Disposable chlorine dioxide wipes for high-level disinfection in the ENT department: A systematic review

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ARTICLE INFO

Keywords:
Endoscopes
Laryngoscopes
Otolaryngology
Chlorine compounds
Disinfection
Nasopharyngoscopes
Chlorine dioxide
High-level disinfection (HLD)
Decontamination
Reprocessing

ABSTRACT

Background: Nasopharyngoscope reprocessing methods should be effective, rapid and reproducible with moderate cost. Tristel Trio Wipes system (TTWS) is a manual reprocessing method based on chlorine dioxide that has lately emerged in ENT department. This review aims to collect evidence on this system.
Methods: The PubMed, Web of Science and Cochrane Library databases were searched for all the studies on TTWS or one of its components. Data were grouped according to the study type.
Results: Ten articles were included in the review. TTWS ensured high-level disinfection in laboratory and clinical setting. Although the limitations of the manual systems, TTWS proved to be faster than automated endoscope reprocessing (AER) and safe for patients and health-care workers. TTWS represented cheaper system than AER or sheaths in low- and medium-volume centers.
Conclusion: TTWS could be a valid, safe and fast HLD method for nasopharyngoscopes, with reasonable costs for medium-low reprocessing volumes.

1. Introduction

Endoscopy represents the most frequent procedure performed by otolaryngologists, accounting for >1000 examinations per year per physician [1]. Flexible and rigid nasopharyngoscopes (NPs) are essential for completing ENT examinations in the outpatient clinic. Because NPs are used numerous times a day, the ideal reprocessing method should be brief enough to make them continuously available and ready for each consecutive examination, while guaranteeing a high level of disinfection, no damage to the devices and a reasonable cost.

According to the Spaulding classification [2] of medical equipment for decontamination, NPs are considered semi-critical instruments since they are used in contact with intact mucous membranes; additionally, this type of endoscope does not have an internal operative channel (non-lumened NPs). Semi-critical devices should at least undergo high level disinfection (HLD), which means the eradication of bacteria, viruses, mycobacteria, and most spores [3].

NPs present many differences from flexible endoscopes destined for respiratory and digestive tracts and for this reason the disinfection guidelines developed for those instruments are not suitable for NPs, and few guidelines have been written specifically.

In a recent review, Cavaliere et al. [4] reports on traditional and emerging NP reprocessing methods, summarizing three available: manual HLD, automated endoscope reprocessing (AER), and disposable sheaths. The two traditional methods are manual immersion and AER, which are most commonly performed with glutaraldehyde. The main disadvantages of these methods are the disinfection times required for each cycle, the costs, and the space needed for the equipment. One emerging reprocessing method is the use of disposable wipes, the Tristel Trio Wipes System (TTWS; Tristel plc, Cambridgeshire, UK) [5]. This type of HLD is based on a chlorine dioxide (ClO_2) manual wipe system that has been recently gaining popularity in clinical practice [6].

Currently, ENT guidelines specifically focused on NP reprocessing are lacking and the available methods are heterogeneous and not standardized. Moreover, most of the existing recommendations generally presume that disinfection takes place in a dedicated HLD area

Abbreviations: NPs, nasopharyngoscopes; HLD, high level disinfection; AER, automated endoscope reprocessing; TTWS, Tristel Trio Wipes System; ClO_2, Chlorine dioxide

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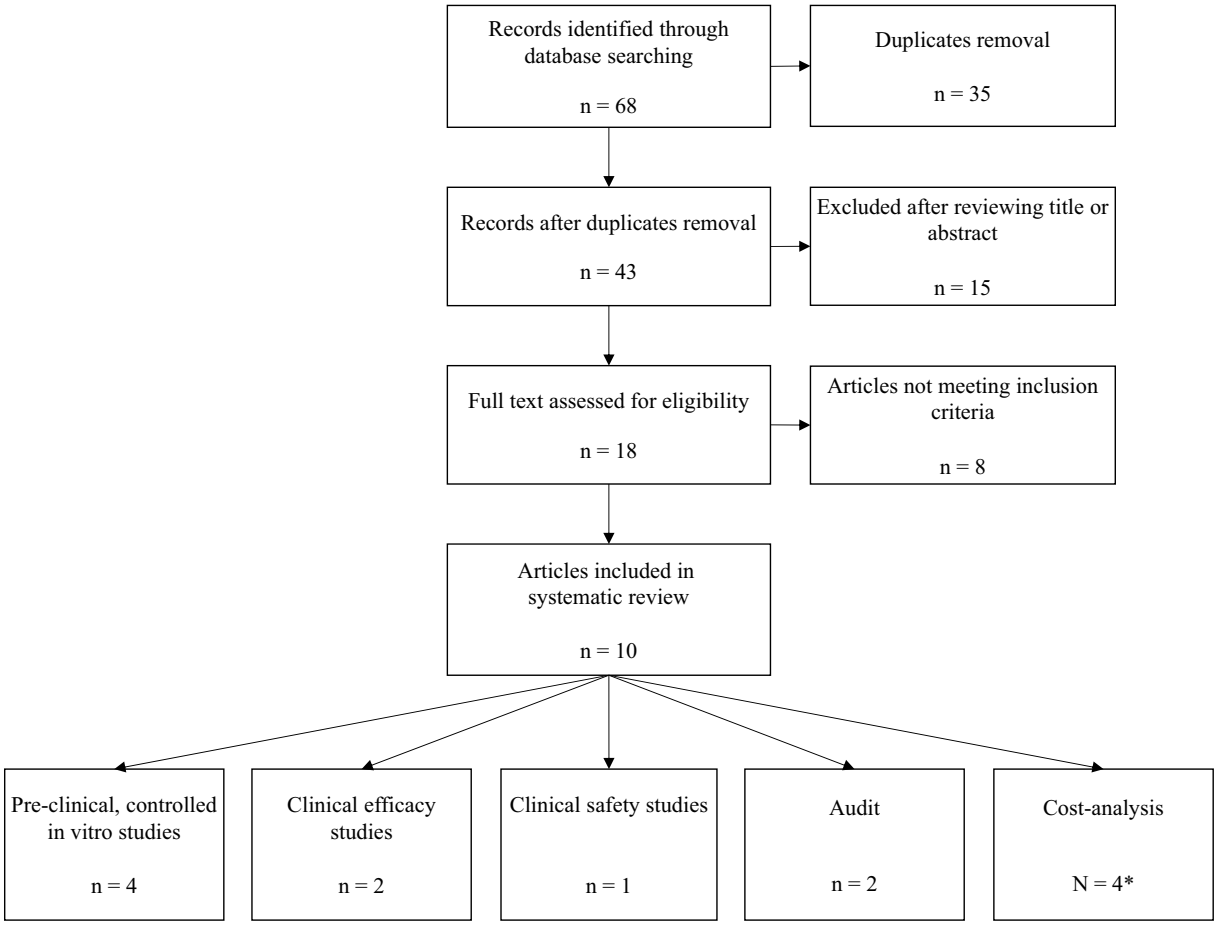

Fig. 1. Flow-chart of eligible and excluded studies, and type of studies included. *(of which 1 included in a pre-clinical study, 1 in a clinical efficacy study, 1 in an audit).

separate from patient space, and advocate the use of AER rather than manual methods to minimize the risk of error.

The introduction of an emergent innovative method such as the use of disposable wipes raises the need to examine the true potential of this system. The purpose of this systematic review was therefore to collect evidence on the effectiveness, safety, time of use and of TTWS, with a view to helping ENT department choose the most appropriate technique for their specific requirements.

2. Materials and methods

The PubMed, Web of Science and Cochrane Library databases were searched from database inception to May 1st 2019 using the search terms: 'chlorine dioxide' or 'Tristel Trio', plus 'endoscope', 'nasendoscope', 'fiberoptic', 'flexible', 'laryngoscope', 'otorhinolaryngology', 'otolaryngology' or 'wipes'. The extended query is reported in the appendix.

Three independent reviewers screened the identified articles for relevance to the topic, and discrepancies were resolved by consensus. Relevant articles were obtained and reviewed in full, and the reference lists from these sources were also screened for additional publications.

The inclusion criteria were: English-language original clinical and pre-clinical studies, case series, case reports, audit and cost analyses reporting on the TTWS or one of its components or on ClO_2 in the form of Tristel (1100 ppm av. ClO_2) for ENT device reprocessing. We excluded papers concerning non-ENT fields, papers not including TTWS or a TTWS component among the reconditioning methods, letters to the editor, papers omitting materials and methods or data.

3. Results

Sixty-eight articles were identified, among which 10 articles were finally included in the review. The diagram in Fig. 1 describes study selection and classification according to type, while Table 1 lists the main features of the articles included in the review.

Pre-clinical studies are summarized in Table 2, which reports the microbiological test used and the microorganisms tested, the time to reach bactericidal or sporicidal disinfection, and the other disinfectants or methods compared [7–10]. Further details of the two studies comparing TTWS to disinfectants cited by the international guidelines [11] are reported in Table 3 [7,10].

Clinical studies report that TTWS achieves HLD according to the Spaulding criteria, with a greater efficacy when compared to peracetic acid and orthophthalaldeyde [12,13].

The only safety study present in the literature reports that TTWS respects the occupational exposure limits for chlorine dioxide [14].

Cost-analyses are summarized in Table 4 [9,13,15,16]. Costs are reported in local currency at the date of original publication and in American dollars, converted on 10th July 2019, not accounting for price and currency fluctuations over time. Two audits were found that assessed the use of TTWS as a common reprocessing method in clinical practice [6,15].

In the selected studies, no evidence was found for inadequate endoscope reprocessing or disease transmission associated with TTWS use.

Table 1
Summary of included studies.

Study	Country of origin	Study type	Aim of the study	Compared disinfectants or reprocessing methods	Tested micro organisms	Materials and methods	Main outcome
Griffiths et al, 1999[7]	United Kingdom	Pre-clinical study	To assess time to reach bactericidal or sporicidal disinfection of TTWS and other disinfectants	TTWS Nu-Cidex ® (peracetic acid) Sanichlor ® (NaDCC) Industrial methylated spirits Gigasept ® (succine-dialdehyde-formaldehyde mix) Virkon ® (peroxygen compound) Asep ® (alkaline glutaraldehyde)	M. chelonae M. cheonae (Epping machine isolate) M. fortuitum *M. avium* intracell. M. tubercolosis	A quantitative suspension test carried out under both clean and dirty conditions was used to assess the activity of various instrument and environmental disinfectants against several species of Mycobacteria	TTWS requires 1 min to reach disinfection, an equal or inferior time when compared to other disinfectants
Hernandez et al, 2008[8]	Spain	Pre-clinical study	To assess mycobactericidal activity of TTWS and contribution of manual wiping to disinfection on a contaminated nasopharyngoscope (NP)	TTWS	M. avium	Mycobactericidal activity of TTWS was assessed by a modified European Standard prEN 14,563 carrier test under clean conditions against M. avium.	TTWS reaches mycobactericidal activity in 30s with wiping, in 60s without wiping
Phua et al, 2012[9]	United Kingdom	Pre-clinical study and cost-analysis	To compare the efficacy and cost-effectiveness of chlorine dioxide wipes versus automated washer on a contaminated NP.	TTWS Automated endoscope reprocessor (AER) loaded with a chlorine dioxide solution	*S. epidermidis*	A microbiological swab sample was obtained from the tip of the NP; the tip was then dipped into an agar culture of S.epidermidis for 2 min, then reprocessed by one of the two methods, and another swab was sampled from the tip. This procedure was repeated 50 times for both the TTWS and AER group.	Endoscopes reprocessed with chlorine dioxide wipes showed significantly lower S. epidermidis growth than AER. Based on a projected 10-year cost calculation in a high volume center, the automated washer was cheaper.
Henoun Loukili et al, 2017[10]	France	Pre-clinical study	To assess the effectiveness of TTWS versus soaking procedure on a contaminated NP.	TTWS Soaking procedure with Peracetic Acid (Anioxyde1000® AniosymeDD1®)	*E. coli* E. hirae P.aeruginosa *S. aureus* *B. subtilis* spores	A NP was contaminated with four strains of bacteria and Bacillus subtilis spores. After disinfection either with TTWS or with the soaking procedure (PA), the reduction of the initial contamination was determined.	TTWS reaches bactericidal and sporicidal activity after 30s and 2 m of contact time, respectively. Soaking procedure with PA reaches bactericidal activity after 10 min of contact time, while does not achieve sporicidal efficacy.
Tzanidakis et al, 2012[12]	United Kingdom	Clinical study	To evaluate the 'in use' efficacy of TTWS in decontaminating NP and to identify any significant contamination between cleaning and usage	TTWS	–	A total of 31 cleaning episodes were performed. One swab from the tip and one from the handle were taken from the NP after the cleaning and before application on the patient. The microbiology unit evaluated all swabs for bacterial, fungal and mycobacterial growth.	None of the swabs taken from the tips of the NP developed any growth, showing 100% efficacy in cleaning the NP of bacteria, fungi and mycobacteria. 3/31 swabs taken from the handle developed staphylococcal growth.
Hitchcock et al, 2016[13]	United Kingdom	Clinical study and cost-analysis	To compare the microbiological efficacy, turnaround time, cost, convenience, and patient and user tolerance of TTWS, PeraSafe® solution and Cidex® OPA solution for the high-level disinfection of NP.	TTWS Soaking procedure with PeraSafe® (peracetic acid solution) AER using Cidex® OPA (ortho-phthalaldehyde solution)	–	NP used in routine clinical encounters were disinfected with one of the three disinfectant methods. Surveillance cultures were taken before and after each disinfection process. Data relating to each of the study parameters were recorded.	Positive bacterial cultures were discovered on NP disinfected with PeraSafe and Cidex OPA. TTWS have no capital outlay cost, the lowest running cost, the greatest convenience and the fastest turnaround time. PeraSafe had a faster turnaround time than Cidex OPA, and lower running costs.
Chang et al, 2018[14]	Singapore	Safety study	To assess the potential exposure of healthcare workers (HCWs) to airborne chlorine dioxide during NP disinfection with TTWS.	TTWS	–	Personal and area samples were collected and analyzed by ion-chromatograph.	The exposure of HCWs to chlorine dioxide during high-level disinfection of NP were deemed insignificant.
Street et al, 2006[15]	United Kingdom	Clinical audit and cost-analysis	To assess the cost-effectiveness and time expenditure of using TTWS as reprocessing method in a medium volume center	TTWS Disposable sheats AER	–	Clinical audit of the NP disinfections over a 6-month period. Cost and time per procedure were recorded, damage to NP were considered.	In a medium volume center, TTWS would cost £863 and require 2 min per procedure; disposable sheats would cost £4008 per month and require no time for reprocessing; AER would cost £7042 per month and require 20 min per procedure. TTWS is more cost- and time-saving than sheats and AER.

(*continued on next page*)

Table 1 (*continued*)

Study	Country of origin	Study type	Aim of the study	Compared disinfectants or reprocessing methods	Tested micro organisms	Materials and methods	Main outcome
Sowerby & Rudmik, 2018[16]	Canada	Cost-analysis	Given equivalent effectiveness outcomes, a cost analysis of four NP reprocessing techniques was performed.	TTWS Steris System 1® (AER using peracetic acid) Revital-Ox® (hydrogen peroxide manual soak) Cidex OPA® (ortho-phthalaldeyde AER)	–	The base-case scenario used an annual volume of 4153 reprocessing events in a tertiary care setting, and a scenario analysis assessed the impact of volume and capital expense.	The cost per reprocessing event for the Steris AER, Cidex OPA, Revital-Ox and TTWS were $20.58, $14.20, $9.57, and $13.14, respectively. TTWS was the least expensive method in practices with low reprocessing volumes, whereas the Revital-Ox system was least expensive at higher volumes
Javed et al, 2014[6]	United Kingdom	National audit	To investigate the current UK practice for decontaminating flexible NP.	–	–	A questionnaire about decontaminating flexible NP was answered by121 outpatient ENT departments in UK, including teaching hospitals, district general hospitals and private hospitals.	Decontamination with TTWS was the most favoured method, used in 58% of the hospitals. AER were used in 34% of the clinics. Only 7% used flexible sheaths. Many departments do not use a separate protocol for high-risk patients.

4. Discussion

Nasopharyngoscopes are commonly used instruments in daily ENT practice and they must be reconditioned after each procedure. To comply with the hygienic requirements of an outpatient clinic, the perfect reprocessing system should be effective, fast and safe for professionals and patients, as well as having reasonable costs; the process should also follow a standardized protocol that staff can reproduce to reduce the risk of NP damage.

TTWS is an HLD procedure that uses ClO_2, whose efficacy in terms of decontamination has been well known since the 60s [17,18]. Over the years, in-vitro and pre-clinical studies reported equal or greater bactericidal, mycobactericidal and sporicidal activities than traditional disinfectants in terms of viable count reduction and time needed to reach the HLD standard [7–10].

Due to its efficacy, ClO_2 has appeared for >10 years in the international HLD guidelines for gastrointestinal endoscopes [19]. TTWS was subsequently produced purposely for flexible and rigid NPs, and it emerged as a routine reprocessing method in ENT after 2006, when Street et al. assessed its application in an audit, reporting that TTSW is more time- and cost-saving than AER and disposable sheaths [15].

Supported by these outcomes, the UK guidelines included TTWS as a common HLD method for NPs in 2010 [20]. Gradually, other public and health authorities introduced TTWS [4,20,21] but to date the evidence has been insufficient to change the international guidelines for NP reprocessing in the ENT department.

We screened the available literature to find results regarding the efficacy, safety, time of use and costs of TTWS and noted that it is in routine use in Oceania and Europe, with most of the included studies coming from European centers.

TTWS consists of a three-step reconditioning procedure corresponding to three different wipes that should be used consecutively and following the instructions provided with the kit. In the cleaning phase, the NP is cleaned with the first wipe saturated with a solution of surfactant, humectants and enzymes. In the second step, the disinfecting phase, the wipe is prepared by applying a double dose of the activator foam onto the wipe and waiting 15 s to allow the wipe components to mix with the activator and produce ClO_2. The activated disinfecting wipe is then mechanically rubbed on the surface of the NP for 30 s. Finally, the NP is rinsed with the third sterile wipe to remove the remaining ClO_2. A specific label to be stored in a designated archive allows identification of each procedure. The wipes are disposable and incorporate their own tracking system, enabling compliance with the hospital protocols on procedure tracking. No drying is required, so the endoscope is expected to be ready in about 2–3 min from the beginning of the sequence [5].

Phua et al. demonstrated the reliability of this manual system by comparing swabs collected from NPs decontaminated using either ClO_2 wipes or an AER washer loaded with a ClO_2 solution. Post-decontamination swabs presented a significantly greater growth of bacteria in the AER group (14/50 vs 1/50, $p < 0.0001$) [9]. It has also been reported that the mechanical wiping action increases cleansing efficacy if compared both to AER and to cleaning without rubbing [8,9]. ClO_2 proved to be effective also in biofilm removal [22]: this feature makes ClO_2 ideal for ENT clinics since biofilms are mostly present in chronic rhinosinusitis [23]. These findings are consistent with the clinical evidence, where TTWS proved to meet HLD standards and to be more effective than peracetic acid and orthophthalaldehyde [12,13]. Tzanidakis et al. tested the swabs taken from NP tips and handles immediately after TTWS reprocessing and just before use on patients. They found only three positive swabs taken from the NP handle just before use, highlighting that contamination occurring between cleaning and use is closely related to instrument storage and transportation rather than to the HLD method adopted [12].

Moreover, the authors reported that in 2006 the UK Health and Safety Executive classified all disinfectants according to their hazard

Table 2
Pre-clinical studies.

Source, year	Test[a]	Evaluation of wiping effect	Definition of bactericidal, mycobactericidal or sporicidal activity	Tested organisms	Time to reach disinfection	Other disinfectants or reconditioning procedures compared
Griffiths et al, 1999[7]	Quantitative suspension test in clean and dirty conditions	No	Log_{10} reduction of viable counts > 5 for mycobacteria and >4 for spores		<1 m	Nu-Cidex (0.35% v/v peracetic acid)
					<1 m	Sanichlor (NaDCC) 1000 ppm 10,000 ppm
				M. chelonae		
						Industrial methylated spirits IMS74OP
				M. chelonae (Epping machine isolate)	<1 m	Gigasept (succine-dialdehyde-formaldehyde mixture)
					<1 m	Virkon (peroxygen compound)
				M. fortuitum		
						Asep (alkaline glutaraldehyde)
					<1 m	
				M. avium intracell.		
				M. tubercolosis		
Hernández et al, 2008[8]	Quantitative carrier test (modified standard prEN 14,536)	Yes	Log_4 reduction of the initial inoculum	M. avium	30s (w) 60s	–
Phua et al, 2012[9]	Sequential cohort carrier test	No	No bacterial growth from post-disinfection swab	S. epidermidis	30s (w)	AER loaded with Tristel chlorine dioxide solution
Henoun Loukili et al, 2017[10]	Quantitative carrier test	No	Log_{10} reduction of viable counts > 5 for mycobacteria and >4 for spores	E. coli E. hirae P. aeruginosa S. aureus B. subtilis spores	<30 s (w) <30 s (w) <30 s (w) <30 s (w) 2 m (w)	Soaking disinfection with Peracetic Acid (Anioxyde1000® AniosymeDD1®)

(w) = disinfectant applied via wiping.
[a] Standard tests are reported in blankets.

potential, and the group associated with the lowest hazard included those that are chlorine- or peroxygen-based. The quantity of ClO_2 present in TTWS is, however, much lower than the limits fixed for exposed personnel [24]. Recently, a safety study conducted by Chang et al. confirmed that exposure to ClO_2 is far below the occupational limits during the entire reprocessing procedure and recorded no complaints from either personnel or patients. The authors specified that the wipes are saturated with a neutral pH and this might justify the absence of skin side effects [14]. Additionally, TTWS has shown to be the least odorous and most user-friendly method when compared to reprocessing systems based on peracetic acid and orthophtalaldehyde [13].

Considering time issues, the studies investigating disinfection time agree that TTWS is the fastest NP reprocessing system, requiring <3 min to complete the cycle [7,9,10,13,15]. This peculiarity makes TTWS ideal for outpatient activity, where NP reprocessing should be prompt to meet the needs of a fast patient turnover.

Among the features justifying the great diffusion of TTWS, cost-effectiveness plays a major role. The available cost-analyses conclude that in low- and medium-volume centers TTWS appears to be more economical than AER or sheaths [9,13,15,16]. Although the cost-minimization analysis performed by Sowerby et al. was conducted in North America, the authors state that the system has not yet received FDA approval, probably due to a need for greater recognition of the difference between NPs and other flexible endoscopes, such as those used for gastrointestinal and bronchial tracts [16]. However, all reprocessing methods included in this cost-analysis proved equivalent in terms of efficacy for decontamination, so that great importance was placed on both staff training and technique. With regard to staff training, manual procedures introduce the potential bias of interindividual variability in execution and, to overcome this potential limit, the manufacturer supplies the kit together with a simple, clear and concise brochure devised to briefly train the staff. The cost-minimization analysis concludes that, in high-volume centers, a minimum reported number of 8400 endoscopies per year (168 examinations per week) allows amortization of the fixed costs of AER [9,16], while Revital-Ox (Steris Canada Inc., Mississauga, Canada) is more economical than TTWS for at least 6240 procedures per year [16]. These estimates also account for the working time spent to complete a reconditioning, for expenditure for repairs in the case of damage and for the minimum number of endoscopes needed to satisfy their turnover [16].

Finally, TTWS proved to be a useful method to deal with emergency needs when AER might take too long and to avoid the higher risk of damage in reprocessing with AER or disposable sheaths [9,13,16]. The manual system allows disinfection particularly of endoscopes used with narrow-band imaging or similar devices with electrical components. In fact, the potential heavy costs of restoration, together with the inability to carry out clinical activities due to NP unavailability, make TTWS valuable even in a high-volume institution devoted to this specific use. In this perspective, therefore, the fact that HDL is performed manually becomes an advantage instead of a potential limitation.

In conclusion, the variability in costs and practices for the HLD of NPs highlights the importance of national guidelines to drive policies, minimizing costs and maximizing efficiency. TTWS use can be recommended for clinics with low-to-medium NP turnover but could also prove useful to face emergencies in high-volume centers.

5. Conclusions

TTWS represents a valid HLD method for non-lumened NPs used in ENT departments. ClO_2 is effective and safe for patients and staff, allowing fast reprocessing of endoscopes. In terms of cost, TTWS may be a good alternative for medium-low reprocessing volumes or when a rapid turnaround is necessary in a high-volume institution.

Table 3
Time taken (minutes) to achieve a Log_{10} reduction > 5 (bacteria) and >4 (spores) by TTWS compared to other disinfectants. When disinfectants were not tested for a specific microorganism, cells were left blank.

Micro organisms	Tristel® 1100 ppm ClO^2	Anioxyde1000® AniosymeDD1® PA	Sanichlor® 1000 ppm NaDCC	Sanichlor® 10,000 ppm NaDCC	Asep® 2% v/v glutaraldehyde	70% v/v IMS 74	Virkon® 1% w/v H_2O_2	Virkon® 3% w/v H_2O_2	Gigasept® 10% v/v succinedialdehyde-formaldehyde	Nu-Cidex® 0.35% PA
E. coli	0,5 (w)	10								
E. hirae	0,5 (w)	10								
P. aeruginosa	0,5 (w)	10								
S. aureus	0,5 (w)	10								
B. subtilis spores	2 (w)	[a]								
M. chelonae NCTC946 (cc)	1		1	1	1	1	20	>60	10	1
M. chelonae NCTC946 (dc)	1		1	1	1	1	60	>60	10	1
M. chelonae Epping (cc)	1		4	1	>60	1	>60	>60	>60	4
M. chelonae Epping (dc)	1		60	1	>60	1	>60	>60	>60	4
M. fortuitum NCTC10394 (cc)	1		10	1	1	1	>60	>60	20	4
M. fortuitum NCTC10394 (dc)	1		10	1	1	1	>60	>60	10	4
M. tuberculosis (cc)	1		1	1	20	1	>60	>60	60	1
M. tuberculosis (dc)	1		4	1	10	1	>60	>60	20	4
M. avium intrac. (cc)	1		60	1	60	4	>60	>60	>60	4
M. avium intrac. (dc)	1		60	10	10	4	>60	>60	>60	4

PA = peracetic acid. NaDCC = sodium-dichloroisocyanurate. IMS = industrial methylated spirits.
cc = clean conditions. dc = dirty conditions, defined as a clean condition test suspension added with 10% donor horse serum containing 5 g/L proteins. (w) = disinfectant applied via wiping.
[a] PA Anioxyde1000® AniosymeDD1® did not reach a Log_{10} reduction > 4.

Table 4
Cost-analysis. HVC = high volume center. LVC = low volume center. MVC = medium volume center.

Source, year	Country	Endoscope reprocessing volume/year	Compared methods	Time taken for a reprocessing event (minutes)	Cost per reprocessing events (other expenses)	Costs in US dollars
Street et al, 2006[15]	United Kingdom	MVC: 3036	TTWS	2	£ 3,41	4,25
			Disposable sheats	0	£ 11	13,70
			AER			
				20	£ 145,336 (installation) £ 84,500 (annual maintenance)	181,055,96 105,267,99
Phua et al, 2012[9]	United Kingdom	HVC: 8400	TTWS	2,5 (2–3)	HVC: £3.60	4,48
			AER + chlorine dioxide	20	HVC: £0,90 £60,400 (installation) £4885 (biannual servicing, periodic testing)	1,12 75,244,81 6085,61
Hitchcock et al, 2016[13]	New Zealand	–	TTWS	2,7 (1,6–4,8)	NZ$ 9,50 per cycle	6,27
			PeraSafe system (peracetic acid)	14,6 (13,2–16,3)	NZ$ 9,60 per cycle NZ$ 227 (cylinder, once)	6,33 149,72
			Cidex OPA solution + Medivators	27,4 (25,2–36,3)	NZ$ 15,88 per cycle NZ$ 76,106,25 (AER machine, once)	10,47 50,195,88
Sowerby & Rudmik, 2018[16]	Canada	HVC: 6240	TTWS	–	HVC: CaD $13,14 LVC: CaD $13,14	10,01 10,01
		LVC: 1040	Steris System 1 (peracetic acid)	–	HVC: CaD $19,48 LVC: CaD $30,47	14,84 23,21
			Revital-Ox	–	HVC: CaD $11,29 LVC: CaD $13,27	8,60 10,11
			Cidex OPA	–	HVC: CaD $15,03 LVC: CaD $11,29	11,45 8,60

Authorship

- Margherita Tofanelli: Conceptualization, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision
- Vincenzo Capriotti: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization
- Carmelo Saraniti: Data Curation, Writing - Review & Editing
- Alberto Vito Marcuzzo: Data Curation, Writing - Review & Editing
- Paolo Boscolo-Rizzo: Data Curation, Writing - Review & Editing
- Giancarlo Tirelli: Conceptualization, Writing - Review & Editing, Visualization, Supervision

Acknowledgements

The authors wish to thank Itala Mary Ann Brancaleone, MA, RSA Dip TEFLA, teacher of Medical English at the University of Trieste, for her support in editing the manuscript.

Funding

Tristel Italia SRL, contributed to the Department of Medicine Surgery and Health of the University of Trieste. This did not fund the research and the authors have no conflict of interest but are part of the Department.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

Appendix A

Extended query: (“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields]) AND (“endoscopes”[MeSH Terms] OR “endoscopes”[All Fields] OR “endoscope”[All Fields])

(“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields]) AND nasendoscope[All Fields]; (“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields]) AND fiberoptic[All Fields]; (“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields]) AND flexible[All Fields]; (“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields]) AND (“laryngoscopes”[MeSH Terms] OR “laryngoscopes”[All Fields] OR “laryngoscope”[All Fields]); (“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields]) AND (“otolaryngology”[MeSH Terms] OR “otolaryngology”[All Fields] OR “otorhinolaryngology”[All Fields]); (“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields] OR “tristel”[All Fields]) AND (“otolaryngology”[MeSH Terms] OR “otolaryngology”[All Fields]); (“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields] OR “tristel”[All Fields]) AND (“otolaryngology”[MeSH Terms] OR “otolaryngology”[All Fields] OR “otorhinolaryngology”[All Fields]); (“chlorine dioxide”[Supplementary Concept] OR “chlorine dioxide”[All Fields] OR “tristel”[All Fields]) AND wipes[All Fields].

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