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Attitudes of general dental practitioners in Europe to the microbial risk associated with dental unit water systems

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Dental Unit Water Systems (DUWS) are used in dental practices to provide water for cooling of dental equipment and irrigation of the oral cavity. However, they have been demonstrated to be contaminated with micro-organisms. There are currently no European Union (EU) Commission guidelines for the microbial quality of water discharged by DUWS. This study was part of an EU research programme to investigate the microbial contamination of DUWS in general dental practice (GDP) in the UK, Denmark, Germany, The Netherlands, Ireland, Greece and Spain. **Objective**: To undertake a questionnaire survey on the type of DUWS in use and determine the attitude of GDPs to the risk of microbial infection from DUWS. **Materials and Methods**: The questionnaire was written and translated into the language of each country before being posted to each participating dentist. Dentists were asked to complete the questionnaire survey and return it by post. **Results and conclusions**: The major findings were that the majority of dentists did not clean, disinfect or determine the microbial load of their DUWS, and that dentists would welcome regular monitoring and advice on maintaining their DUWS; the introduction of guidelines; and recommendations on controlling the microbial load of DUWS.

Key words: Dental unit water system, microbial risk, attitudes, disinfection, cross-infection, dentists

Dental unit water systems (DUWS) are used to irrigate the oral cavity during dental treatment and provide cooling to certain items of equipment such as air rotors and mechanical scalers. Water delivered from these devices is not sterile and has been shown to contain relatively high numbers of bacteria[1-3]. Bacterial cells accumulating and growing on the inner surface of the tubing as a biofilm are responsible for the high levels of contamination of DUWS[3,4]. Currently, dentists in Europe have no evidence-based guidelines to control bacterial numbers in DUWS. A number of surveys have demonstrated that in general DUWS are supplied by tap water[5]. In the

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EU, guidelines only recommend that bottled drinking water should contain <100 cfu.ml^{-1},[6] whilst tap water must not contain specified pathogenic micro-organisms. Yet it is clear that once water enters the DUWS the number of bacteria can increase, with numbers as high as 1.6 x 10^{8} cfu.ml^{-1} having been recovered in the outflow[7]. Such high numbers can result from numerous factors including ambient temperatures, stagnation and the presence of biofilms[7]. In the USA, the Centers for Disease Control and Prevention has set a limit of 500 cfu.ml^{-1} [8] (equivalent to the regulatory standard for safe drinking water established by EPA and APHA/AWWA) but the American Dental Association (ADA) has set a more stringent standard of <200 cfu.ml^{-1} [9], (equivalent to that required for dialysis water). The EU has yet to set an equivalent standard.

Typically, patients visit a GDP every six months in the EU (with >20million visits per annum in 1998, in one large EU country alone). During almost every visit, the patient and the dental health care staff are exposed to the water from DUWS systems, which harbour high numbers of micro-organisms, including pathogens[10]. Pathogens such as *Legionella pneumophila*, *Mycobacterium* spp, *Pseudomonas aeruginosa* and *Candida* spp have been recovered from DUWS so it is evident that these medical devices have the potential to harbour opportunistic or frank pathogens[11-13]. Exposure of dental personnel to such pathogens can occur, since dental surgery staff have been shown to have significantly higher antibody titre to *L. pneumophila* than personnel in other equivalent employment sectors[14, 15]. A number of studies have also demonstrated a potentially increased risk of exposure to tuberculosis for dental surgery staff[16,17]. *P. aeruginosa* has been responsible for hospitalisation of two medically compromised patients thought to be associated with a contaminated DUWS[18]. The presence of pathogens has further implications when one considers the risk of cross-infection due to the failure of the 3-in-1 hand piece anti-retraction valve[19].

The majority of studies on DUWS contamination have focussed mainly on dental hospital DUWS units. However, the vast majority of dental treatment takes place in the GDP setting where the degree of microbial contamination of DUWS, and its qualitative nature are only just being evaluated. Dentists across the EU have only limited information on DUWS quality, and no clear guidelines to follow, in order to manage the situation. Patients attending GDPs may include groups who are highly susceptible to infection such as medically compromised patients, and others may be carriers of microbial pathogens. Across Europe risks arising from DUWS, including occupational exposure and cross-infection from such systems, are therefore unquantified.

The aims of this study were, therefore, to carry out a questionnaire survey on the type of DUWS in use and to determine the attitude of GDPs to the risk of microbial infection from DUWS.

Material and methods

A questionnaire consisting of 22 questions was used to collect data from a representative sample of 436 GDPs in the United Kingdom (UK), Ireland (IE), Greece, Spain (ES), Germany (DE), Denmark (DK) and The Netherlands (NL). The GDPs were randomly chosen from private dental practices adjacent to participating laboratories. The questionnaire, which was translated in to the local language, was forwarded to, and collected from, the GDPs using the postal service. A copy of the questionnaire is available from the corresponding author.

Dentists were asked to respond to questions designed to determine:

- The type of water system and age of DUWS
- Their attitude towards cleaning / disinfecting the DUWS
- Their knowledge about the need for cleaning / disinfecting the DUWS
- Their opinion about the potential microbial hazard from the dental unit water
- Their estimate of the amount of time and money needed to treat their DUWS properly
- Their opinion about the potential microbial hazard from the water in the DUWS
- Their willingness to be informed and follow simple advice for the proper maintenance of the DUWS.

Results

Recruitment, risk assessment questionnaire and survey of GDP attitudes

Four hundred and thirty six GDPs from the UK, Germany, The Netherlands, Greece, Spain, Denmark and Ireland were selected to participate in the GDP questionnaire; 258 (59%) GDPs completed and returned their questionnaires. It was found that 60% of DUWS were more than five years old (*Figure 1*) and only 74% of units were fitted with anti-retraction valves. The majority of units (64%) were fed by mains water, and only 9% by tank and 27% by independent water bottle reservoirs, however this distribution did vary between countries (*Table 1*). In Greece and Germany all systems were mains fed and in Ireland the majority were tank-fed, whereas in Spain there was a mixture of mains, bottle and tank. As far as hardness of the water is concerned, 40% of the surgeries were supplied by hard water, 29% by soft water and 31% by deionised water (*Table 1*). The vast majority of surgeries (83%) did not have any microbiological analyses carried out on their water (*Figure 2*). Although 49% of the units were flushed between patients, 55% of surgeries indicated that they did not disinfect or clean their DUWS in any way. This varied among countries, e.g. 78%, 68%, and 91% of surgeries in The Netherlands,

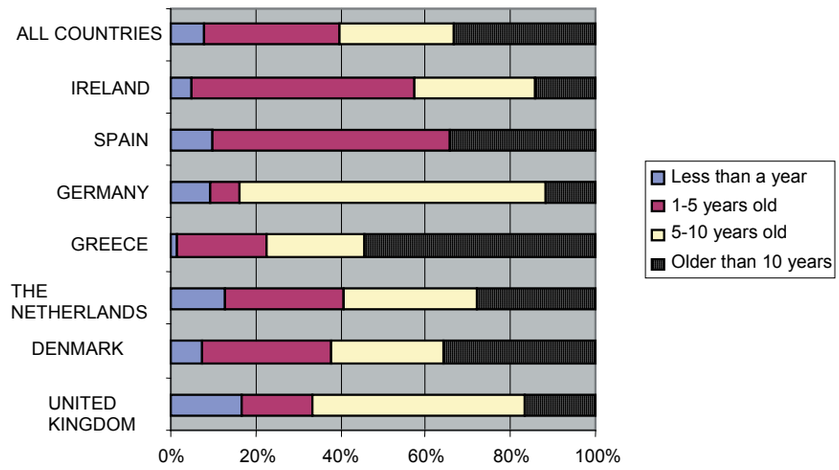

Figure 1. Age of the dental unit (DU) in a survey of 258 general dental practices in 7 countries.

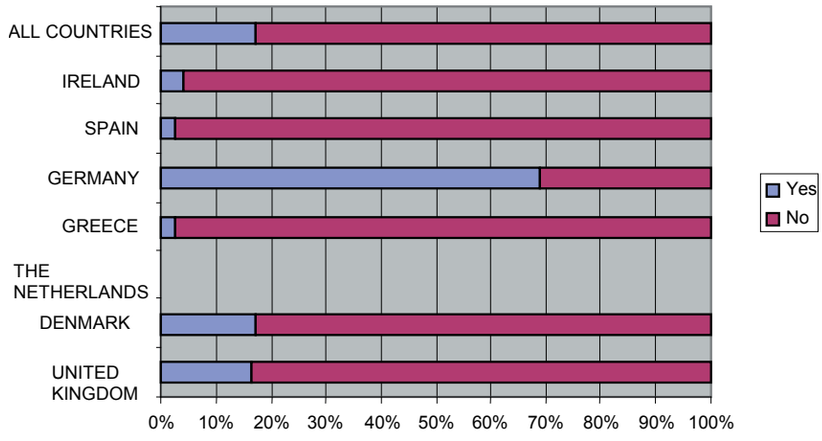

Figure 2. The proportion of GDPs who have undertaken microbiological testing of the water from DUWS.

Ireland and Greece, respectively, did not clean or disinfect their DUWS compared to 21% of surgeries in Germany (*Table 2*) where 68% had undertaken microbiological testing . A number of GDPs were using products to decontaminate DUWS – these included Oxygenal, Dentosept, BioBLUE, sodium hypochlorite, Orotol and Alpron. Whilst 34% of the dentists had received guidance on cleaning/disinfection of the water lines, 98% were not aware of national/international guidelines for microbial contamination of DUWS (*Table 3*). Fifty-one per cent of dentists did not spend any money on treating their DUWS, whilst 19%, 19% and 11% spent 25, 50 and 75 Euro per month, respectively (*Figure 3*). In terms of time, 46% of dentists did not spend any time treating their DUWS whilst 38% and 16% spend 2 or 4 hours per month, respectively (*Figure 4*). Although 65% of dentists were seriously concerned about the quality of water flowing through the dental unit (*Figure 5*), the vast majority of patients, 97%, had never expressed concern about the quality of the dental unit water. Almost half of the dentists believed that the quality of water delivered by their dental unit was the same as the water that was put into it (*Figure 6*), while 35% agreed that the water was a hazard to them, 32% agreed it was a hazard to their staff and 48% agreed that it was a hazard to their patients (*Table 4*). Since half of the dentists disagreed with the statement that the quality of water delivered by their dental unit was the same as the water that is put into the unit, this indicated that they understood that the DUWS is a potential source of contamination. Since a large number of dentists were concerned about the quality of water flowing through their dental unit, 89% of them would welcome regular microbiological testing of the water and a large majority (98%) would gladly take simple advice on cleaning/disinfection of the water supply in their dental unit (*Table 5*).

Table 1 Water supply and water type of the DUWS in each country (%).

	UK	DK	NL	GR	DE	ES	IE	All
Mains fed	0	71	96	100	100	44	23	64
Tank fed	4	0	4	0	0	18	77	27
Bottle fed	96	29	0	0	0	38	0	9
Soft water	33	0	54	72	62	4	13	29
Hard water	0	83	46	14	38	40	0	40
Deionised water	67	17	0	14	0	56	87	31

Table 2 The proportion of GDPs that undertake flushing or disinfecting DUWS in each country (%).

	UK	DK	NL	GR	DE	ES	IE	All
Flush the waterline between patients	17	22	59	55	36	68	43	49
Clean/disinfect the waterline	60	52	22	9	79	69	32	45

Table 3 Guidance received on the disinfection of DUWS and knowledge of national, international and EU Guidelines for DUWS in each country (%).

	UK	DK	NL	GR	DE	ES	IE	All
Guidance received on disinfection of DUWS	0	48	22	5	79	51	14	34
National International, EU Guidelines for DUWS	17	5	0	2	0	2	0	2

Table 4 Perception of the potential hazard of the water delivered by the DUWS to the dentists, staff and patients of each country (%).

	UK	DK	NL	GR	DE	ES	IE	All
Potential hazard to the dentists	33	8	70	10	32	41	47	35
Potential hazard to the staff	33	4	65	9	35	41	38	32
Potential hazard to the patients	33	27	74	39	43	67	50	48

Table 5 Percentages of dentists who would welcome simple advice or a microbiological testing that ensures the high quality water delivered by the DUWS and the following of the advice.

	UK	DK	NL	GR	DE	ES	IE	All
Simple advice	100	96	100	95	90	95	100	96
Microbiological testing	100	81	83	90	91	84	100	89
Follow the advice on the cleaning of DUWS	100	100	96	95	100	98	100	98

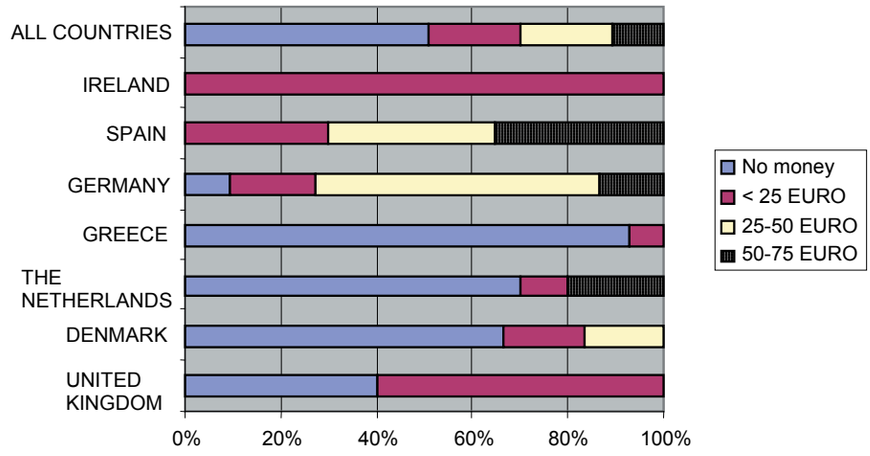

Figure 3. Money spent per month by GDPs on treating the DUWS.

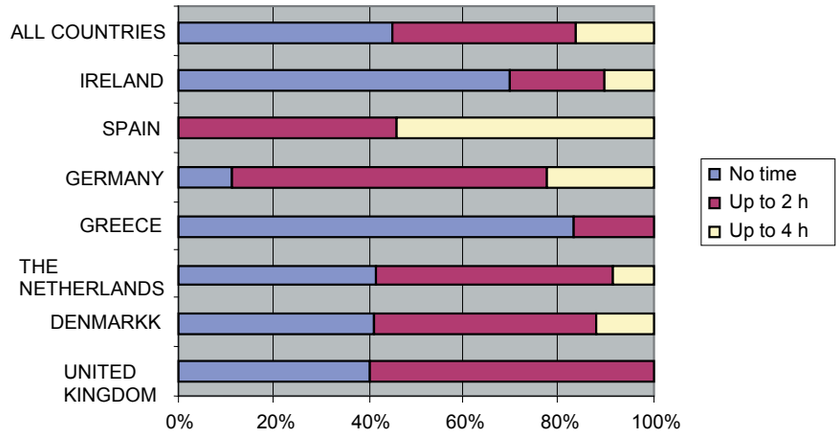

Figure 4. Time spent per month by GDPs for treating the DUWS.

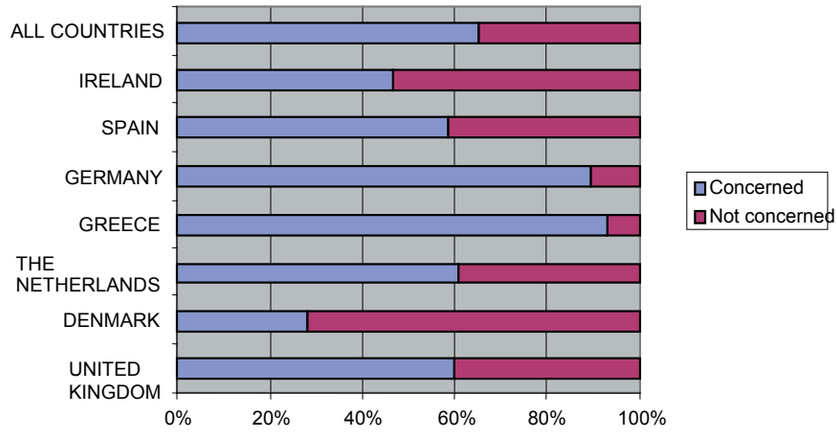

Figure 5. Dentists' concern on quality of water in the DUWS.

Almost 80% of the GDPs agreed that the optimum interval for treating the water supply would be on a daily or even a weekly basis (*Figure 7*). Fifty-seven per cent would spend up to 50 Euro per month to treat their DUWS, whereas 31% were prepared to spend up to 150 Euro to do so (*Figure 8*).

Discussion

Questionnaire Survey of GDPs

DUWS are used in dental practice on a routine basis to deliver water to the oral cavity. Various research groups have now demonstrated that the water in DUWS can contain high numbers of bacteria including opportunistic pathogens. This part of a large EU programme examined the prevailing attitudes of dentists to microbial contamination and the associated cross-infection risks of dental unit water systems in 258 practices in seven countries across the EU, the largest survey of this type conducted within the EU.

The majority of the DUWS (60%) were more than five years old and were fed by mains water. This may have treatment implications as older systems may have established mature biofilms that are the most difficult to treat. In the UK all the DUWS were fed by independent water reservoirs reflecting the requirement of the local water authority that potential back-siphonage incidents be reduced by disconnecting DUWS from the mains water. Countries such as The Netherlands, Greece and Germany have more than 98% of DUWS supplied by mains water. In this context, the application of disinfectants becomes more complex. Independent purge dispensers may need to be fitted to the mains supply line for disinfectants to be added to the DUWS. Countries including Spain and Ireland had 18%, and 77%, respectively, of systems supplied by water from tanks.

The mains water supply chemistry varied depending on whether soft (<50ppm $CaCO_3$) or hard water (>200ppm $CaCO_3$) was used. Twenty nine percent of GDPs reported using soft water, whilst 40% reported using a hard water supply. A supply of hard water may result in a calcium layer being deposited on the inner pipelines and valves, providing an even greater ratio of surface area to volume for biofilm growth and possibly contributing to early anti-retraction valve failure[20]. Irrespective of overall levels of water contamination, however, pathogens such as *Pseudomonas* sp., enterobacteria, *Legionella* spp., *Mycobacterium* spp. and *Candida* spp. could be present. Also, oral bacteria have been recovered from DUWS, presumably due to the failure of the antiretraction vavle, which emphasises the potential for cross infection-incidents[10].

Only 9% of all the systems surveyed used a bottle supply for the DUWS. The use of tap water or even sterile water in DUWS would be anticipated to decrease the likelihood of failure to meet the water guidelines. Unfortunately, with time, even DUWS supplied by sterile water (either deionised or distilled) will become colonised to the same extent as those supplied by tap water[10] because the whole system and particularly the reservoir is not sterile. Once bacteria have gained access to the DUWS there will be sufficient nutrients from the plastic tubing, and the turnover of the bacteria themselves, to support biofilm growth[21]. This creates a difficulty for some practitioners who may believe they have a sterile dental line because they are using sterile water. Dedicated sterile water systems are now recommended for use during surgical or implantation procedures. Systems can be designed to employ single-use disposable or autoclavable tubing to by-pass the DUWS and provide sterile irrigating solution directly to the hand-piece (assuming that the hand-piece has also been disinfected). Unfortunately, microbial growth, even in 'sterile' water reservoirs, leaves the practitioner with little option but to consider treatment to reduce the microbial count in the water phase and to remove the biofilm. An advantage of the bottle systems is that they allow disinfectants to be applied simply and regularly.

Very few (17%) of the surgeries have microbiological analysis carried out on their water, indicating that most others were not aware of the microbial load of their DUWS. From the survey it was found that 49% of the units were flushed between patients. Previously, a number of professional bodies, including the British Dental Association (BDA), American Dental Association (ADA) and Centers for Communicable Disease Control and Prevention (CDC) have recommend flushing the water line for several minutes prior to the first patient and for 20-30 seconds between patients. Flushing between patients has been shown to decrease the number of bacteria in the water phase[22]. However, this reduction will be transient, as the micro-organisms will multiply logarithmically back to high numbers relatively quickly, as has been shown with *L. pneumophila* in water systems[23,24]. In addition to this, it has been demonstrated that flushing has little or no effect on the biofilm, as the laminar flow will barely result in sloughing[25]. Due to the biofilm phenomenon, it may be advisable for professional bodies to re-consider their control strategies in terms of flushing and to focus on treatment/removal of the biofilm and its potential for disease transmission as demonstrated in other health-care settings[26].

Fifty-five per cent of surgeries indicated that they did not clean or disinfect their DUWS. This varied within countries (78%, 68% and 91% of surgeries questioned in The Netherlands, Ireland and Greece, respectively, did not clean or disinfect the DUWS). A small number of GDPs were currently using antimicrobial products within their DUWS – these included Oxygenal, Dentosept, BioBLUE, sodium hypochlorite, Orotol and Alpron. Whilst 34% of the dentists had received guidance on cleaning/disinfection of the water lines, presumably from the supplier of the DUWS, 98%

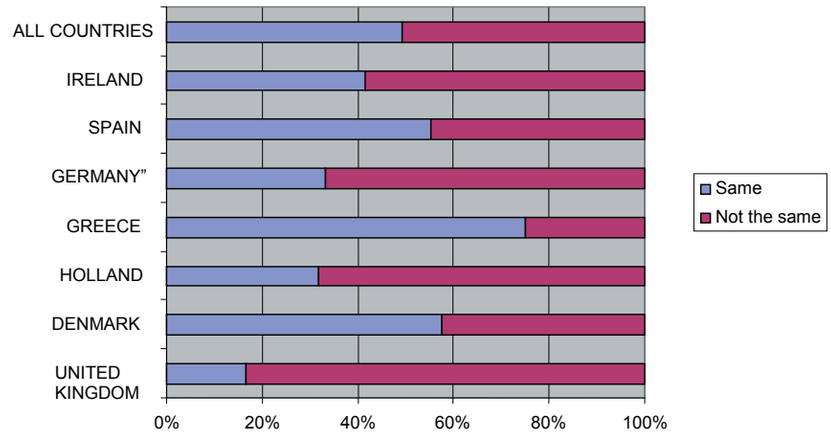

Figure 6. Dentists' understanding of water quality of DUWS.

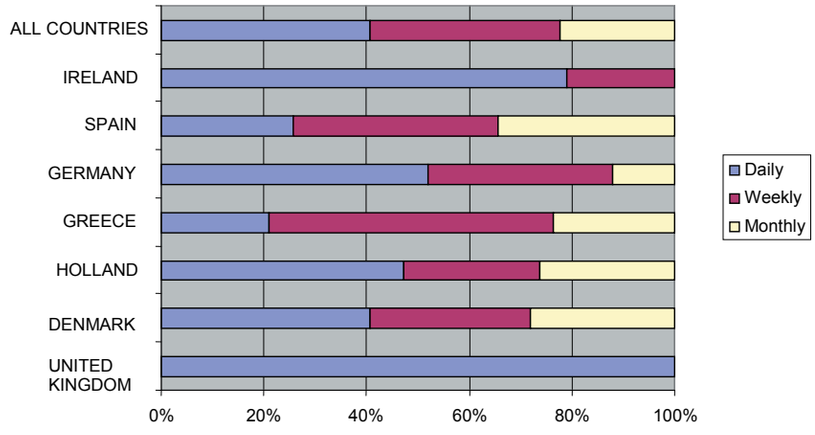

Figure 7. The preferred optimum interval for treating the DUWS by GDPs.

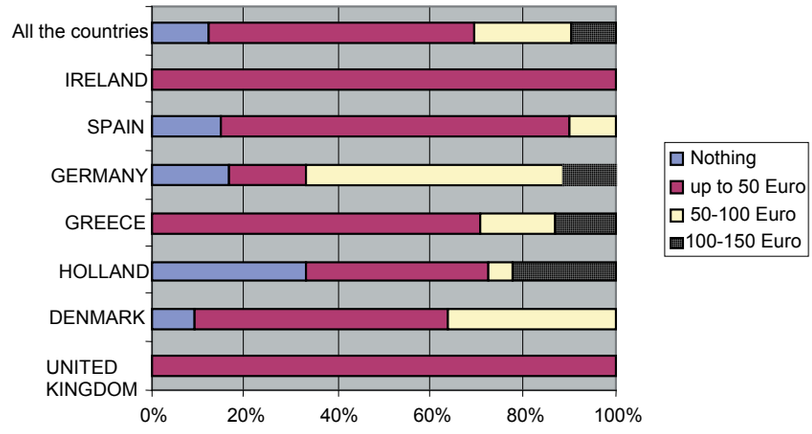

Figure 8. The total amount of money that GDPs were prepared to spend in order to control the microbial quality of the water in DUWS.

were not aware of national/international guidelines for controlling microbial contamination of DUWS. This indicates that the national dental organisations should be more proactive in the dissemination of information on this area of cross-infection control. Approximately half of all dentists spend neither any money (51%) nor time (45%) treating their DUWS. Extrapolated across the EU this would represent a large number of units that receive no treatment. Although 65% of dentists expressed a concern about the quality of water flowing through the dental unit, half of them believed that the quality of water delivered by their dental unit was the same as the water that was put into it. This perhaps indicates that more education and information about microbial growth and the risks from the growth of opportunistic pathogens in the DUWS is required to be disseminated to dentists across the EU. These findings may also have implications for the training of dentists and other dental staff.

Dentists questioned suggested that only 4% of patients expressed an interest or concern about the quality of the dental water. These views may reflect the confidence they have in their dentists to minimise cross-infection risks. Similarly, the majority of dentists did not perceive the water in the DUWS as a hazard to them (65%) or their staff (68%). This may have been surprising since other studies, particularly in dental schools, have demonstrated that dental personnel have higher antibody titres to *Legionella* than other non-dental control populations[27,28], again highlighting the need for a wider dissemination of information. A more recent study[29] reported comparable levels of *L. pneumophila* recovered from DUWS in both dental schools (16%) and GDP (22%). However, a study of DUWS in GDP in London and Northern Ireland recently reported that the incidence of *L. pneumophila* was only 0.37% and that the prevalence of *L. pneumophila* antibodies in this study's population of dentists did not exceed the background level seen in a blood donor control group[30].

Finally, the majority of dentists were concerned about the quality of water flowing through their DUWS and would welcome regular microbiological testing of the water and clear advice on cleaning/disinfection of the water supply in their dental unit, indicating that they understood that the DUWS is the source of contamination. The availability of simple and rapid methods to assess water quality and monitor the effectiveness of treatments would play an important role in achieving this goal[31]. Effective products that have been designed specifically to control biofilms in DUWS are now available[32-36], and will make a major contribution in helping GDPs to manage the associated microbial risk. The provision of clear guidelines within the EU would improve the safety of the GDP including staff and visiting patients.

Conclusions

- The majority of GDPs are working with equipment that is >5 years old
- The majority of dentists do not clean nor disinfect their DUWS
- GDPs did not undertake analysis of the microbial load of the water
- GDPs would welcome regular microbiological monitoring and advice on cleaning/disinfecting of their DUWS.

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