disease 2019 (COVID-19) pandemic, there has been an increased emphasis on hospital infection control in dental clinics, with particular attention to the potential role of dental unit waterline (DUWL) as a source of infection. Dental Chair Unit (DCU) is the complex integrated systems of water, electrical and pneumatic lines that support a wide range of dental treatments. Dental unit waterline (DUWL) as vital components of DCU, consists of internally interconnected plastic hoses and metal control valves. Dental treatment water delivered by DUWL is supplied to the DCU cup filler outlet for oral rinsing of patients and the bowl-rinse outlet

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for rinsing DCU spittoon, as well as to cool down dental instruments such as handpieces in order to prevent potential tooth damage caused by heat generated during their use. Additionally, dental treatment water is also supplied to air/water syringe for irrigation [1].

In 1963, Blake conducted a study revealing elevated levels of microorganisms in DUWL, marking the initial documentation of DUWL contamination [2]. Over the past few decades, numerous studies have consistently reported microbial counts easily exceeded 10^6 colony-forming units per milliliter (CFU/mL) in DUWL because of the texture and composition of plastic tubes and prolonged stagnation of dental treatment water [3,4]. These microorganisms originate not only from oral microbiota due to patients' oral bacterial retraction during dental procedures but also from the dental treatment water itself [5,6]. The contaminated DUWL harbors pathogenic microorganisms including *Pseudomonas aeruginosa*, *Legionella* species, and non-tuberculosis *Mycobacterium* [7–10]. Direct exposure of patients' skin, mucous membranes, and dental tissues to this contaminated water during dental treatment may result in wound infections [7,11,12]. Moreover, the inhalation of aerosols generated from contaminated dental treatment water poses a risk of healthcare-associated infections for both patients and healthcare workers [13]. Therefore, the high microbial loads present in DUWL represent a potential public health concern, particularly for vulnerable populations such as the elderly or immune-compromised individuals. At present, the Centers for Disease Control and Prevention (CDC) and the American Dental Association (ADA) recommend that concentration of heterotrophic water bacteria in DUWL output water should not exceed 500 CFU/mL [14]. When concentration of heterotrophic water bacteria in DUWL output water exceeds the limits issued by CDC, ADA or other guidelines, the water sample from outlets is considered contaminated. To ensure meet these standards, DUWL water quality control measures involving physical and chemical disinfection methods have been proposed. Chemical methods are the use of various chemical disinfectants (e.g., hydrogen peroxide, chlorine disinfectants, and electrolysed oxidising water). Physical methods include installing anti-back draft devices, emptying and drying pipelines, flushing, and changing the type of water source.

Currently, the types of water sources commonly used in DCU include tap water and purified water. Purified water refers to tap water is treated by distillation, ion exchange or reverse osmosis, including distilled water, reverse osmosis water, deionized water, demineralized water, soft water and sterile water [15]. Compared with tap water, purified treated water has relatively few impurities, inorganic salts, and microorganisms. That may reduce the multiplication of microorganisms within the DUWL so that biofilms are less likely to form in the pipeline, and is expected to reduce output water contamination [16]. Several original studies have investigated the impact of water source selection on microbial contamination in DUWL [17–21], but the varying results across studies have not led to a unified conclusion regarding which type of water sources should be selected for DUWLs. Therefore, this study aims to conduct the first systematic review and meta analysis to evaluate the effect of different types of water sources on DUWL contamination.

2. Methods

The present systematic review and meta analysis was rigorously conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) [22]. The protocol of the present study has been registered in PROSPERO platform (registration ID: CRD42023413453).

2.1. Searching strategy

A comprehensive search was conducted across 5 electronic databases, including PubMed, EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), China National Knowledge Internet (CNKI), and Wanfang Database. The search period spanned from the inception of these databases to December 23, 2023. Monthly updates were performed to identify any potential studies. Two independent reviewers identified more eligible studies by reviewing their reference lists. Language restrictions were not applied during the search process. The search terms included "dental unit", "waterline", and "water". MeSH terms and text words were combined in the search strategy, which was tailored to each database's characteristics. A complete search strategy for PubMed was provided in Table 1. All retrieved records were managed using Endnote X20.0 software.

Table 1
The search queries in PubMed.

Search number	Search details
7	#3 **OR** #6
6	#4 **AND** #5
5	"waterline"[Text Word] **OR** "waterlines"[Text Word] **OR**"waterline"[Text Word] **OR** "waterlines"[Text Word] **OR**"water system"[Text Word]**OR** "water systems"[Text Word]
4	"dental-unit"[Text Word] **OR** "dental"[Text Word]
3	#1 **AND** #2
2	"water"[Text word]
1	"dental unit"[Text Word] **OR** "dental units"[Text Word] **OR** "dental chair"[TextWord] **OR** "dental chairs"[TextWord]

2.2. Selecting criteria

The selection criteria were initially formulated based on five key aspects, namely the object of study, intervention, comparison, outcome measures, and study design prior to conducting the search. The inclusion criteria were as follows: 1) object of study - DCU for clinical treatment; 2) intervention - purified water including distilled water, reverse osmosis water, deionized water, demineralized water, soft water or sterile water as water sources of DUWL; 3) comparison - tap water as water sources of DUWL; 4) outcome measures: the primary outcome was the contamination rate of water samples from outlets (contamination rate = number of contaminated water samples/number of all the water samples), and the secondary outcome was the detection rate of opportunistic pathogen (the detection rate of opportunistic pathogen = number of water samples contaminated with opportunistic pathogen/number of all the water samples); and 5) study design - randomized controlled trials (RCTs) or clinically controlled trials (CCTs). Exclusion criteria included: in vitro studies, insufficient data and duplicate publications.

2.3. Study selection

The downloaded citations were imported into Endnote X20.0 software for de-duplication. Two independent reviewers (TYS and LJY) conducted a thorough literature screening and cross-checked the results. Initially, the title and abstract of each literature were screened to exclude obviously irrelevant ones. Only when both reviewers deemed a literature eligible based on its title and abstract, its full text was obtained for further selection. The full text was meticulously assessed and re-screened to make final determinations on eligible studies. Disagreements between the two reviewers were resolved through consultation, with involvement of a third reviewer (ZWW) if consensus could not be reached.

2.4. Data extraction

Two independent reviewers (TS and SYH) extracted data from the included studies using a pre-designed data extraction table, ensuring accuracy through cross-checking of the final results. The extracted information encompassed the first author, publication year, country, study design, number of DCU, type of water sources, collection method of water sample, microbiological analysis method, and reported outcomes. Any discrepancies between the two reviewers were resolved through consultation with a third reviewer (MFJ) if necessary. In cases where missing or additional data were required, the authors of the respective papers were contacted for clarification.

2.5. Evaluation of methodological quality of included studies

The quality of the included literature was independently assessed and cross-checked by two researchers (TS and LJY) based on the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Quasi-Experimental Studies, which consists of nine items [23]. Assessment criteria included descriptions of causality, variables, baseline, controls, outcome measures, follow-up, and data analysis. Each item in the included literature was evaluated as “yes”, “no”, “unclear” or “not applicable” to determine its appropriateness. A study with less than 50 % “yes” answers was considered to have a high risk of bias, while a study with 50 %–69 % “yes” answers was rated as having a moderate risk of bias. A study with 70 % or more “yes” answers was classified as having a low risk of bias [24]. Any disagreements were resolved through consultation with a third researcher (XEL).

2.6. Statistical analysis

The data synthesis was conducted using Review Manager 5.4 version software. For this study, the outcome indicator consisted of dichotomous data, and therefore the results were presented as risk ratios (RR) with a 95 % confidence interval (CI). Statistical significance for the combined result of multiple studies was considered at a level of $P < 0.05$. To account for heterogeneity within and across trials, a random-effects model was employed to perform statistical analysis on the contamination rate and detection rate of opportunistic pathogen in this meta-analysis [25]. Heterogeneity was assessed using I^2 and the chi-square test [26]. Subgroup analyses were performed to evaluate differences between groups based on whether chemical disinfection was implemented. If there were 10 or more studies included in the meta-analysis, a funnel plot would be generated to assess publication bias [27].

2.7. Quality of evidence

The GRADE guidelines were adhered to for assessing the overall quality of evidence, utilizing the GRADE pro GDT software (guideline development tool) [28]. The a priori ranking has been downgraded to ‘moderate’ based on all the included studies being non-RCTs [29]. Subsequently, we evaluated five factors that could further diminish the quality of evidence: risk of bias, inconsistency, indirectness, imprecision, and publication bias. Ultimately, we assigned a judgment of “high”, “moderate”, “low” or “very low” for each piece of evidence.

3. Results

3.1. Results of searching and selecting

A total of 2408 records were retrieved, and after de-duplication, 1550 unique records were obtained. The title and abstract of these records underwent initial screening, resulting in the removal of 1528 irrelevant articles. Subsequently, the remaining 22 articles were evaluated in full text and only 5 articles were included in the meta analysis [17–21]. The detailed process of literature screening was illustrated in Fig. 1.

3.2. The basic characteristics of included studies

The study design of all the included studies was CCTs. A total of 561 water samples were analyzed across five studies, with 295 in the intervention group and 266 in the control group. These studies were conducted in Italy, China, and India. Water samples were collected from handpieces and air-water syringes in two studies [17,19], air-water syringes in two studies [18,20], and bottle storage tank and cup fillers in one study [21]. The types of purified water used in these studies included deionized water, distilled water, and sterile water. All included studies reported contamination rates, while three also reported detection rates of opportunistic pathogens [19–21]. Detailed information on the included studies can be found in Table 2.

3.3. Risk of bias of included studies

Only one study was rated as "No" for item 5 because it did not include multidimensional measures of outcome indicators before and after the intervention [17].For item 2, two studies received an "unclear" rating as they did not clearly describe whether the baselines were comparable [19,21]. The remaining studies scored a "Yes" in all other items. All the included studies achieved 80 % or higher "Yes" ratings, indicating a low risk of bias and high overall methodological quality. Fig. 2 presented the results of the risk of bias assessment.

3.4. The meta analysis of contamination rate of water samples from outlets

The meta-analysis included a total of 561 samples, encompassing all the included studies conducted to calculate the contamination rate in water samples [17–21]. The pooled results showed that there was no statistically significant difference in contamination rate between purified water and tap water as water sources (RR = 1.01; 95 % CI, 0.72–1.41; $P = 0.96$, $I^2 = 62$ %). In the subgroup analysis for disinfection, two studies with four arms were included [19,20], and the pooled result indicated that there was no statistically significant difference in contamination rate between purified water and tap water as water sources (RR = 0.56; 95 % CI, 0.28–1.12; $P = 0.10$; $I^2 = 37$ %). Similarly, in the subgroup analysis for no disinfection, four studies with five arms were included [17–19,21], and the pooled result revealed that there was no statistically significant difference in contamination rate when purified water was

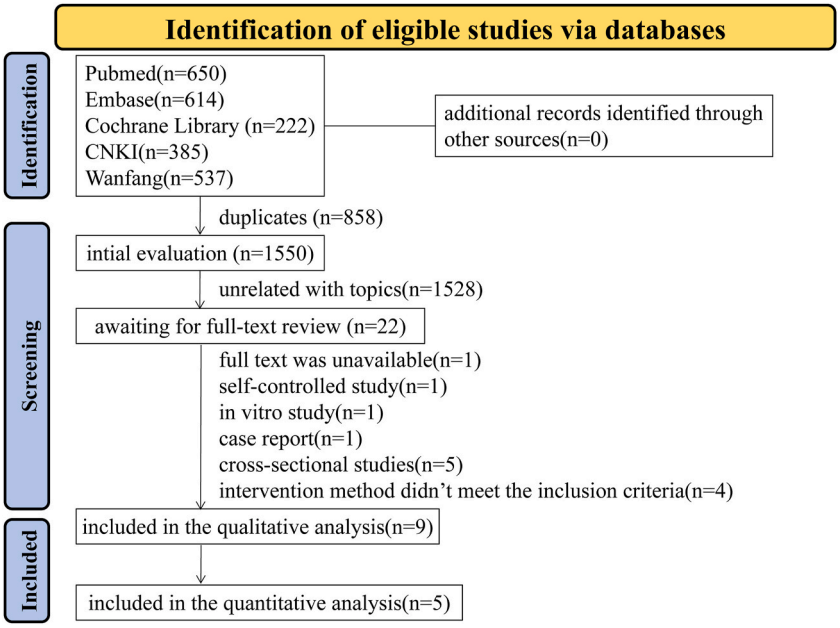

Fig. 1. The flow chart of study selection.

Table 2
The basic characteristics of the included 5 studies.

Study ID	Country	Study design	No. of DCU (T/C)	Intervention	Comparison	Water sample collection			Microbiological analysis method			Outcomes
						Outlets	No. of water samples (T/C)	Sampling frequency	Culture medium	Culturing temperature and time	Cutoff values (CFU/mL)	
Wu2019	China	CCT	1/2	supplying purified water (obtained by reverse osmosis) by a bottle storage tank	municipal water supply	HP, two AWS	39/78	once a month, 13 months	nutrient agar 37 °C for 48h	37 °C for 48 h	10	contamination rate
Lizzadro2019	Italy	CCT	10/4	supplying sterile or distilled water by a bottle storage tank	municipal water supply	HP, bottle storage tank, CF	84/16	NR	tryptic glucose yeast agar	36 °C for 48 h	20	contamination rate, detection rate of opportunistic pathogen
Mungara 2013	India	CCT	5,5/5	T1: supplying purified water (not reported water treatment method) by a bottle storage tank; T2: supplying sterile distilled water by a bottle storage tank	supplying tap water by a bottle storage tank	AWS	5/5/5	sampling only once	R2A agar	35 °C for 5d	200	contamination rate
Liu2014	China	CCT	3,3,3,3/3,3,3,3	T1:supplying distilled water by a bottle storage tank, 50 mg/L chlorine disinfectant once a day; T2: supplying distilled water by a bottle storage tank, 20 mg/L chlorine disinfectant once a day; T3: supplying sterile distilled water by a bottle storage tank, 10 mg/L chlorine disinfectant once a day; T4:only supplying sterile distilled water by a bottle storage tank	C1: municipal water supply, 50 mg/L chlorine disinfectant once a day; C2: municipal water supply, 20 mg/L chlorine disinfectant once a day; C3: municipal water supply, 10 mg/L chlorine disinfectant once a day; C4: only municipal water supply	HP,AWS,	36,36,36,36/36,36,36,36	sampling 6 times	nutrient agar 37 °C for 48h	37 °C for 48h	200	contamination rate, detection rate of opportunistic pathogen
Laura 2014	Italy	CCT	1/1	supplying deionized water (not reported water treatment method) by a bottle storage tank, hydrogen peroxide for intermittent disinfection	municipal water supply, hydrogen peroxide for intermittent disinfection	AWS	18/18	sampling 18 times	plate count agar	22 °C for 72 h	500	contamination rate, detection rate of opportunistic pathogen

Notes: DCU: dental chair unit; CCT: clinical controlled trial; T: treatment group; C: control group; HP: handpiece; AWS: air-water syringe; CF: cup filler; NR: not reported; CFU/mL: colony-forming units per milliliter.

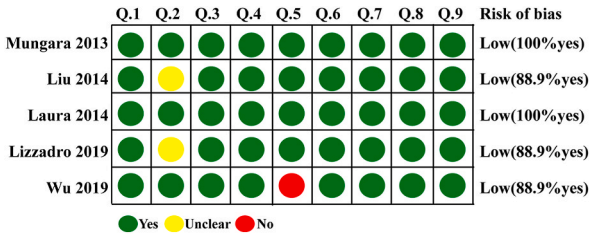

Fig. 2. The results of risk of bias assessment.

compared to tap water as water sources (RR = 1.26; 95 % CI, 0.83–1.93; $P = 0.28$; $I^2 = 77$ %). Importantly, there was no significant subgroup difference observed between these findings ($P = 0.05$). These results were presented graphically in Fig. 3.

3.5. The meta analysis of detection rate of opportunistic pathogen

3.5.1. Pseudomonas aeruginosa

Three studies involving 208 water samples reported the detection rate of *Pseudomonas aeruginosa* [19–21]. The pooled results indicated no significant difference in the detection rate of *Pseudomonas aeruginosa* between purified water and tap water as water sources (RR = 0.78; 95 % CI, 0.15–4.13; $P = 0.77$; $I^2 = 83$ %). In the subgroup analysis of disinfection, only one study was identified [20], which indicated no significant difference in the detection rate of *Pseudomonas aeruginosa* between purified water and tap water as water sources (RR = 0.50; 95 % CI, 0.21–1.17; $P = 0.11$). In the subgroup analysis of no disinfection, two studies were included [19, 21], and the pooled result revealed that there was no statistically significant difference in the detection rate of *Pseudomonas aeruginosa* between purified water and tap water as water sources (RR = 0.78; 95 % CI, 0.03–21.19; $P = 0.88$; $I^2 = 80$ %). There was also no significant subgroup difference observed between them ($P = 0.80$). The results were presented in Fig. 4.

3.5.2. Legionella species

Only one study reported the detection rate of *Legionella* species [21], with a detection rate of 91.7 % (77/84 water samples) in the purified water group and 37.5 % (6/16 water samples) in the tap water group. The results indicated no significant difference in levels of *Legionella* species between purified water and tap water as water sources of DUWL ($P = 0.05$).

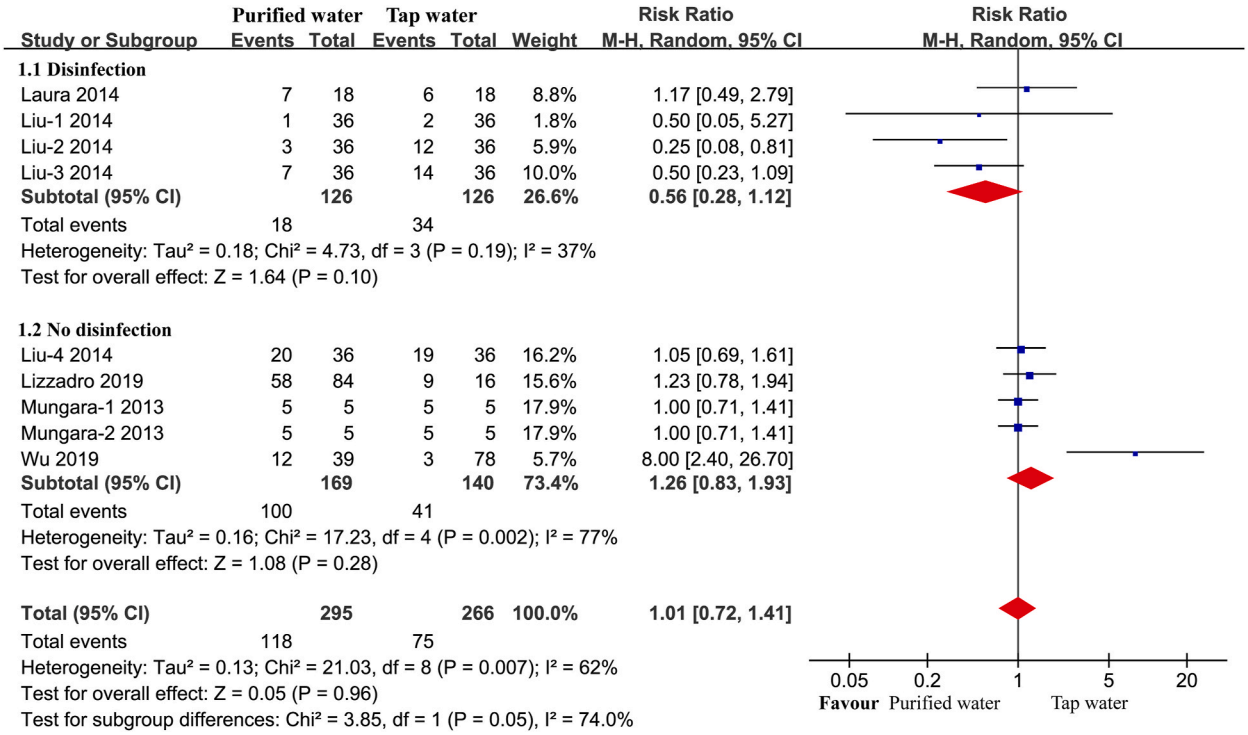

Fig. 3. The meta analysis of contamination rate of water samples from outlets.

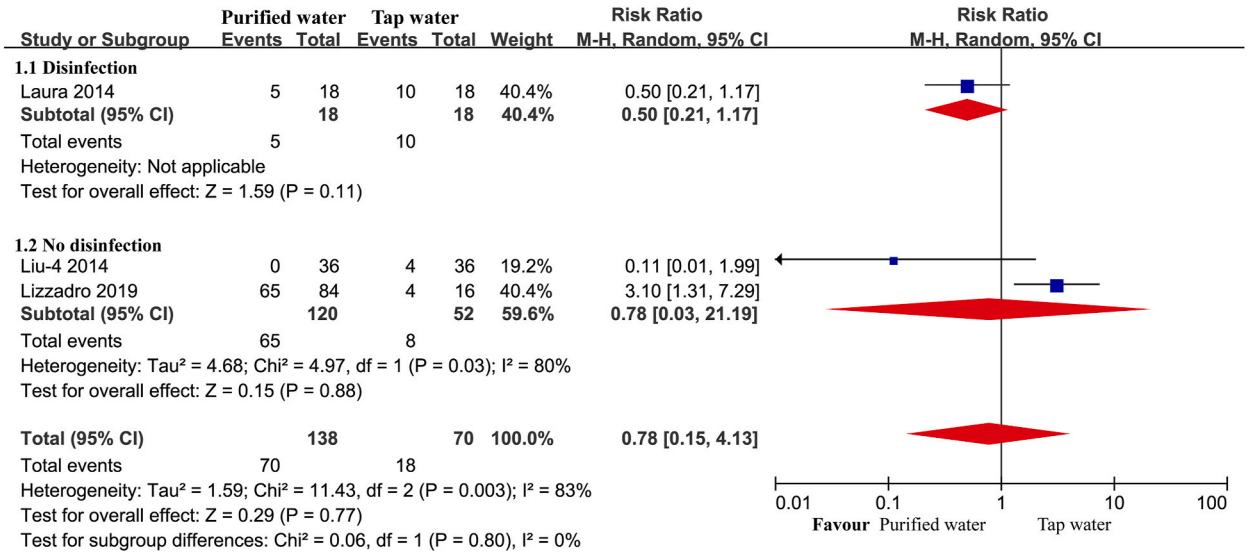

Fig. 4. The meta analysis of detection rate of opportunistic pathogen.

3.6. Evidence evaluation

We conducted an evidence evaluation for the results of meta analysis, revealing a high degree of heterogeneity in the combined outcome indicators "contamination rate" and "detection rate of opportunistic pathogens". Consequently, the "contamination rate" was assigned a low-quality rating due to inconsistency, while the "detection rate of opportunistic pathogens" received a very low-quality rating due to both inconsistency and imprecision, as depicted in Table 3.

3.7. Publication bias

There were only 5 studies included in the meta analysis, so we didn't assess publication bias.

4. Discussion

Due to the potential increase in hospital infection risk, effective disinfection of DUWL has emerged as a pivotal measure for hospital infection control. A few studies have investigated the impact of different types of water sources on DUWL contamination in recent years. Wu et al. and Mungara et al. found that using tap water as water sources of DUWL was more effective and resulted in lower contamination rate at outlet samples [17,18], while Liu et al. reported that purified water was more effective [19]. Laura et al. and Lizzadro et al., however, found no significant difference between purified water and tap water as water sources of DUWL [20,21]. Relevant to the diverse outcomes observed in various studies, a systematic review becomes imperative for comprehensive analysis and synthesis. In our study, we conducted a comprehensive search and included 5 clinical trials to systematically evaluate whether using purified water or tap water leads to differences in terms of contamination rate of water samples from outlets [17–21].

The results of the present meta analysis showed that whether chemical disinfection was employed or not, purified water as water sources of DUWL had no significant difference compared with tap water in terms of reducing contamination rate and detection rate of opportunistic pathogen.

Purified water is produced by distillation, ion exchange or reverse osmosis of tap water and so purified treated water has relatively few impurities, inorganic salts, and microorganisms [16]. Because of its properties such as low ionic concentration and low mineral content, some researchers thought that purified water as water sources of DUWL may reduce the multiplication of microorganisms within the DUWL by interfering with the environment in which microorganism live so that biofilms were less likely to form in the pipeline, and to reduce output water contamination [30]. But the factors resulting in DUWL contamination are complex. DUWL itself features a significantly narrow inner diameter (approximately 2–3 mm), along with a sluggish water flow and prolonged stagnation, thereby creating optimal conditions for the rapid proliferation of microorganisms in the water [31]. Microorganisms in DUWL originate not only from patients' oral microbiota due to bacterial retraction during dental procedures but also from the dental treatment water itself [32,33].Therefore, despite the utilization of purified water as a water source to reduce microbial presence, rapid reproduction of microbes from patients' oral microbiota could still lead to DUWL contamination, even in the new DUWL without biofilm [34]. Moreover, in the case of existing mature biofilm on old DCU, regardless of the types of water sources employed, the biofilm detaches and disperses into the water due to the impact of water flow, thereby facilitating further reproduction and resulting in DUWL contamination [35,36].Finally, if purified water is used as the water source of DUWL, it needs to be supplied separately through a bottle storage tank [37]. On the one hand, the material composition, cleanliness level, storage duration, and temperature control of the

Table 3
GRADE classification for evidence evaluation.

Outcomes	No. of studies	Quality assessment						No. of patients (T/C)	Effect size		Certainty of the evidence (GRADE)
		Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias		RR(95%CI) *P*	MD	
Contamination rate	5	CCT	No serious	Serious[a]	No serious	No serious	No serious	295/266	1.01(0.72, 1.38) $P = 0.96$	–	⨁⨁◯◯ Low
Detection rate of opportunistic pathogen	3	CCT	No serious	Serious[a]	No serious	Serious[b]	No serious	138/70	0.78(0.15, 4.13) $P = 0.77$	–	⨁◯◯◯ Very low

Note: CCT: clinical controlled trial; T: treatment group; C: control group; RR: risk ratio; MD: mean difference; CI: confidence interval.
[a] : I^2 value of the pooled results was large and high heterogeneity.
[b] : small sample size and the confidence intervals were wide.

bottle storage tank could impact the water quality of DUWL; On the other hand, factors including stagnant water in the bottle storage tank, non-standardized disinfection measures (such as failure to timely disinfect and clean the bottle storage tank), prolonged use without changing the water, inadequate aseptic procedures during water changes, and failure to completely empty the bottle storage tank after use may result in biofilm formation within the bottle storage tank and significant bacterial contamination levels that greatly affect overall water quality of DUWL [21,38]. Although both the 2018 guidelines issued by the Organization for Safety, Asepsis and Prevention in America and the 2017 guidelines from the British Dental Association recommended using purified water as water sources of DUWL, it was important to note that the two guidelines were based on expert consensus rather than high-level evidence [39,40]. This limitation restricted the validity of their results. In contrast, our up-to-date meta-analysis included five studies which indicated that changing the type of water source didn't effectively control DUWL contamination. Besides, a study was conducted to explore the effect of different types of water sources on the incidence of postoperative bacteraemia, and demonstrated that there were no significant differences in the incidence of postoperative bacteraemia, which aligned with the results obtained from our current meta-analysis [41].

Although all the included studies were assessed low risk of bias, GRADE classification showed low and very low-quality evidence supported these results. Given the relatively low quality of evidence, it was possibly attributable to sample size, study design and the inconsistency and imprecision of outcome indicator. Therefore, clinical practitioner should approach these clinical decisions with caution, employing judiciously in accordance with practical circumstances.

The limitations of the present study cannot be disregarded given the quantity and quality of the included studies. Firstly, despite a total of 561 water samples from 5 studies being included in the meta-analysis, the small sample size in each individual study may have adversely affected the reliability of the pooled results. Secondly, due to the limited number of included studies, it was not possible to perform a meta-regression analysis or further subgroup analyses based on other basic characteristics such as cutoff values for DUWL contamination and methods of water sampling in order to explore potential sources of heterogeneity. Although a random-effects model was employed to account for heterogeneity among studies, caution is still required when interpreting conclusions. Thirdly, all the included studies were CCTs rather than RCTs, which limits the reliability of evidence obtained. The execution of high-quality, large-scale, multi-center randomized controlled trials remain necessary in order to obtain more robust evidence, particularly with an extended duration for follow-up observations. Lastly, despite employing a rigorous search algorithm across 5 electronic databases, it is inevitable that some potential studies might have been missed due to lack of access to certain sources like Google Scholar.

5. Conclusions

The available evidence suggested that, regardless of the use of chemical disinfectants, there was no significant difference in reducing contamination rate and detection rate of opportunistic pathogens when comparing purified water with tap water as water sources of DUWL. However, due to some certain limitations such as a limited number of included studies and low quality of evidence, further systematic evaluation through high-quality, large-sample, multi-center randomized controlled trials are necessary.

Data availability statement

Data availability is not applicable to this article as no new data were created or analyzed in this study.

Informed consent

Not required.

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CRediT authorship contribution statement

Ting Shuai: Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Tianyi Shao:** Writing – original draft, Methodology, Formal analysis, Data curation. **Lijuan Yi:** Methodology, Formal analysis, Data curation, Conceptualization. **Shuyu Han:** Software, Methodology, Formal analysis. **Maria F. Jiménez-Herrera:** Software, Formal analysis. **Zhiwen Wang:** Writing – review & editing, Supervision. **Xiue Li:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] A.M. Spagnolo, M. Sartini, M.L. Cristina, Microbial contamination of dental unit waterlines and potential risk of infection: a narrative review, Pathogens 9 (8) (2020) 651, https://doi.org/10.3390/pathogens9080651.
[2] G.C. Blake, The incidence and control of bacterial infection in dental spray reservoirs, Br. Dent. J. 115 (1963) 413–416.
[3] Y. Dang, Q. Zhang, J. Wang, et al., Assessment of microbiota diversity in dental unit waterline contamination, PeerJ 10 (2022) e12723, https://doi.org/10.7717/peerj.12723.
[4] X.Y. Ji, C.N. Fei, Y. Zhang, et al., Three key factors influencing the bacterial contamination of dental unit waterlines: a 6-year survey from 2012 to 2017, Int. Dent. J. 69 (3) (2019) 192–199, https://doi.org/10.1111/idj.12456.
[5] M.J. O'Donnell, M.A. Boyle, R.J. Russell, et al., Management of dental unit waterline biofilms in the 21st century, Future Microbiol. 6 (10) (2011) 1209–1226, https://doi.org/10.2217/fmb.11.104.
[6] M. Cicciù, Water contamination risks at the dental clinic, Biology 9 (3) (2020) 43, https://doi.org/10.3390/biology9030043.
[7] M.A. Hoogenkamp, B.W. Brandt, A.M.G.A. Laheij, et al., The microbiological load and microbiome of the Dutch dental unit; 'please, hold your breath', Water Res. 200 (2021) 117205 https://doi.org/10.1016/j.watres.2021.117205.
[8] A.J. Schel, P.D. Marsh, D.J. Bradshaw, et al., Comparison of the efficacies of disinfectants to control microbial contamination in dental unit water systems in general dental practices across the European Union, Appl. Environ. Microbiol. 72 (2) (2006) 1380–1387, https://doi.org/10.1128/AEM.72.2.1380-1387.2006.
[9] B. Lal, K. Ravindra, M. Biswal, Appraisal of microbial contamination of dental unit water systems and practices of general dental practitioners for risk reduction, Environ. Sci. Pollut. Res. Int. 25 (33) (2018) 33566–33572, https://doi.org/10.1007/s11356-018-3298-y.
[10] A. Baudet, J. Lizon, J.M. Martrette, et al., Dental unit waterlines: a survey of practices in eastern France, Int. J. Environ. Res. Publ. Health 16 (21) (2019) 4242, https://doi.org/10.3390/ijerph16214242.
[11] A.M. Spagnolo, M. Sartini, D.D. Cave, et al., Evaluation of microbiological and free-living Protozoa contamination in dental unit waterlines, Int. J. Environ. Res. Publ. Health 16 (15) (2019) 2648, https://doi.org/10.3390/ijerph16152648.
[12] B. Tuvo, M. Totar, M.L. Cristina, et al., Prevention and control of *Legionella* and *Pseudomonas spp*. colonization in dental units, Pathogens 9 (2020) 305, https://doi.org/10.3390/pathogens9040305.
[13] V. Barbot, A. Robert, M.H. Rodier, et al., Update on infectious risks associated with dental unit waterlines, FEMS Immunol. Med. Microbiol. 65 (2) (2012) 196–204, https://doi.org/10.1111/j.1574-695X.2012.00971.x.
[14] W.G. Kohn, A.S. Collins, J.L. Cleveland, et al., Centers for Disease Control and Prevention (CDC), Guidelines for infection control in dental health-care settings-2003, MMWR Recomm. Rep. (Morb. Mortal. Wkly. Rep.) 52 (2003) 1–61.
[15] Y.H. Li, L.S. Zhang, Y. Li, et al., Types of major microorganisms in pharmaceutical water systems and control measures, Chin J of Mod Appl Pharm. (2022) 1–5.
[16] P.S. Brown, B. Bhushan, Bioinspired materials for water supply and management: water collection, water purification and separation of water from oil, Philos Trans A Math Phys Eng Sci 374 (2073) (2016) 20160135, https://doi.org/10.1098/rsta.2016.0135.
[17] G.J. Wu, J. Li, Q.Q. Ye, et al., Microbial detection of water samples from Sinodis Intego dental units under different water source patterns, Guangxi Med J 41 (11) (2019) 1452–1453 +1457.
[18] J. Mungara, N.C. Dilna, E. Joseph, et al., Evaluation of microbial profile in dental unit waterlines and assessment of antimicrobial efficacy of two treating agents, J. Clin. Pediatr. Dent 37 (4) (2013) 367–371, https://doi.org/10.17796/jcpd.37.4.l6851n9g01223450.
[19] Y.H. Liu, H.H. Jing, L. Xu, et al., Observation on disinfection effect of low concentration chlorine-containing disinfectant on dental unit waterlines, Chin J Disinfection 31 (7) (2014) 686–688.
[20] L. Dallolio, A. Scuderi, M.S. Rini, et al., Effect of different disinfection protocols on microbial and biofilm contamination of dental unit waterlines in community dental practices, Int. J. Environ. Res. Publ. Health 11 (2) (2014) 2064–2076, https://doi.org/10.3390/ijerph110202064.
[21] J. Lizzadro, M. Mazzotta, L. Girolamini, et al., Comparison between two types of dental unit waterlines: how evaluation of microbiological contamination can support risk containment, Int. J. Environ. Res. Publ. Health 16 (3) (2019) 328, https://doi.org/10.3390/ijerph16030328.
[22] M.J. Page, D. Moher, P.M. Bossuyt, et al., PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews, Br. Med. J. 372 (2021) n160.
[23] C. Tufanaru, Z. Mun, E. Aromataris, et al., Checklist for Quasi-Experimental Study [Internet], The Joanna Briggs Institute, 2020. Available from: https://jbi.global/sites/default/files/2020-08/Checklist_for_Quasi-Experimental_Appraisal_Tool.pdf. (Accessed 16 February 2024).
[24] F.F.B. Lemos, C.T. de Castro, M.S. Calmon, et al., Effectiveness of Helicobacter pylori eradication in the treatment of early-stage gastric mucosa-associated lymphoid tissue lymphoma: an up-to-date meta-analysis, World J. Gastroenterol. 29 (14) (2023) 2202–2221, https://doi.org/10.3748/wjg.v29.i14.2202.
[25] D. Jackson, R. Turner, Power analysis for random-effects meta-analysis, Res. Synth. Methods 8 (3) (2017) 290–302, https://doi.org/10.1002/jrsm.1240.
[26] J.P. Higgins, S.G. Thompson, Quantifying heterogeneity in a meta-analysis, Stat. Med. 21 (11) (2002) 1539–1558, https://doi.org/10.1002/sim.1186.
[27] J.A. Sterne, A.J. Sutton, J.P. Ioannidis, et al., Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials, BMJ 343 (2011) d4002, https://doi.org/10.1136/bmj.d4002.
[28] G.H. Guyatt, A.D. Oxman, G.E. Vist, et al., GRADE: an emerging consensus on rating quality of evidence and strength of recommendations, BMJ 336 (7650) (2008) 924–926, https://doi.org/10.1136/bmj.39489.470347. AD.
[29] P.A. Swinton, K. Cooper, E. Hancock, Workplace interventions to improve sitting posture: a systematic review, Prev. Med. 101 (2017) 204–212, https://doi.org/10.1016/j.ypmed.2017.06.023.
[30] M. Florjanič, J. Kristl, The control of biofilm formation by hydrodynamics of purified water in industrial distribution system, Int. J. Pharm. 405 (1–2) (2011) 16–22, https://doi.org/10.1016/j.ijpharm.2010.11.038.
[31] M. Bayani, K. Raisolvaezin, A. Almasi-Hashiani, et al., Bacterial biofilm prevalence in dental unit waterlines: a systematic review and meta-analysis, BMC Oral Health 23 (1) (2023) 158, https://doi.org/10.1186/s12903-023-02885-4.
[32] M. Wu, Z. Shi, X. Yu, et al., Disinfection methods of dental unit waterlines contamination: a systematic review, J. Med. Microbiol. 71 (6) (2022).
[33] M.E. Cataldi, S. Al Rakayan, C. Arcuri, et al., Dental unit wastewater, a current environmental problem: a sistematic review, Oral Implant. 10 (4) (2017) 354–359, https://doi.org/10.11138/orl/2017.10.4.354.
[34] D.C. Coleman, M.J. O'Donnell, A.C. Shore, et al., The role of manufacturers in reducing biofilms in dental chair waterlines, J. Dent. 35 (9) (2007) 701–711, https://doi.org/10.1016/j.jdent.2007.05.003.
[35] J.A. Molinari, Dental infection control at the year 2000. Accomplishment recognized, Dent. Assist. 69 (3) (2000).
[36] S.E. Mills, The dental unit waterline controversy: defusing the myths, defining the solutions, J. Am. Dent. Assoc. 131 (10) (2000) 1427–1441, https://doi.org/10.14219/jada.archive.2000.0054.
[37] L. Genlin, H. Fei, Y. Jun, et al., Influences of water supply sources of dental comprehensive treatment platform on intra-pipeline water quality, Chin. Med. Equip. J. 38 (2) (2017) 98–100.
[38] S. Ke, D. Xiaoming, Y. Le, et al., Efficacy of aseptic processing on dental unit waterlines, Chin. J. Infect. Control 16 (7) (2017) 639–642.

[39] S. Mills, N.B. Porteous, J. Zawada, Dental unit water quality: organization for safety, Asepsis and prevention white paper and recommendations–2018, Available from: https://www.osap.org/assets/docs/resources/toolkits-topics/dental-unit-water-quality-organization-for-safety-asepsis-and-prevention-white-paper-and-recommendations-2018.pdf. (Accessed 16 February 2024).
[40] Caroline L. Pankhurst , Wilson A. Coulter. Basic Guide to Infection Prevention and Control in Dentistry (Basic Guide Dentistry Series) second ed. Available from: https://www.nature.com/articles/vital1022 (accessed on 16 February 2024).
[41] R.A. Reinhardt, R.W. Bolton, G. Hlava, Effect of nonsterile versus sterile water irrigation with ultrasonic scaling on postoperative bacteremias, J. Periodontol. 53 (2) (1982) 96–100, https://doi.org/10.1902/jop.1982.53.2.96.