

A Descriptive Study of Chlorhexidine as a Disinfectant in Cleft Palate Surgery

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Abbreviations: CP - cleft palate

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Abstract

Objectives: Chlorhexidine is seen as the golden standard of disinfectants. It is widely used to clean surgical sites. Many articles indicate resistance of pathogens to chlorhexidine. One study indicated that pathogenic micro-organisms were isolated from the soft palate cleft region in 57% of patients with facial clefts. The objective was to determine if chlorhexidine application is effective in removing pathogens from the surgical site in these patients. Secondly, if any pathogens were isolated, are they resistant to any other antimicrobials.

Design: A descriptive observational study was designed and all patients (N = 50) that presented for primary repair of the soft palate cleft were included in the study. The average age of patients is 7 months and 16 days with 25 male and 25 female.

Settings: A private practice that specializes in facial cleft surgery, with a country wide patient base was the research site. All procedures were executed by one Oral and Maxillofacial surgeon.

Participants: All patients that presented for primary repair of the soft palate cleft were included in the study. Inclusion criteria: written consent from parents, and patients cleared as systemic healthy by a pediatric physician.

Methods: Swabs were taken from the surgical site of all 50 patients with cleft soft palate and were sent for culture, identification and antimicrobial sensitivity. The swabs were taken before disinfecting the site as well as after 2 minutes of disinfecting the surgical site with Chlorhexidine. Results were compared against each other.

Results: Forty seven patients showed positive cultures with 28 different pathogenic micro-organisms that were identified before cleaning the surgical site with the chlorhexidine. The most dominant pathogens were *K pneumonia* (n= 22), *H influenza* (n=18) and *S aureus* (n=10). Thirteen of the 28

pathogens were still present on the second swabs taken after disinfecting with chlorhexidine. *K pneumonia* (n= 13), *H influenza* (n=11) and *S aureus* (n=9) were still the most prevalent pathogens.

Conclusions: This study demonstrated that 61 of the total of 113 pathogens isolated (54%), survived after 2 minutes of disinfecting the surgical and surrounding area with CHG, thus intensifying the chances of post-operative infection.

Keywords: Chlorhexidine, resistance, pathogens, cleft soft palate

Introduction

Pathogenic microorganisms with resistance to anti-microbial drugs are a major concern in surgical treatment of facial clefts.¹ This is especially a factor in the treatment of soft and hard palate clefts where post-operative infection can lead to the formation of oro-nasal fistulas or even breakdown of the whole surgical site. A complication like this will have a detrimental effect on future feeding and speech of the patient, creating the need for additional surgical interventions. As more evidence of resistance of pathogenic micro-organisms against anti-microbial drugs is published, the question comes to mind: How much resistance has developed against chlorhexidine?

Micro-organisms like *Klebsiella pneumonia*, *Haemophilus influenza* and *Staphylococcus aureus* are opportunistic pathogens that is often detected pre-operatively in infants that present for the first stage of repair of the soft palate, and is of increasing importance.^{1,2} Of great concern are the recent outbreaks of carbapenemase producing *K. Pneumonia*.³⁻⁵

Chlorhexidine was first introduced commercially in the United Kingdom as a disinfectant and topical antiseptic in 1954.^{6,7} It is effective against Gram-negative, Gram-positive bacteria and fungi and kills by disruption of the cell membrane. Thus, it was set as the golden standard for surface and surgical site disinfectant.⁸⁻¹⁰ One study¹¹ demonstrated the effectiveness of antimicrobial surgical gloves of which the inner surface is coated with chlorhexidine digluconate (CHG), against *K pneumonia* after a 2h wear time. The authors found that a mean reduction factor of 6.22 log₁₀ was achieved after 5 minutes' contact. A study done in a "Long-term acute care hospital" had success in controlling an outbreak of *Klebsiella pneumonia* carbapenemase (KPC)–producing *K pneumonia* by combining daily 2% CHG baths for patients with enhanced environmental cleaning, surveillance cultures at admission, serial point

prevalence surveillance (PPS), isolation precautions, and training of personnel.¹² Numerous additional studies have also confirmed the effectiveness of chlorhexidine¹³⁻¹⁵ and, its effectivity against biofilm formation was also proven.¹⁶ However, other research projects have found that the effectiveness of chlorhexidine against *K pneumonia* is greatly reduced.¹⁷⁻²⁰

A study in a hospital environment in China observed that isolates of *Staphylococcus aureus* showed reduced susceptibility to chlorhexidine²¹ and was confirmed in Taiwan.²² It was also stated that the “reduced microbial susceptibility to biocides represents a serious cause for concern in the clinical environment”.²³ In a study done on soft palate cleft patients,¹ results indicated that 35 patients out of the total of 200 were infected pre-operatively with *K pneumonia*. This pathogen also showed the highest resistance to anti-microbials. *H influenza*, *S aureus* and 20 other micro-organisms were also isolated pre-operatively.

The protocol for the first stage of soft palate cleft repair at the Wilgers Surgical Center Pretoria, uses CHG as disinfectant on the area to be operated to remove all pathogenic micro-organisms in an effort to minimize post-operative infections as much as possible. In light of above mentioned literature the objective is to determine if chlorhexidine application is effective in removing pathogens from the surgical site in these patients and if any pathogens were isolated, are they resistant to any other antimicrobials. Answering this objective can guide all surgical disciplines that make use of CHG as disinfectant of the surgical site.

Methods

A descriptive observational study was designed and approved by the Faculty of Health Science Research Ethics Committee (467/2015) of the University of Pretoria. All patients (N = 50) that presented for primary repair of the soft palate cleft were included in the study. Only patients where written consent from the parents was received and that were cleared as systemic healthy by a pediatric physician were included in the study. Patients with systemic infections (e.g. flu) and / or any local infections (e.g. tonsillitis) were excluded from the study. History of previous medications prescribed to the patients was not recorded. All procedures were executed by one Oral and Maxillofacial surgeon.

The Copan Transystem® Bacteriology Swab Collection system with Amies Agar Gel® for aerobic and anaerobic culture was used to collect and transport specimens. The first swab was taken pre-operatively from the cleft soft palate and adjacent nasopharynx of all patients immediately after they were anaesthetized (general anesthesia) by removing the swab from the sterile packing, rubbing it gently against the mucosa of the indicated area, inserting the swab in the transport tube to seal it and marked as “Pre-cleaning”. Next, the mouth and oro-pharyngeal area were cleansed (disinfected) with a chlorhexidine solution (Andolex-C Oral Rinse)® for 2 minutes. The cleaning was done by using three sterile sponges (40 x 70 x 20mm attached to a plastic spatula of 150mm) that were soaked in the chlorhexidine solution. The sponges were applied by rubbing the whole mouth and oro-pharyngeal area consecutively to make up the 2 minutes. A second swab was then taken from the cleft soft palate and nasopharynx and marked as “Post-cleaning”. All swabs were transported in this format within 1 hour to a laboratory for culturing in order to determine the type, colony size and sensitivity of any possible micro-organisms.

The organisms were isolated using standard microbiological methods: all samples were inoculated onto a non-selective blood agar plate as well as a selective and differential MacConkey agar plate. Plates were incubated overnight at 35 degrees Celsius. Next morning, incubated colonies are transferred to a target slide that is introduced into VITEK® MS, an automated mass spectrometry microbial identification system for identification of pathogens. Kirby-Bauer antibiotic testing was utilized to determine antimicrobial sensitivity or resistance to indicate which antimicrobial agents will be effective in treating the patient if any infections develop.

Pre-cleaning and post-cleaning data from the laboratory results were recorded per patient and analyzed in Excel®. Frequencies and proportions, with 95% confidence intervals are used to describe the presence of bacteria in patients, before and after cleaning, as well as the proportion of the bacteria that was eliminated.

Results

From the swabs taken prior to disinfecting with chlorhexidine, pathogenic micro-organisms could be cultured in all but 3 patients (n = 47).

The average age of the 50 patients is calculated at 7 months and 16 days (Standard deviation: 3 months 18 days). There is an equal sex distribution with 25 patients male and 25 female. Race distribution is as follows: Indian (3), Black (10) and White (37).

Of the 47 patients that showed positive cultures, twenty-eight different pathogenic micro-organisms were identified (Table 1). *K pneumonia* was present in 22 of these patients, *H influenza* in 18 patients

and *S aureus* in 10 patients. The following micro-organisms were isolated in 9 patients each: *Enterobacter cloacae*, *Escherichia coli* and *Streptococcus mitis/oralis*. The rest of the organisms numbered between 1 and 4 patients with 13 of them in only one patient each. A total of 113 pathogens were cultured from the 47 patients.

Table 1: Pathogens identified pre-cleaning

Micro-organism	Number
<i>Acinetobacter baumannii</i>	2
<i>Aeromonas hydrophila/caviae</i>	1
<i>Candida albicans</i>	3
<i>Candida famata</i>	1
<i>Candida kefyr</i>	1
<i>Candida krusei</i>	1
<i>Candida lusitaniae</i>	1
<i>Candida parapsilosis</i>	2
<i>Candida tropicalis</i>	2
<i>Chryseobacterium gleum</i>	1
<i>Citrobacter freundii</i>	1
<i>Edwardsiella tarda</i>	1
<i>Enterobacter cloacae</i>	9
<i>Escherichia coli</i>	9
<i>Geobacillus thermoglucosidasium</i>	1
<i>Haemophilus influenza</i>	18
<i>Klebsiella oxytoca</i>	4
<i>Klebsiella pneumonia</i>	22
<i>Neisseria subflava</i>	1
<i>Proteus mirabilis</i>	1
<i>Pseudomonas aeruginosa</i>	2
<i>Pseudomonas putida</i>	1
<i>Saccharomyces cerevisiae</i>	1
<i>Serratia marcescens</i>	2
<i>Staphylococcus aureus</i>	10
<i>Streptococcus mitis/oralis</i>	9
<i>Streptococcus parasanguinis</i>	2
<i>Streptococcus pneumoniae</i>	4

Post-cleaning (disinfecting) cultures isolated 13 different micro-organisms that had various levels of resistance to chlorhexidine (Table 2). Thirteen out of the 22 *K pneumoniae* cases (59.1%) were not

eradicated. Out of the 18 *H influenza* cases, 11 (61.1%) and for the *S aureus*, 9 of the 10 (90%) survived. The three organisms, *E cloacae*, *E coli* and *S mitis/oralis* that were present in 9 cases each, had 3 (33.3%), 6 (66.6%) and 7 (77.8%) cases surviving the chlorhexidine.

This result showed that 61 of the 113 pathogens (54%) survived after 2 minutes of disinfecting the surgical and surrounding area with CHG.

Table 2: Pathogens identified after cleaning / disinfecting with chlorhexidine. Number of pathogens identified before cleaning indicated in brackets

Micro-organism	Number
<i>Aeromonas hydrophila/caviae</i>	1 (1)
<i>Candida albicans</i>	1 (3)
<i>Candida parapsilosis</i>	1 (2)
<i>Enterobacter cloacae</i>	3 (9)
<i>Escherichia coli</i>	6 (9)
<i>Haemophilus influenza</i>	11 (18)
<i>Klebsiella oxytoca</i>	2 (4)
<i>Klebsiella pneumonia</i>	13 (22)
<i>Pseudomonas aeruginosa</i>	2 (2)
<i>Staphylococcus aureus</i>	9 (10)
<i>Streptococcus mitis/oralis</i>	7 (9)
<i>Streptococcus parasanguinis</i>	2 (2)
<i>Streptococcus pneumoniae</i>	3 (4)

Antimicrobial resistance of the pathogens cultured from the pre-cleaning swabs was determined. 76 of the 113 (67.3%) pathogens showed resistance to different anti-microbial agents that they were tested against. Table 3 is a summary of the resistance of the 6 most prevalent micro-organisms.

Table 3: AB resistance of 6 most predominant pathogens

AB resistance		
Pathogen (N)	Ab	No / cases
Klebsiella pneumoniae (22)	Ampicillin	21
	Amoxicillin-Clavulanic Acid (I)	3
	Cefuroxime	4
	Cefotaxime	3
	Ceftazidime	2
	Cefepime	1
	Amikacin (I)	1
	Tobramycin (I)	2
	Cotrimoxazole	4
Haemophilus influenzae (18)	Cotrimoxazole	9
	Moxifloxacin	1
Staphylococcus aureus (10)	Pen-G	10
	B-Lactamase +	2
	Cotrimoxazole	1
Enterobacter cloacae (9)	Ampicillin	9
	Amoxicillin-Clavulanic Acid	9
	Cefuroxime	8
Escherichia coli (9)	Ampicillin	6
	Amoxicillin-Clavulanic Acid	1
	Cefuroxime	2
	Cefutaxime	2
	Ciprofloxacin	1
	Cotrimoxazole	5
	Tobramycin	1
Streptococcus mitis/oralis (9)	Ampicillin	3
	Pen-G	5
	Amoxicillin-Clavulanic Acid	4
	Erythromycin	6
	Clindamycin	3

Discussion

Drug resistance in the medical field is a growing concern on an exponential level and it is of utmost importance to ensure that the surgical area be pathogen free pre-operatively. With all the information of infectious diseases on the internet, the widespread use of disinfectants has increased dramatically.

Chlorhexidine seems to be the most widely used disinfectant⁸ and as a result of this phenomena, more and more evidence of resistance to chlorhexidine is emerging.¹⁷⁻²³

In 2002, one research study indicated that strains of micro-organisms resistant to antibiotics were also less susceptible to chlorhexidine.²⁴ The number of anti-microbial resistant organisms indicated in soft palate cleft patients in the literature,¹ prompted the current study to investigate what the effectiveness of disinfecting the surgical site with chlorhexidine in these specific cleft patients is. Post-cleaning cultures indicated that 61 of the 113 pathogens (54%) isolated pre cleaning, survived after 2 minutes of disinfecting the surgical and surrounding area with chlorhexidine, demonstrating that it is not as effective as required. More articles were published in current years where lower susceptibility of pathogens against chlorhexidine was indicated.²¹ One study found that the efficacy of chlorhexidine was weak in comparison to other disinfectants against five pathogens¹⁸. This is in line with our study that compared similar to two of the same pathogens. In general, Gram-positive bacteria are considered more sensitive to disinfectants than Gram-negative bacteria due to the composition of the cell wall.⁸ Gram-negative microbes in this study involve 7 out of the 13 pathogens that survived the chlorhexidine, 4 were gram-positive and 2 were yeasts.

In this descriptive observational study, the authors found that for the pathogen *S aureus*, 90% of cases identified were resistant to chlorhexidine and this compared favorably with other studies that indicated lesser susceptibility to chlorhexidine.²¹⁻²³ For both patients where *Pseudomonas aeruginosa* was detected as well as the two cases where *Streptococcus parasanguinis* was cultured and the single case of *Aeromonas hydrophila/caviae*, 100% resistance to chlorhexidine was indicated (Fig 1) being in line with

other studies^{18,24}. This is also supported by a study that proved the low susceptibility of *Pseudomonas stutzeri*.²⁵

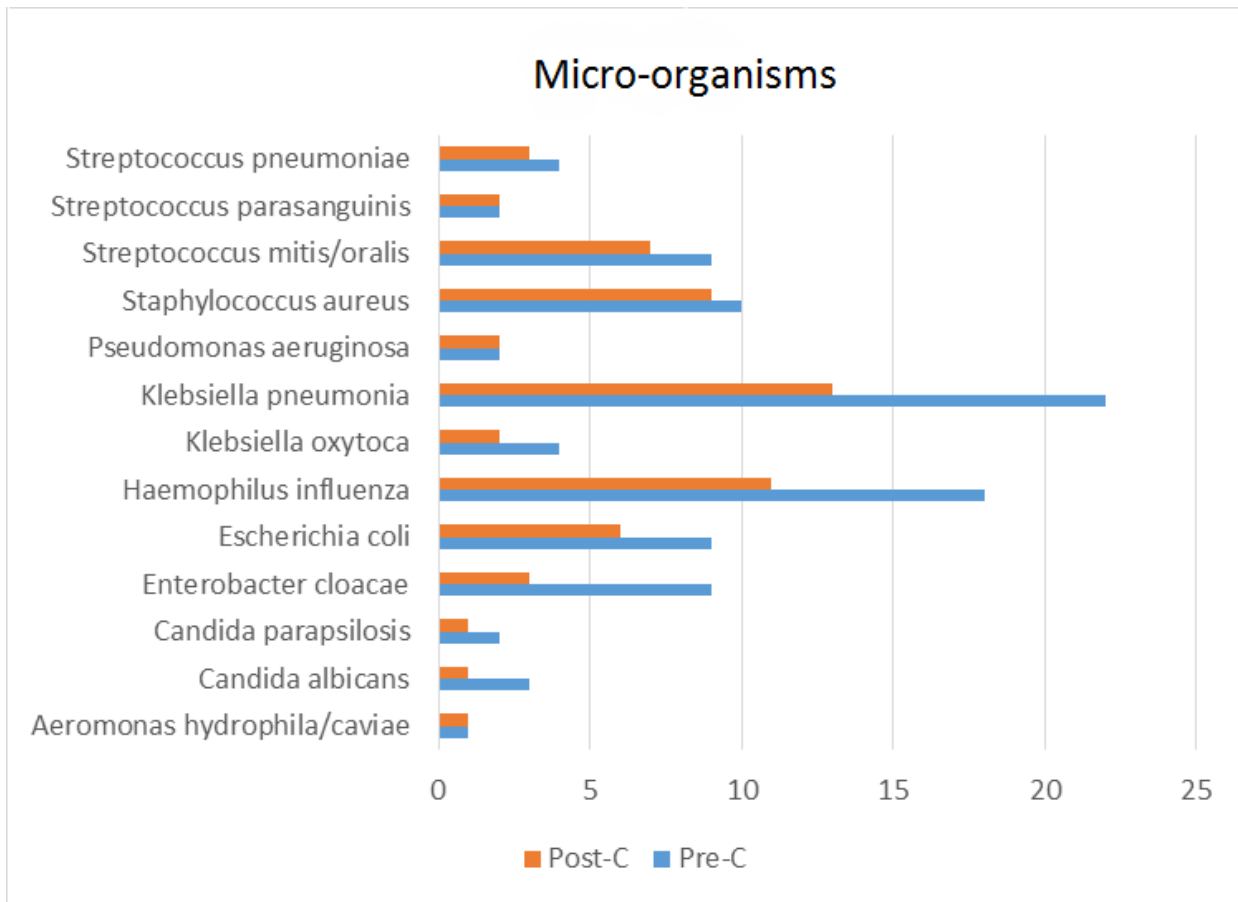


Figure 1. Pathogenic micro-organisms (Post-C = Post cleaning, Pre-C = Pre-cleaning)

As far back as 1991, research has indicated the resistance of *K pneumonia* against chlorhexidine.²⁶ One study found that chlorhexidine-resistant subpopulations of *K pneumonia* were independent of the bacterial sequence type,²⁷ while another study proved that Carbapenem-resistant *K pneumoniae* (CRKP) has a pan-resistance to disinfectants.¹⁷ With this in mind, it is of great concern that 11 fatal cases in one clinical Centre were connected to CRKP²⁸ as well as 5 deaths in France.²⁹ In 2004, the intrinsic contamination of a 2% chlorhexidine hand soap with *K pneumonia* was reported.³⁰ In the current study,

K pneumonia was the most prominent pathogen cultured pre-cleaning in 22 of the total of 50 cases treated. Thirteen of the 22 cases (59.1%) were resistant to chlorhexidine.

Comparing antimicrobial resistance of pathogens isolated in this study parallels to other studies^{1,23,24,27,31}. Resistance to the more commonly used antimicrobials equates to the following with number of pathogens out of the total of 113 indicated in brackets: Ampicillin (20), Amoxicillin-Clavulanic Acid (25), Cefuroxime (18), Cotrimoxazole (29) and Erythromycin (14).

Limitation of this study is that the results apply to a very special group of patients and might not be representative of the general population. Of concern is that such a high number of antimicrobial resistant micro-organisms was cultured in a patient group where the average age is 7.5 months.

The purpose of disinfecting a surgical site is to remove all pathogens to prevent post-operative infections. The results of this descriptive observational study indicates that CHG is less than 50% effective as disinfectant in cleft soft palate patients.

Conclusion

The resistance of pathogens to the golden standard of disinfectants, chlorhexidine, leads to the more intensive use of antimicrobials to reduce the post-operative complications of infection. This practice is leading to the negative effect of a wider usage of antimicrobials that leads to greater resistance of the pathogens to these antimicrobials. This results indicates that surgeons should refrain from using CHG as a surgical site disinfectant and use a more effective substitute. A natural alternative like honey, that in

vitro does not have any antimicrobial resistance to it, should be tested *in vivo* for its effectiveness. It might just be the ideal solution.

References

1. Roode GJ, Bütow K-W, Naidoo S. Preoperative evaluation of micro-organisms in non-operated cleft in soft palate: impact on use of antibiotics. *Br J Oral Maxillofac Surg* 2016;55:127-31.
2. Wand ME, Baker KS, Benthall G, McGregor H, McCowen JWI, Deheer-Graham A, Sutton JM. Characterization of pre-antibiotic era *Klebsiella pneumoniae* isolates with respect to antibiotic/disinfectant susceptibility and virulence in *Galleria mellonella*. *Antimicrob Agents Chemother* 2015;59:3966-72.
3. Ducombe T, Faucheux S, Helbig U, Kaisers UX, König B, Knaust A, Lubbert C, Moller I, Rodloff AC, Schweickert B, Eckmanns T. Large hospital outbreak of KPC-2-producing *Klebsiella pneumoniae*: investigating mortality and the impact of screening for KPC-2 with polymerase chain reaction. *J Hosp Infect* 2015;89:179-85.
4. Lippmann N, Lubbert C, Kaiser T, Kaisers UX, Rodloff AC. Clinical epidemiology of *Klebsiella pneumoniae* carbapenemases. *Lancet Infect Dis* 2014;14:271-2.
5. Giuffrè M, Bonura C, Geraci DM, Saporito L, Catalano R, Di Noto S, Nociforo F, Corsello G, Mammina C. Successful control of an outbreak of colonization by *Klebsiella pneumoniae* carbapenemase-producing K. pneumoniae sequence type 258 in a neonatal intensive care unit, Italy. *J Hosp Infect* 2013;85:233-6.
6. About Chlorhexidine. 2017; Available from: <http://chlorhexidinefacts.com/>.
7. Davies GE, J. Francis, A. R. Martin, F. L. Rose and G. Swain. 1:6-di-4'-chlorophenyldiguanidohexane ("hibitane"). Laboratory Investigation of a New Antibacterial Agent of High Potency. *Br J Pharm Chem* 1954;9:192-96.
8. McDonnell G, Russell AD. Antiseptics and Disinfectants: Activity, Action and Resistance. *Clin Microbiol Rev* 1999;12:147-79.

9. Larson ELaBEL. Chlorhexidine Gluconate to Cleanse Patients in a Medical Intensive Care Unit. *Antimicrob Agents Chemother* 1987;31:1572-74.
10. Puig Silla M MCJ, Almerich Silla JM. . Use of chlorhexidine varnishes in preventing and treating periodontal disease: a review of the literature. *Med Oral Patol Oral Cir Bucal* 2008; 13:E257-60. 2008;13:E257-60.
11. Leitgeb J, Schuster R, Yee BN, Chee PF, Harnoss J-C, Starzengruber P, Schaffer M, Assadian O. Antibacterial activity of a sterile antimicrobial polyisoprene surgical glove against transient flora following a 2-hours simulated use. *BMC Surg* 2015;15:81.
12. Munoz-Price LS, Hayden MK, Lolans K, Won S, Calvert K, Lin M, Stemer A, Weinstein RA. Successful control of an outbreak of *Klebsiella pneumoniae* carbapenemase-producing *K. pneumoniae* at a long-term acute care hospital. *Infect Control Hosp Epidemiol* 2010;31:341-7.
13. Soares AF, Aquino ARLd, Carvalho CHPd, Nonaka CFW, Almeida D, Pinto LP. Frequency of oral mucositis and microbiological analysis in children with acute lymphoblastic leukemia treated with 0.12% chlorhexidine gluconate. *Braz Dent J* 2011;22:312-6.
14. Mann-Salinas EA, Joyner DD, Guymon CH, Ward CL, Rathbone CR, Jones JA, Akers KS. Comparison of Decontamination Methods for Human Skin Grafts. *J Burn Care Res* 2015;36:636-40.
15. Lin MY, Lolans K, Blom DW, Lyles RD, Weiner S, Poluru KB, Moore N, Hines DW, Weinstein RA, Hayden MK. The effectiveness of routine daily chlorhexidine gluconate bathing in reducing *Klebsiella pneumoniae* carbapenemase-producing Enterobacteriaceae skin burden among long-term acute care hospital patients. *Infect Control Hosp Epidemiol* 2014;35:440-2.
16. Houari A, Di Martino P. Effect of chlorhexidine and benzalkonium chloride on bacterial biofilm formation. *Lett Appl Microbiol*, 2007;45:652-6.

17. Guo W, Shan K, Xu B, Li J. Determining the resistance of carbapenem-resistant *Klebsiella pneumoniae* to common disinfectants and elucidating the underlying resistance mechanisms. *Pathog Glob Health* 2015;109:184-192.
18. Shimizu M, Okuzumi K, Yoneyama A, Kunisada T, Araake M, Ogawa H, Kimura S. In vitro antiseptic susceptibility of clinical isolates from nosocomial infections. *Dermatology* 2002;204 Suppl 1:21-7.
19. Brown AT, Shupe JA, Sims RE, Matheny JL, Lillich TT, Douglass JB, Henslee PJ, Raybould TP, Ferretti GA. In vitro effect of chlorhexidine and amikacin on oral gram-negative bacilli from bone marrow transplant recipients. *Oral Surg Oral Med Oral Pathol* 1990;70:715-9.
20. Gautier G, Noguer M, Costa N, Canela J, Vinas M. Mouthrinses: a comparative microbiological study. *Bull Group Int Rech Sci Stomatol Odontol* 2000;42:23-9.
21. Lu Z, Chen Y, Chen W, Liu H, Song Q. Characteristics of qacA/B-positive *Staphylococcus aureus* isolated from patients and a hospital environment in China. *J Antimicrob Chemother* 2015;70:
22. Wang JT, Sheng WH, Wang JL, Chen D, Chen ML, Chen YC, Chang SC. Longitudinal analysis of chlorhexidine susceptibilities of nosocomial methicillin-resistant *Staphylococcus aureus* isolates at a teaching hospital in Taiwan. *J Antimicrob Chemother* 2008;62:514-7.
23. Vali L, Davies SE, Lai LL, Dave J, Amyes SG. Frequency of biocide resistance genes, antibiotic resistance and the effect of chlorhexidine exposure on clinical methicillin-resistant *Staphylococcus aureus* isolates. *J Antimicrob Chemother* 2008;61:524-32.
24. Koljalg S, Naaber P, Mikelsaar M. Antibiotic resistance as an indicator of bacterial chlorhexidine susceptibility. *J Hosp Infect* 2002;51:106-13.

25. Tattawasart U, Maillard J-Y, Furr JR, Russell AD. Development of resistance to chlorhexidine diacetate and cetylpyridinium chloride in *Pseudomonas stutzeri* and changes in antibiotic susceptibility. *J Hosp Infect* 1999;42:219-29.
26. Stickler D, Dolman J, Rolfe S, Chawla J. Activity of some antiseptics against urinary tract pathogens growing as biofilms on silicone surfaces. *Eur J Clin Microbiol Infect Dis* 1991;10:410-5.
27. Naparstek L, Carmeli Y, Chmelnitsky I, Banin E, Navon-Venezia S. Reduced susceptibility to chlorhexidine among extremely-drug-resistant strains of *Klebsiella pneumoniae*. *J Hosp Infect* 2012;81:15-9.
28. Shaw G. Breaking News: Deadly *Klebsiella Pneumoniae* Strain Resistant to Carbapenems. *Emergency Medicine News* 2013;35:1,38.
29. Decre D, Verdet C, Emirian A, Le Gourrierec T, Petit JC, Offenstadt G, Maury E, Brisse S, Arlet G. Emerging severe and fatal infections due to *Klebsiella pneumoniae* in two university hospitals in France. *J Clin Microbiol* 2011;49:3012-4.
30. Brooks SE, Walczak MA, Malcolm S, Hameed R. Intrinsic *Klebsiella pneumoniae* contamination of liquid germicidal hand soap containing chlorhexidine. *Infect Control Hosp Epidemiol* 2004;25:883-5.
31. Suller MTE, Russel AD. Antibiotic and biocide resistance in methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococcus. *J Hosp Infect* 1999;43:281-91

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Transparency Declaration

Gieljam J Roode (corresponding author) and Kurt-Wilhelm Bütow did not receive any payment or services from a third party for any aspect of the submitted work “Chlorhexidine: Effectivity on pathogenic micro-organisms in Cleft soft palate patients”. There are not any relevant conflicts of interest as well as not any patents planned, pending or issued relevant to this work. No other relationships or activities has influenced what is written in this work. We have nothing to disclose.

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GJ Roode collected and analysed the data and reports the findings.

K-W Butow assisted in collecting the data and reviewed the manuscript.