

# Bacterial contamination of disinfectants: prevalence and students' compliance with infection control practices

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## ABSTRACT

### Introduction

Contaminated disinfectants have been occasional vehicles of healthcare associated infections.

### Aims and objectives

To determine the presence and level of bacterial contamination of disinfectants used to decontaminate suction devices and to assess the extent to which students comply with infection control practices.

### Design

A two-part cross-sectional descriptive study consisting of microbiological testing of disinfectants and a questionnaire-based observation of students

### Methods

Unannounced observation of students disinfecting suction devices were recorded using a questionnaire. The process involved collecting a prepared disinfectant from a storage bin using a kitchen measuring jug. Specimens of disinfectants and swabs of jugs were collected for aerobic culture. Data pertaining to compliance with infection control practices was gathered.

### Results

Only 33.6% of the students were observed unannounced. An overwhelming majority (84.9%) of students disinfected suction devices; 52% cleaned and disinfected the external surface of suction hoses and the spittoon bowl; 18.6% allowed the disinfectant to remain in the system long enough, and 14% advised their patients not to close their lips around the suction device. The majority of disinfectant

samples (56.3%) as well jugs (55.6%) were contaminated with bacteria.

Conclusion Bacterial contamination of disinfectants was common in addition to poor compliance with infection control practices.

## INTRODUCTION AND BACKGROUND

Healthcare-associated infections are a major global safety concern for both patients and healthcare professionals.<sup>1</sup> The biofilm-derived microorganisms from contaminated hoses of dental chair suction devices – for example, the high-volume suction and saliva ejector – are a potential source of cross-contamination and cross-infection.<sup>2</sup> High-volume evacuation systems (HVE) prevent contaminated aerosols from escaping the immediate operating site.<sup>3</sup> Studies have shown HVE to reduce more than 90% of aerosols arising from the operative site.<sup>4,5</sup> The efficiency of HVE is determined by the suction force of the appliance, the proximity of the HVE to the operating site and the number of evacuators used.<sup>6</sup> Clinicians need to check the power and airflow volume of the HVE periodically.<sup>7</sup> Saliva ejectors prevent contaminated aerosols from escaping the mouth.<sup>3</sup> They may, however, create unsanitary conditions by allowing a backflow of previous patients' waste material or substances from the tubing into a patient's mouth. Three interrelated predisposing factors for backflow have been identified. They are: simultaneous use of saliva ejector and HVE; the positioning of the suction tubing attached to the ejector above the patient's mouth; and the presence of less pressure in a patient's mouth than in the saliva ejector.<sup>8</sup>

International Organization for Standardization (ISO) standards recommend manufacturers provide appropriate cleaning and disinfection directions to use on the suction devices unit which should be followed.<sup>9</sup> Failure to clean suction devices daily leads to biofilm growth, a heavy bioburden and a greater risk of infections. Daily cleaning protects the equipment and maintains full suction power.<sup>10</sup> Inadequate disinfection of suction hoses and bacterial contamination of disinfectants are additional potential sources of healthcare associated infections.<sup>11</sup> Boyle and colleagues (2015) demonstrated that the method of disinfection influences the effectiveness of decontamination of suction hoses.<sup>12</sup> They found that standard aspiration disinfection was more effective in decontaminating high volume suction hoses than low volume suction hoses and that standard aspiration was less effective than manual or automated flood disinfection.<sup>12</sup> Contaminated disinfectants and antiseptics have been occasional vehicles of health-care associated infections

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and pseudo epidemics for more than 70 years.<sup>13</sup> Two recent reviews (a scoping review and a systematic review) found glaring differences in risk factors for bacterial contamination between low- and middle-income countries and high-income countries. The differences were found at the level of container (reused, recycled or inadequate processing vs design and functioning, presence of cork and cotton, biofilm formation) preparation (place, utensils or tap water, high and incorrect dilutions vs nonsterile water, overdilution) and practices (topping up or too long use vs too long expiry dates, inappropriate container reprocessing, topping up of containers and deviations from procedures).<sup>13,14</sup> The reviews found similarities in contaminating bacteria between low- and middle-income countries and high-income countries. Non-fermentative Gram negative rods and Enterobacterales were the most frequent isolates from contaminated antiseptics, disinfectants and hand hygiene products.<sup>13,14</sup> Previous research reported that members of the genus *Pseudomonas* (*P. aeruginosa*, for example) were the most frequent isolates from contaminated disinfectants.<sup>15</sup>

It has been reported that contaminated disinfectants exhibit decreased efficacy and effectiveness.<sup>16</sup> Also of therapeutic significance are reports that a number of bacterial contaminants isolated from disinfectants have exhibited resistance to commonly used antimicrobial agents.<sup>17</sup>

This study was designed to investigate the potential for healthcare-associated infections related to the process of disinfecting dental unit suction systems.

## OBJECTIVES

To determine the presence and grade of bacterial contamination of disinfectants used to decontaminate suction devices.

To assess the extent to which students comply with infection control practices.

## MATERIALS AND METHODS

### Study design

This two-part cross-sectional descriptive study consisted of microbiological testing of disinfectants and a questionnaire-based observation of students during the process of disinfecting suction devices.

### Target populations

The two populations studied were dental students who had clinical sessions and prepared disinfectant solutions, and jugs used to draw the solutions from storage bins. The study was conducted between June and August 2022 at a dental school in Gauteng, South Africa.

### Dental students

Slightly more than one-third (33.6%) of the total population of 143 dental students had clinical sessions during the study period. At the clinics, students, in their classes, were organised into equal-sized groups and allocated dental chairs for the purposes of supervision. The number of groups and their size was dependent on class size.

### Disinfectant solutions

A total of 16 60-litre capacity storage bins contained the disinfectant solutions. Nine one-litre capacity kitchen measuring jugs were used to draw from the bins.

## Data collection

### Microbiological testing

Five millilitre samples of disinfectants were collected in sterile universal containers using sterile pipettes from storage bins at the clinics over a period of one week during the 11am to 1pm clinic session while sterile swabs (premoistened with sterile saline) were used to collect samples for aerobic culture from the walls of the jugs. All samples reached the laboratory within 2 hours of collection and were processed immediately upon arrival.

Disinfectant samples were cultured on blood agar, incubated at 37°C for 24–48 hours, using two different methods as specified by Danchavijitr and colleagues (2005).<sup>18</sup> Each labelled swab was uncapped and lightly rolled over the entire surface of a blood agar plate with the same label and incubated at 37°C for 48 hours. Resultant colonies were graded on a scale of 0 to 4+ based on the number of quadrants on each plate that showed positive growth according to the procedure used by Bible and colleagues (2009).<sup>19</sup> They were classified according to the Gram stain procedure of Engelkirk and Duben-Engelkirk (2008).<sup>20</sup> A selection of colonies was subcultured in blood agar and the bacteria identified in VITEK®2, an automated instrument used for the identification and antimicrobial susceptibility testing.

### Observation-based survey

Unannounced observation of individual third, fourth and fifth-year dental students in their groups was performed by the researcher and co-supervisor using a questionnaire adapted from the Centers for Disease Control and Prevention's (CDC) Quick Observation Tools (QUOTs).<sup>21</sup> The questionnaire consisted of a series of closed questions which could only be answered with a yes or no. The questions related to precautions, activities or practices which were necessary for infection control. The process of disinfecting dental unit suction systems involved collecting a prepared dental suction disinfectant from a storage bin using a jug. The dental suction disinfectant, Bacterex, was prepared i.e. 4 x 15 gram sachets of chlorine disinfectant cleaner powder were mixed in 60 litres of cold water, in cleaned and disinfected storage bins. It was stored out of direct sunlight. It was not freshly prepared on each workday. The storage bins were not labelled with the date prepared and the use-by date. The jugs used to draw the prepared dental suction disinfectant for aspiration disinfection of the suction devices were hygienic. They were stored in a dry, cool, clean environment. None of the nine jugs was graduated in units of volume i.e. millilitres and litres. The order in which the groups were observed was decided randomly – the groups were assigned numbers; these were thoroughly mixed and drawn at random without replacement. The third and fourth-year clinics were held separately in the same floor of the hospital. The agreement of the observations between the researcher and co-supervisor was assessed in one group of students in each class.

### Definition of variables and terms

Overwhelming majority refers to a majority that is about 70% or more.

Vast majority refers to a majority that is 85% or more.

### Ethical considerations

The study protocol was approved by the University Ethics Committee (SMREC/D/208/2020:PG). Permission to conduct the study was granted by the Chief Executive Officer (CEO) of the Oral Health Centre.

### Statistical analysis/Hypothesis testing

Collected data was captured and analysed in SPSS software. Means and proportions (percentages) were calculated. The Chi-squared tests was performed to test for the statistical significance of the differences in proportions of the summary of observations. The chosen significance level for the tests was a p-value equal to or less than 0.05.

### Results

The results of microbiological testing and the observation-based survey are presented separately.

### Microbiological testing

Data obtained from microbiological testing of prepared disinfectant and swabs of the walls of the jugs were analysed.

**Table 1: Presence and grades of bacterial contamination of prepared disinfectants by clinics**

Clinics	Grades of bacterial growth					Total number of storage bins
	0	1+	2+	3+	4+	
Third year	2	0	0	0	2	4
Fourth year	1	4	0	0	3	8
Fifth year	4	0	0	0	0	4
Total number of storage bins	7	4	0	0	5	16

Bacterial contamination was found in 56.3% of the samples. Grade 4+ bacterial growth was detected in 31.3% of the samples.

**Table 2: Presence and grades of bacterial contamination of the swabs of jugs by clinic**

Clinics	Grades of bacterial growth					Total number of jugs
	0	1+	2+	3+	4+	
Third year	2	0	0	0	1	3
Fourth year	0	3	0	1	0	4
Fifth year	2	0	0	0	0	2
Total number of jugs	4	3	0	1	1	9

Bacterial contamination was found in 55.6% of the samples. Grade 1+ bacterial growth predominated.

### Microscopy

The overwhelming majority of the bacteria were Gram-positive. Cocci in pairs, clusters or chains predominated. Rod-shaped single cells were also seen.

### Bacterial identification

**Table 3: Identity of bacteria isolated from prepared disinfectants and swabs of jugs**

Bacteria	Sample type	
	Prepared disinfectant	Swabs of jugs
Kocuria varians	√	√
Staphylococcus saprophiticus	√	√
Sphingomonas paucimobilis	√	-
Aeromonas salmonicida	√	-
Bacillus species	√	-

√ = Present - = Absent

Five different bacteria were isolated from the prepared disinfectant while only two were isolated from the jugs.

### Structured observations

Data gathered from structured observations of classes of third, fourth and fifth-year dental students were analysed.

**Table 4: Observation report of the third-year class**

Student observation	Summary of observations		Total n (%)
	Yes n (%)	No n (%)	
The student is using personal protective equipment	9 (100)	0 (0)	9 (100)
The suction lines are disinfected at the start of the clinic session	9 (100)	0 (0)	9 (100)
The recommended volume (250ml) of the disinfectant is drawn through each evacuation system line	0 (0)	9 (100)	9 (100)
The external surface of suction hoses is disinfected and cleaned daily through wiping	3 (33.3)	6 (66.7)	9 (100)
The spittoon is cleaned and disinfected at the same time as the suction lines	5 (55.6)	4 (44.4)	9 (100)
The suction cleaning solution is allowed to remain in the system for at least 10 minutes	0 (0)	9 (100)	9 (100)
Patients are advised not to close their lips around the suction device. Is the re a notice?	0 (0)	9 (100)	9 (100)

None of the students: drew the recommended volume of the solution through the evacuation system lines; advised patients not to close their lips around the suction device; allowed the disinfectant to remain in the system for at least 10 minutes before they started working. Merely a third of the students disinfected the external surface of suction hoses during the time that they were disinfecting the suction lines.

Table 5: Observation report of the fourth-year class

Student observation	Summary of observations		Total n (%)
	Yes n (%)	No n (%)	
The student is using personal protective equipment	29 (93.5)	2 (6.5)	31(100)
The suction lines are disinfected at the start of the clinic session	22 (71%)	9 (29)	31(100)
The recommended volume (250ml) of the solution is drawn through each evacuation system line	0 (0)	31 (100)	31(100)
The external surface of suction hoses is disinfected and cleaned daily through wiping	22 (71)	9 (29)	31(100)
The spittoon is cleaned and disinfected at the same time as the suction lines	16 (51.6)	15 (48.4)	31(100)
The suction cleaning solution is allowed to remain in the system for at least 10 minutes	6 (19.4)	25 (80.6)	31(100)
	6 (19.4)	25 (80.6)	31(100)

None of the students drew the recommended volume of the solution through the evacuation system lines. An equal proportion (19.4%) of students advised patients not to close their lips around the suction device as allowed the disinfectant to remain in the system for at least 10 minutes before they started working.

Table 6: Observation report of the fifth-year class

Student observation	Summary of observations		Total n (%)
	Yes n (%)	No n (%)	
The student is using personal protective equipment	3 (100)	0 (0)	*3 (100)
The suction lines are disinfected at the start of the clinic session	3 (100)	0 (0)	*3 (100)
The recommended volume (250ml) of the solution is drawn through each evacuation system line	0 (0)	3 (100)	*3 (100)
The external surface of suction hoses is disinfected and cleaned daily through wiping	3 (100)	0 (0)	*3 (100)
The spittoon is cleaned and disinfected at the same time as the suction lines	3 (100)	0 (0)	*3 (100)
The suction cleaning solution is allowed to remain in the system for at least 10 minutes	2 (66.7)	1 (33.3)	*3 (100)
Patients are advised not to close their lips around the suction device	0 (0)	3 (0)	*3 (100)

\*A total of eight students were present during the session. Of these, only three were observed. Trainee dental assistants disinfected the suction lines of the dental chairs of five students.

Table 7: Interclass comparison of the summary of observations

Student observation	Year of study						Chi-squared test
	3rd Year		4th Year		5th Year		
	Yes	No	Yes	No	Yes	No	
The student is using personal protective equipment	9	0	29	2	3	0	
The suction lines are disinfected at the start of the clinic session	9	0	22	9	3	0	
The external surface of suction hoses is disinfected and cleaned daily through wiping	3	6	22	9	3	0	
The spittoon is cleaned and disinfected at the same time as the suction lines	5	4	16	15	3	0	
The suction cleaning solution is allowed to remain in the system for at least 10 minutes	0	9	6	25	2	1	
Patients are advised not to close their lips around the suction device	0	9	6	25	0	3	

The differences in the proportions of summary of observations between the classes by year of study was significant for the observations: the spittoon is cleaned and disinfected at the same time as the suction lines ( $p=0.007$ ); the suction cleaning solution is allowed to remain in the system for at least 10 minutes ( $p=0.001$ ) and patients are advised not to close their lips around the suction device ( $p=<0.001$ ).

Of the three students observed, two allowed the disinfectant to remain in the system for at least 10 minutes. None of the students drew the recommended volume of the solution through the evacuation system lines.

## DISCUSSION

This study set out to determine the presence and level of bacterial contamination of prepared suction system disinfectants and observe students' compliance with infection control practices.

### Microbiological testing

The most interesting finding was that the majority of the samples of prepared disinfectants (56.3%) and of the jugs (55.6%) were contaminated with bacteria. Bacterial contamination of a disinfectant prepared by dissolving a known mass of solute in a known amount of solvent has not previously been described. A great deal of the previous research has been performed on disinfectant prepared by diluting a stock solution.<sup>11,13,16</sup> The prevalence of contamination recorded in this study is 15% higher than the 40% range of published previous studies (3%,<sup>22</sup> 6.1%,<sup>23</sup> 7.9%,<sup>24</sup> 34.4%<sup>25</sup> and 43%<sup>11</sup>). It seems possible that the jugs played a significant role in the contamination of the disinfectants.

Another important finding was that the highest grade (4+) of bacterial growth was recorded in 31.3% samples of the prepared disinfectants. This rather disappointing finding suggests that the bacteria were able to adapt and multiply in solutions.<sup>26</sup> This could be related to the reduced efficacy of the disinfectant.<sup>27</sup> The factors that are known to affect the efficacy of disinfectants include: pH, concentration, temperature structure,<sup>15</sup> nature, composition and condition of the organism,<sup>28</sup> organic and inorganic load present, type and level of microbial contamination, presence of biofilms,<sup>15</sup> overdilution of disinfectants, poor personal hygiene, non-adherence to proper techniques in their uses and reuse, and improper storage.<sup>29</sup> The factors that may have played a role in this study are too long use and too long expiry dates related to the fact that storage bins were not labelled.

### Microscopic identification

The results of this study show that gram-positive cocci were the predominant organisms. Although these results differ from some published studies,<sup>14,15</sup> they are consistent with those Kgabi (2015) who found mainly gram-positive cocci and some gram-negative bacilli in samples of antiseptics and surface disinfectants.<sup>30</sup>

### Biochemical identification

Bacteria cultured in this study were identified as *Kocuria varians*, *Staphylococcus saprophiticus*, *Aeromonas salmonicida*, *Sphingomonas paucimobilis* and *Bacillus* species. The findings of the current study do not support the previous research in that neither *Enterobacteriales* nor *P. aeruginosa* were isolated from the disinfectants.<sup>13-15</sup> It seems possible that the contaminants isolated in this study originated from hand contact or oral contamination as they naturally inhabit the skin and mucous membranes.<sup>31,32</sup>

## OBSERVATION-BASED SURVEY

### Response rate

The results of this study show that the response rate was low at an average of 34%. This finding was unexpected. There are several possible explanations for this result: students were away on off-campus rotations; patients did not honour appointments and the days of data collection for the study coincided with test dates. The data of the observation-based survey must be interpreted with caution because the sample is not representative of the population as a whole.

The results of this study show that a vast majority (95.3%) of students used personal protective equipment during the time that they were disinfecting the suction lines (Table 7). It is disappointing that a few students (almost five percent) disregarded safety

precautions. The health effects of the chlorine-based disinfectant include the irritation and burning of eyes and hands, among others.

The results of this study indicate that an overwhelming majority (79.1%) of students disinfected the suction lines at the start of the clinic session (Table 7). The present finding confirms the existence of a disinfection policy at the clinics. This is consistent with the results of Shah and colleagues (2007) who found that 92% of orthodontics departments in the United Kingdom had a policy to disinfect waterlines and suction tubing.<sup>33</sup> It is rather disappointing that 20.9% of the students did not follow the policy as it is well established that improperly disinfected suction apparatus provides a favourable environment for biofilm proliferation.<sup>12</sup>

The most interesting finding was that none of the students drew the recommended volume of the solution through the evacuation system lines (Tables 4-6). This finding is not surprising considering that none of the nine jugs used was graduated in the most common units of volume i.e. millilitres and litres. Failure to follow the manufacturer's recommendation may affect the efficacy of disinfection practices.<sup>34</sup>

Another important finding was that a little less than 20% (18.6%) of the students allowed the disinfectant to remain in the system for at least 10 minutes before they started working (Table 7). One unanticipated finding was that the contact time for the disinfectant used (Bacterex) was five minutes.<sup>35</sup> This oversight makes it difficult to explain the results of this study. The oversight was due to the fact that most EPA-registered hospital disinfectants have a label contact time of 10 minutes.<sup>15</sup>

The results of this study show that the proportion of students who cleaned and disinfected the external surface of suction hoses together with the spittoon bowl at the same time as the suction lines varied widely i.e. the ranges were 66.7% and 48.4% respectively (Table 7). It is very concerning that not all students cleaned and disinfected the external surface of suction hoses and the spittoon bowl for the reason that *Staphylococcus* and *Bacillus* species have been isolated from these surfaces.<sup>36</sup>

The results of this study show that at most 14% (6 out of 43) of the students advised their patients not to close their lips around the suction device (Table 7). This result has not previously been described. This result may be explained by the fact that there were no notices in the clinics reminding student to comply with this recommendation. This finding is rather disappointing considering that the cross contamination potential of saliva ejectors has been investigated and reported on since 1990s. Although there is no direct proof of cross-contamination, a great deal of research has indicated that fluid can flow backward in low-volume suction lines when patients close their lips around the saliva ejector tip.<sup>37-39</sup>

## LIMITATIONS

## CONCLUSION

The current study found that bacterial contamination of disinfectants was common in addition to poor compliance with infection control practices.

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## Online CPD in 6 Easy Steps



The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.

