Appendices

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Appendix 1 – Search strategies

Database: **Embase** <1974 to 2021 February 15>
Search Strategy:
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1 Endoscopes/ (14688)
2 Endoscopes, Gastrointestinal/ (1375)
3 Endoscopy/ (108311)
4 Endoscopy, Gastrointestinal/ (32860)
5 Endoscopy, Digestive System/ (4707)
6 Bronchoscopy/ (50884)
7 Cholangipancreatography.mp. or *endoscopic retrograde cholangiopancreatography/ (12162)
8 Endoscop*.tw. (342141)
9 Cystoscopy/ (22886)
10 rinsing.mp. (6436)
11 final rinse.mp. (197)
12 water supply/ or water quality/ or water contamination/ or supply water.mp. (102384)
13 final rinse.mp. (197)
14 hospital water.mp. (489)
15 medical device contamination/ or Automated endoscope reprocessor.mp. (1035)
16 endoscope reprocessing.mp. (253)
17 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 (455417)
18 10 or 11 or 12 or 13 or 14 or 15 or 16 (110232)
19 17 and 18 (687)
20 limit 19 to yr="2000 -Current" (604)

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Database: Ovid **Emcare** <1995 to 2021 Week 05>
Search Strategy:
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1 Endoscopes/ (3875)
2 Endoscopes, Gastrointestinal/ (325)
3 Endoscopy/ (19390)
4 Endoscopy, Gastrointestinal/ (9107)
5 Endoscopy, Digestive System/ (862)
6 Bronchoscopy/ (11729)
7 Cholangipancreatography.mp. or *endoscopic retrograde cholangiopancreatography/ (2361)
8 Endoscop*.tw. (57207)
9 Cystoscopy/ (3454)
10 rinsing.mp. (1591)
11 final rinse.mp. (151)
12 water supply/ or water quality/ or water contamination/ or supply water.mp. (10024)
13 final rinse.mp. (151)
14 hospital water.mp. (135)
15 medical device contamination/ or Automated endoscope reprocessor.mp. (298)
16 endoscope reprocessing.mp. (126)
17 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 (82519)
18 10 or 11 or 12 or 13 or 14 or 15 or 16 (12124)
19 17 and 18 (267)
20 limit 19 to yr="2000 -Current" (243)

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Database: Ovid **MEDLINE**(R) ALL <1946 to February 15, 2021>
Search Strategy:
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1 Endoscopes/ (6848)
2 Endoscopes, Gastrointestinal/ (1705)
3 Endoscopy/ (53348)
4 Endoscopy, Gastrointestinal/ (19045)
5 Endoscopy, Digestive System/ (9240)
6 Bronchoscopy/ (25569)
7 Cholangipancreatography.mp. or *endoscopic retrograde cholangiopancreatography/ (7239)
8 Endoscop*.tw. (214587)
9 Cystoscopy/ (7687)
10 rinsing.mp. (5433)
11 final rinse.mp. (202)
12 water supply/ or water quality/ or water contamination/ or supply water.mp. (38901)
13 final rinse.mp. (202)
14 hospital water.mp. (390)
15 medical device contamination/ or Automated endoscope reprocessor.mp. (22)
16 endoscope reprocessing.mp. (191)
17 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 (272498)
18 10 or 11 or 12 or 13 or 14 or 15 or 16 (44861)
19 17 and 18 (353)
20 limit 19 to yr="2000 -Current" (290)

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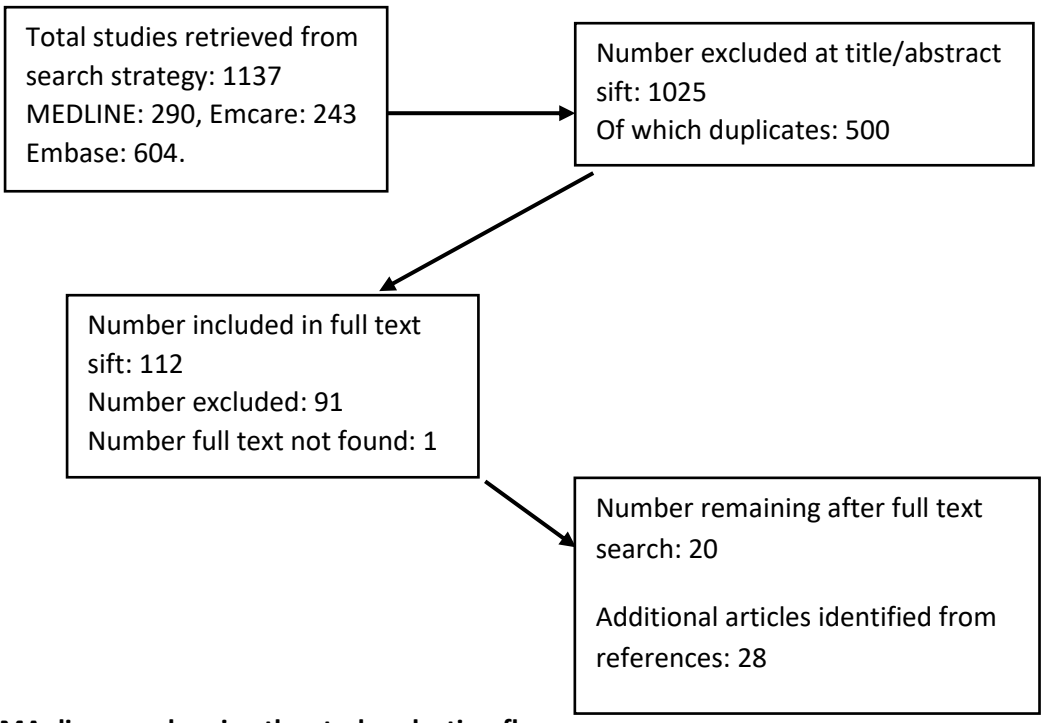
Appendix 2 – Results of study selection

a. Study selection



PRISMA diagram showing the study selection flow

b. Excluded studies table

Citation	Reason for exclusion
(2013). Reprocessing of endoscopic accessories and valves. Gastroenterology nursing : the official journal of the Society of Gastroenterology Nurses and Associates 36(4): 291-292.	not primary data
(2013). Standards of infection control in reprocessing of flexible gastrointestinal endoscopes. Gastroenterology nursing : the official journal of the Society of Gastroenterology Nurses and Associates 36(4): 293-303.	not primary data
Aabakken, L. (2016). Endoscope reprocessing - Painted into a corner? Endoscopy 48(7): 605-606.	not primary data
Adams, J. and K. Baker (2010). Recommended cleaning and processing of flexible otolaryngology endoscopes. ORL-head and neck nursing : official journal of the Society of Otorhinolaryngology and Head-Neck Nurses 28(2): 8-12.	not available
Alfa M.J. DeGagne P. Olson N. et al. EVOTECH endoscope cleaner and reprocessor (ECR) simulated-use and clinical-use evaluation of cleaning efficacy. BMC Infect Dis. 2010; 10: 200	evaluation of disinfection process, no data on rinse water
Alfa M.J., Fatima I., Olson N. The adenosine triphosphate test is a rapid and reliable audit tool to assess manual cleaning adequacy of flexible endoscope channels. Am J Infect Control, 2013; 41(3):249-253	detection method, no mention of rinse water
Alfa M.J., Fatima I., Olson N. Validation of adenosine triphosphate to audit manual cleaning of flexible endoscope channels. Am J Infect Control, 2013; 41 (3):245-248	detection method, no mention of rinse water
Alfa M.J., Olson N., DeGagne P. Automated washing with the Reliance Endoscope Processing System and its equivalence to optimal manual cleaning. Am J Infect Control. 2006; 34(9):561-570	evaluation of disinfection process, no data on rinse water
Alfa MJ, Olson N, Degagne P et al. Development and validation of rapid use scope test strips to determine the efficacy of manual cleaning for flexible endoscope channels. Am J Infect Control 2012; 40: 860–865	detection method, no mention of rinse water
Alfa MJ, Olson N, DeGagne P, Jackson M. A survey of reprocessing methods, residual viable bioburden, and soil levels in patient-ready endoscopic retrograde choliangiopanc reatography duodenoscopes used in Canadian centers. Infect Control Hosp Epidemiol 2002; 23: 198-206	survey of practice, no mention of rinse water
Alfa MJ, Olson N, Murray BL. 2014. Comparison of clinically relevant benchmarks and channel sampling methods used to assess manual cleaning compliance for flexible gastrointestinal endoscopes. Am J Infect Control 42:e1– e5.	detection method, no mention of rinse water
Alfa, M. J. (2020). Quality Systems Approach for Endoscope Reprocessing: You Don't Know What You Don't Know! Gastrointestinal Endoscopy Clinics of North America 30(4): 693-709.	not primary data
Alfa, M. J., et al. (2012). Establishing a clinically relevant bioburden benchmark: A quality indicator for adequate reprocessing and storage of flexible gastrointestinal endoscopes. American Journal of Infection Control 40(3): 233-236.	detection method, no mention of rinse water
Alfa, M.J. (2013). Monitoring and improving the effectiveness of cleaning medical and surgical devices. American Journal of Infection Control, 41(5 suppl), S56-S59.	not primary data

Alfa, M.J. (2016). Current issues result in a paradigm shift in reprocessing medical and surgical instruments. American Journal of Infection Control, 44, e41-45.	not primary data
Alipour N, Karagoz A, Taner A, et al. Outbreak of Hospital Infection from Biofilm-embedded Pan Drug-resistant Pseudomonas aeruginosa Due to a Contaminated Bronchoscope. J Prev Med. 2017;2(1):1-9.	outbreak, no mention of rinse water
Almario CV, May FP, Shaheen NJ, et al. Cost Utility of Competing Strategies to Prevent Endoscopic Transmission of Carbapenem-Resistant Enterobacteriaceae. Am J Gastroenterol 2015; 110(12): 1666-74.	not primary data
Alrabaa SF, Nguyen P, Sanderson R et al. Early identification and control of carbapenemase-producing *Klebsiella pneumoniae,* originating from contaminated endoscopic equipment. Am J Infect Control 2013; 41: 562–564	outbreak, no mention of rinse water
Alvarado CJ, Anderson AG, Maki DG. Microbiologic assessment of disposable sterile endoscopic sheaths to replace high-level disinfection in reprocessing: a prospective clinical trial with nasopharygoscopes. Am J Infect Control 2009; 37: 408-413	assessing the use of sheaths
Alvarado, C. (2000). Reconciliation of FDA and societal guidelines for endoscope reprocessing. Gastrointestinal Endoscopy Clinics of North America 10(2): 275-281.	not primary data
American Society for Gastrointestinal Endoscopy. Transmission of CRE bacteria through endoscopic retrograde cholangiopancreaticography (ERCP) Interim Guid 2015	not primary data
Appel, T., et al. (2015). Recommendations by the Quality Task Group (89): Programme Controls Part 2: Endoscope washer-disinfectors with chemothermal disinfection. Zentralsterilisation - Central Service 23(1): 67-72.	not primary data
Armellino, D. (2016). Infection prevention and control: Ongoing discovery of high-level disinfection of endoscope practices and the use of performance improvement methodologies in to improve processes. The Joint Commission Journal on Quality and Patient Safety, 42(6), 262-264.	not primary data
Astagneau P, Desplaces N, Vincent V, et al. *Mycobacterium* xenopispinal infections after discovertebral surgery: investigation and screening of a large outbreak. Lancet 2001; 358:747–51	not endoscopes
Aumeran C, Poincloux L, Souweine B et al. Multidrug-resistant *Klebsiella pneumoniae* outbreak after endoscopic retrograde cholangiopancreatography. Endoscopy 2010; 42: 895 – 899	outbreak, no mention of rinse water
Aumeran C, Thibert E, Chapelle FA, Hennequin C, Lesens O, Traoré O: Assessment on experimental bacterial biofilms and in clinical practice of the efficacy of sampling solutions for microbiological testing of endoscopes. J Clin Microbiol 2012, 50(3):938–942.	detection method, no mention of rinse water
Axon AT, Beilenhoff U, Bramble MG et al. Variant Creutzfeldt–Jakob disease (vCJD) and gastrointestinal endoscopy. Endoscopy 2001; 33: 1070-1080	not primary data
Ayliffe, G. and G. Minimal Access Therapy Decontamination Working (2000). Decontamination of minimally invasive surgical endoscopes and accessories. The Journal of hospital infection 45(4): 263-277.	not primary data
Azizi J, Basile RJ. Doubt and proof: the need to verify the cleaning process. Biomed Instrum Technol 2012;(46):49-54.	not primary data
Babb, J., et al. (2000). Decontamination of minimally invasive surgical endoscopes and accessories. Journal of Hospital Infection 45(4): 263-277.	duplicate, see Ayliffe, 2000
Babcock HM, Carroll C, Matava M, et al. Surgical site infections after arthroscopy: outbreak investigation and case control study. Arthroscopy 2003;19:172–81	not endoscopes
Bader L, Blumenstock G, Birkner B. HYGEA (Hygiene in der Gastroenterologie Endoskop Aufbereitung): Studie zur Qualität der Aufbereitung von flexiblen	not in English

Endoskopen in Klinik und Praxis [HYGEA (Hygiene in gastroenterology ± endoscope reprocessing): Study on quality of re− processing flexible endoscopes in hospitals and in the practice setting]. Z Gastroenterol 2002; 40: 157±170	
Ball, K. (2000). Reprocessing anesthesia instruments and devices. CRNA: Clinical Forum for Nurse Anesthetists 11(1): 20-33.	not endoscopes
Banerjee S. Nelson D.B. Dominitz J.A. ASGE Standards of Practice Committee Reprocessing failure. Gastrointest Endosc. 2007; 66: 869-871	not primary data
Batailler P, Saviuc P, Picot-Gueraud R, Bosson JL, Mallaret MR. Usefulness of adenosine triphosphate bioluminescence assay (ATPmetry) for monitoring the reprocessing of endoscopes. Infect Control Hosp Epidemiol 2015; 36: 1437- 43.	detection method, no mention of rinse water
Becheur H, Harzic M, Colardelle P et al. Hepatitis C virus contamination of endoscopes and biopsy forceps. Gastroenterol. Clin. Biol. 2000; 24: 906–10.	not in English
Beilenhoff, U. (2020). Europe-wide curriculum for endoscope reprocessing. Gastrointestinal Nursing 18: S4-S5.	not primary data
Beilenhoff, U., et al. (2007). ESGE-ESGENA guideline for quality assurance in reprocessing: Microbiological surveillance testing in endoscopy. Endoscopy 39(2): 175-181.	not primary data
Beilenhoff, U., et al. (2017). ESGE-ESGENA technical specification for process validation and routine testing of endoscope reprocessing in washer-disinfectors according to en ISO 15883, parts 1, 4, and ISO/TS 15883-5. Endoscopy 49(12): 1262-1274.	not primary data
Beilenhoff, U., et al. (2017). Prevention of multidrug-resistant infections from contaminated duodenoscopes: Position Statement of the European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastroenterology Nurses and Associates (ESGENA). Endoscopy 49(11): 1098-1106.	not primary data
Bettiker RL, Axelrod PI, Fekete T, et al. Delayed recognition of a pseudo-outbreak of *Mycobacterium terrae.* Am J Infect Control 2006;34:343-7.	not endoscopy
Bourdon, L. (2015). Addressing the complexities of flexible endoscope reprocessing. AORN journal 101(3): P7-P9.	not primary data
Brandabur JJ Leggett JE Wang L et al. Surveillance of guideline practices for duodenoscope and linear echoendoscope reprocessing in a large healthcare system. Gastrointest Endosc. 2016; 84 (99.e3): 392	not available
Bruguera M, Saiz JC, Franco S, Giménez-Barcons M, Sánchez- Tapias JM, Fabregas S, Vega R, Camps N, Domínguez A, Salleras L. Outbreak of nosocomial hepatitis C virus infection resolved by genetic analysis of HCV RNA. J Clin Microbiol 2002; 40: 4363-4366	not endoscopes
Brullet E, Ramirez-Armengol JA, Campo R; Board of the Spanish Association for Digestive Endoscopy. Cleaning and disinfection practices in digestive endoscopy in spain: results of a national survey. Endoscopy 2001;33:864-868	survey of practice, no mention of rinse water
Calderwood	not primary data
Carbonne A Thiolet JM Fournier S et al. Control of a multi-hospital outbreak of KPC-producing Klebsiella pneumonia type 2 in France, September to October, 2009. Eurosurveillance. 2010; 15: 19734	outbreak, no mention of rinse water
Catalone B, Koos G. Reprocessing flexible endoscopes. Avoiding Reprocessing Errors Critical for Infection Prevention and Control. Manag Infect Control 2005: 74-80.	not primary data
Cattoir L, Vanzieleghem T, Florin L, et al. Surveillance of Endoscopes: Comparison of Different Sampling Techniques. Infect Control Hosp Epidemiol 2017; 38(9): 1062-9.	not AWD

Cetre JC, Salord H, Vanhems P. Outbreaks of infection associated with bronchoscopes. N Engl J Med. 2003;348:2039–40	not primary data
Chapman CG Siddiqui UD Manzano M et al. Risk of infection transmission in curvilinear array echoendoscopes: results of a prospective reprocessing and culture registry. Gastrointest Endosc. 2016; 85: 390-397	not primary data
Chapman, W. (2019). Endoscope decontamination: Making the guidance work in practice. Gastrointestinal Nursing 17(6): 28-37.	not primary data
Cheung, D. Y., et al. (2020). Multidisciplinary and Multisociety Practice Guideline on Reprocessing Flexible Gastrointestinal Endoscopes and Endoscopic Accessories. Clinical Endoscopy 53(3): 276-285.	not primary data
Chiu KW, Fong TV, Wu KL, Chiu YC, Chou YP, Kuo CM, Chuah SK, Kuo CH, Chiou SS, Chang Chien CS: Surveillance culture of endoscope to monitor the quality of high-level disinfection of gastrointestinal reprocessing. Hepatogastroenterology 2010, 57:531–534.	surveillance of endoscopes, no data on rinse water
Chiu KW, Lu LS, Wu KL, Lin MT, Hu ML, Tai WC, Chiu YC, Chuah SK, Hu TH: Surveillance culture monitoring of double-balloon enteroscopy reprocessing with high-level disinfection. Eur J Clin Invest 2012, 42:427–431.	evaluation of disinfection process, no data on rinse water
Chiu, K. W., et al. (2012). Surveillance cultures of samples obtained from biopsy channels and automated endoscope reprocessors after high-level disinfection of gastrointestinal endoscopes. BMC Gastroenterology 12: 120.	surveillance of endoscopes, no data on rinse water
Chiu, K.-W., et al. (2015). High-level disinfection of gastrointestinal endoscope reprocessing. World journal of experimental medicine 5(1): 33-39.	not primary data
Choi, H. H. and Y.-S. Cho (2015). Endoscope Reprocessing: Update on Controversial Issues. Clinical Endoscopy 48(5): 356-360.	not primary data
Ciancio A., Manzini P., Castagno F., D'Antico S., Reynaudo P., Coucourde L. et al. Digestive endoscopy is not a major risk factor for transmitting hepatitis C virus. Ann Intern Med 2005; 142: 903-909	assessing the risk of infection, no mention of rinse water
Collins, W. O. (2009). A review of reprocessing techniques of flexible nasopharyngoscopes. Otolaryngology - Head and Neck Surgery 141(3): 307-310.	not primary data
Committee, A. T., et al. (2010). Automated endoscope reprocessors. Gastrointestinal Endoscopy 72(4): 675-680.	duplicate, see Desilets, 2010
Corne P, Godreuil S, Jean-Pierre H et al. Unusual implication of biopsy forceps in outbreaks of *Pseudomonas aeruginosa* infections and pseudo- infections related to bronchoscopy. J Hosp Infect 2005; 61: 20–26	outbreak, no mention of rinse water
Correa L, Martino MD, Siqueira I, Pasternak J, Gales AC, Silva CV, Camargo TZ, Scherer PF, Marra AR. A hospital-based matched case-control study to identify clinical outcome and risk factors associated with carbapenem-resistant *Klebsiella pneumoniae* infection. BMC Infect Dis. 2013;13:80	not endoscopes
Cosgrove S.E., Ristaino P., Caston-Gaa A., Fellerman Nowakowski E.F., Carroll K.C., Orens J.B. et al. Caveat emptor: the role of suboptimal bronchoscope repair practices by a third-party vendor in a pseudo-outbreak of *Pseudomonas* in bronchoalveolar lavage specimens. Infect Control Hosp Epidemiol 2012; 33: 224–229.	pseudo-outbreak, no mention of rinse water
Costa, E. A. M. (2015). Reprocessing of endoscopes in Hospitals in Salvador - BA. GED - Gastrenterologia Endoscopia Digestiva 34(3): 115-122.	not in English
Cowen AE. The clinical risks of infections associated with endoscopy. Can J Gastroenterol 2001; 15: 321±331	not primary data

de Bruijn A., van Drongelen A. Quality of the final rinse water for endoscope washer disinfectors. A literature review. RIVM letter report 360050019	not primary data
De Caprio, M. T. and A. G. Casalini (2015). Reprocessing the bronchoscope. Rassegna di Patologia dell'Apparato Respiratorio 29(6): 305-309.	not in English
Desilets, D., et al. (2010). Automated endoscope reprocessors. Gastrointestinal Endoscopy 72(4): 675-680.	not primary data
DiazGranados CA, Jones MY, Kongphet-Tran T et al. Outbreak of *Pseudomonas aeruginosa* infection associated with contamination of a flexible bronchoscope. Infect Control Hosp Epidemiol 2009; 30: 550–555	outbreak, no mention of rinse water
Dirlam Langlay, A. M., et al. (2013). Reported gastrointestinal endoscope reprocessing lapses: The tip of the iceberg. American Journal of Infection Control 41(12): 1188-1194.	not primary data
Dortet L, Naas T, Boytchev I, Fortineau N. Endoscopy-associated transmission of carbapenemase-producing Enterobacteriaceae: return of 5 years' experience. Endoscopy. 2015;47(6):561.	not primary data
Duarte R.S., Lourenco M.C., Fonseca Lde S., Leao S.C., Amorim Ede L., Rocha I.L. et al. Epidemic of postsurgical infections caused by *Mycobacterium massiliense*. J Clin Microbiol, 2009; 47:2149– 2155.	not endoscopes
Dutta, A. K. and A. Chacko (2009). Hepatitis B virus transmission and reprocessing of endoscopes. Hepatitis B Annual 6(1): 110-115.	not primary data
Ece G, Erac B, Limoncu MH, Baysak A, Oz AT, Ceylan KC: *Stenotrophomonas maltophilia* pseudo-outbreak at a university hospital bronchoscopy unit in Turkey. West Indian Med J 2014; 63: 59–61.	pseudo-outbreak, no mention of rinse water
Elta, G. H. and R. L. Law (2020). What are the needed criteria for the adoption of new technology aimed at preventing duodenoscope-transmitted infections? Gastrointestinal Endoscopy 92(1): 209-210.	not primary data
Emmermann, A., et al. (2012). Systematic review of key issues in endoscope reprocessing-guideline adherence, health outcomes and resource use. Value in Health 15(7): A295.	conference abstract
Endo	not primary data
EpsteinL., Hunter J.C., Arwady M.A., Tsai V., Stein L. Gribogiannis M. et al. New Delhi metallo-β-lactamase-producing carbapenem-resistant *Escherichia coli* associated with exposure to duodenoscopes. 2014	outbreak, no mention of rinse water
Ezpeleta-Baquedano, C., et al. (2013). Article on SEIMC Procedure No.42: Environmental microbiological monitoring. Enfermedades Infecciosas y Microbiologia Clinica 31(6): 396-401.	not in English
Fejleh, M. P., et al. (2019). Getting to zero: Enhanced reprocessing and future directions. Techniques in Gastrointestinal Endoscopy 21(4): 150626.	not primary data
Fernandes Garcia de Carvalho, N., et al. (2018). Hospital bronchoscopy-related pseudo-outbreak caused by a circulating *Mycobacterium abscessus* subsp. *massiliense*. Journal of Hospital Infection 100(3): e138-e141.	pseudo-outbreak, not due to rinse water
Forte L, Shum C. Comparative cost-efficiency of the EVOTECH endoscope cleaner and reprocessor versus manual cleaning plus automated endoscope reprocessing in a real-world Canadian hospital endoscopy setting. BMC Gastroenterol 2011;11:105.	evaluation of disinfection process, no data on rinse water
Fraser TG Reiner S Malczynski M et al. Multidrug-resistant *Pseudomonas aeruginosa* cholangitis after endoscopic retrograde chalngiopancreatography: failure of routine endoscope cultures to prevent an outbreak. Infect Control Hosp Epidemiol. 2004; 25: 856-859	outbreak, no mention of rinse water
Frăţilă O, Tanţău M. Cleaning and disinfection in gastrointestinal endoscopy: current status in Romania. J Gastrointestin Liver Dis 2006;15: 89-93.	survey of practice, no

	mention of rinse water
Fushimi R, Takashina M, Yoshikawa H, Kobayashi H, Okubo T, Nakata S, et al. Comparison of adenosine triphosphate, microbiological load, and residual protein as indicators for assessing the cleanliness of flexible gastrointestinal endoscopes. Am J Infect Control 2013;41:161-4.	detection method, no mention of rinse water
Galdys AL, Marsh JW, Delgado E, Pasculle AW, Pacey M, Ayres AM, et al. Bronchoscope- associated clusters of multidrug-*resistant Pseudomonas aeruginosa* and carbapenem- resistant *Klebsiella pneumonia*. Infect Control Hosp Epidemiol 2019;40:40-6.	outbreak, no mention of rinse water
Gastmeier P, Vonberg RP. Klebsiella spp. in endoscopy-associated infections: we may only be seeing the tip of the iceberg. Infection 2014; 42: 15 – 21	not primary data
Gillespie EE, Kotsanas D, Stuart RL. 2008. Microbiological monitoring of endoscopes: 5-year review. J Gastroenterol Hepatol 23:1069–1074	surveillance of endoscopes, no data on rinse water
Gillespie JL, Arnorl KE, Noble-Wang J, Jensen B, Arduino M, Hageman J, et al. Outbreak of *Pseudomonas aeruginosa* infections after transrectal ultrasoundguided prostate biopsy. Urology 2007;69:912-4.	not endoscopes
Gonzalez-Candelas F, Guiral S, Carbo R, et al. Patient-to-patient transmission of hepatitis C virus (HCV) during colonoscopy diagnosis. Virol J 2010;7:217.	not endoscopes
Greenwald, D. (2010). Reducing Infection Risk in Colonoscopy. Gastrointestinal Endoscopy Clinics of North America 20(4): 603-614.	not primary data
Guglielmi, C. L., et al. (2016). Effectively Processing Flexible Endoscopes. AORN journal 104(5): 440-447.	not primary data
Hambrick, D., 3rd (2001). Debate and evaluation of various methods of endoscope reprocessing. Gastroenterology nursing : the official journal of the Society of Gastroenterology Nurses and Associates 24(6): 300-301.	not primary data
Hamed MMA, Shamseya MM, Alah IDAND, El Sawaf GED. Estimation of average bioburden values on flexible gastrointestinal endoscopes after clinical use and cleaning: Assessment of the efficiency of cleaning processes. Alexandria J Med 2015; 51(2): 95-103.	surveillance of endoscopes, no data on rinse water
Hansen D, Benner D, Hilgenhoner M, Leisebein T, Brauksiepe A, Popp W. ATP measurement as method to monitor the quality of reprocessing flexible endoscopes. German Med Sci 2004;2:1612-3174	detection method, no mention of rinse water
Heeg, P. (2004). Reprocessing endoscopes: National recommendations with a special emphasis on cleaning - The German perspective. Journal of Hospital Infection 56(SUPPL. 2): S23-S26.	not primary data
Herve R, Keevil CW. Current limitations about the cleaning of luminal endoscopes. J Hosp Infect 2013;83:22-9.	survey of practice, no mention of rinse water
Herve RC Keevil CW Persistent residual contamination in endoscope channels; a fluorescence epimicroscopy study. Endoscopy. 2016; 48: 609-616	surveillance of endoscopes, no data on rinse water
Heudorf U., Exner M. German guidelines for reprocessing endoscopes and endoscopic accessories: guideline compliance in Frankfurt/Main, Germany	not primary data

Higa JT, Choe J, Tombs D, Gluck M, Ross AS. Optimizing duodenoscope reprocessing: rigorous assessment of a culture and quarantine protocol. Gastrointest Endosc 2018;88:223-229.	surveillance of endoscopes, no data on rinse water
Holodniy M, Oda G, Schirmer PL, Lucero CA, Khudyakov YE, Xia G, et al. Results from a large-scale epidemiologic look-back investigation of improperly reprocessed endoscopy equipment. Infect Control Hosp Epidemiol 2012;33:649-56	assessing the risk of infection, no mention of rinse water
Holtmann G.J., Huelsen A., Shah A., Hourigan L.F., Morrison M. Is a Fundamental Design Change for Gastrointestinal Endoscopes Required?	not primary data
Hong, K. H. and Y. J. Lim (2013). Recent update of gastrointestinal endoscope reprocessing. Clinical Endoscopy 46(3): 267-273.	not primary data
Hookey L.C., Armstrong D., Enns R., Matlow A.; Singh H., Love J. Summary of guidelines for infection prevention and control for flexible gastrointestinal endoscopy. 2013	not primary data
Hubner N.O., Assadian O., Poldrack R., Duty O., Schwarzer H., Moller H. et al. Endowashers: an overlooked risk for possible post-endoscopic infections	surveilance of endowashers (not AER), no mention of rinse water
Humphreys, H., et al. (2002). Quality of final rinse water used in washer-disinfectors for endoscopes [5]. Journal of Hospital Infection 51(2): 151-153.	not primary data
Humphries RM Yang S Kim S et al. Duodenoscope-related outbreak of a carbapanem-resistant *Klebsiella pneumoniae* identified using advanced molecular diagnostics. Clin Infect Dis. 2017; 65: 1159-1166	outbreak, no mention of rinse water
Humphries, R. M. and G. McDonnell (2015). Superbugs on duodenoscopes: The challenge of cleaning and disinfection of reusable devices. Journal of Clinical Microbiology 53(10): 3118-3125.	not primary data
Ishino Y, Ido K, Sugano K. Contamination with hepatitis B virus DNA in gastrointestinal endoscope channels: Risk of infection on reuse after on-site cleaning. Endoscopy 2005;37:548-51.	surveillance of endoscopes, no data on rinse water
Israil AM, Delcaru C, Palade RS, Chifiriuc C, Iordache C, Vasile D, Grigoriu M, Voiculescu D: Bacteriological aspects implicated in abdominal surgical emergencies. Chirurgia (Bucur) 2010, 105:779–787.	not endoscopes
Jadczak, U., et al. (2017). Flexible endoscope decontamination-is it good enough? Antimicrobial Resistance and Infection Control 6(Supplement 2).	conference abstract
Jimeno A Alcalde MM Ortiz M Rodriguez A Alcaraz B Vera F Outbreak of urinary tract infections by Salmonella spp. after cystoscopic manipulation. Actas Urol Esp. 2016; 40: 646-649	outbreak, no mention of rinse water
Jorgensen SB Bojer MS Boll EJ Martin Y Helmersen K Skogstad M et al. Heat-resistant, extended-spectrum beta-lactamase-producing *Klebsiella pneumoniae* in endoscope-mediated outbreak. J Hosp Infect. 2016; 93: 57-62	outbreak, no mention of rinse water
Joshi, N. (2013). Infection control and endourology. European Urology, Supplements 12(3): 49-50.	conference abstract
Kassis-Chikhani Outbreak of *Klebsiella pneumoniae* producing KPC-2 and SHV-12 in a French hospital J Antimicrob Chemother 2010	not endoscopes
Katsinelos P., Dimiropoulos S., Katsiba D., Arvaniti M., Tsolkas P., Galanis I. et al. *Pseudomonas aeruginosa liver* abscesses after diagnostic endoscopic retrograde cholangiography in two patients with sphincter of Oddi dysfunction type 2. Surg Endosc. 2002;16(11):1638.	outbreak, no mention of rinse water

Kayabas U, Bayraktar M, Otlu B et al. An outbreak of *Pseudomonas aeruginosa* because of inadequate disinfection procedures in a urology unit: a pulsed-field gel electrophoresis-based epidemiologic study. Am J Infect Control 2008; 36: 33–38	not endoscopes
Kenters, N., et al. (2015). Infectious diseases linked to cross-contamination of flexible endoscopes. Endoscopy International Open 3(4): E259-E265.	not primary data
Kim S, Russell D, Mohamadnejad M et al. Risk factors associated with the transmission of carbapenem-resistant Enterobacteriaceae via contaminated duodenoscopes. Gastrointest Endosc 2016; 83: 1121 – 1129	not endoscopes
Kircheis U, Martiny H: Comparison of the cleaning and disinfecting efficacy of four washer-disinfectors for flexible endoscopes. J Hosp Infect 2007, 66(3):255-261.	evaluation of disinfection process, no data on rinse water
Klefisch FR, Schweizer C, Kola A, et al. A flexible bronchoscope as a source of an outbreak with OXA-48 carbapenemase producing *Klebsiella pneumoniae*. Hyg Med. 2015;40(1/2):1-6.	not in English
Kola A, Piening B, Pape UF et al. An outbreak of carbapenem-resistant OXA-48-producing *Klebsiella* pneumonia associated to duodenoscopy. Antimicrob Resist Infect Control 2015; 4: 8	outbreak, no mention of rinse water
Koo VS, O'Neill P, Elves A. Multidrug-resistant NDM-1 *Klebsiella* outbreak and infection control in endoscopic urology. BJU Int 2012; 110: E922–E926	survey of practice, no mention of rinse water
Kovaleva J, Meessen NE, Peters FT, Been MH, Arends JP, Borgers RP, et al. Is bacteriologic surveillance in endoscope reprocessing stringent enough? Endoscopy 2009;41:913-6.	outbreak, no mention of rinse water
Kovaleva J, Peters FTM, van der Mei HC et al. Transmission of infection by flexible gastrointestinal endoscopy and bronchoscopy. Clin Microbiol Rev 2013; 26: 231 – 254	not primary data
Kovaleva, J. (2016). Infectious complications in gastrointestinal endoscopy and their prevention. Best Practice and Research: Clinical Gastroenterology 30(5): 689-704.	not primary data
Kozisek, F. (2018). Good clinical practice for endoscope rinsing. Gastroenterologie a Hepatologie 72(6): 531-533.	not in English
Kressel A.B., Kidd F. Pseudo-Outbreak of *Mycobacterium chelonae* and *Methtlobactertum mesophilicum* Caused by Contamination of an Automated Endoscopy Washer	pseudo-outbreak not due to rinse water
Kutyla M. O'Connor S. Gurusamy S. et al. Influence of simethicone added to the rinse water during colonoscopies on polyp detection rates: results of an unintended cohort study. Digestion. 2018; 98: 217-221	not reprocessing
La Scola B, Rolain JM, Maurin M, Raoult D. Can Whipple's disease be transmitted by gastroscopes? Infect Control Hosp Epidemiol 2003; 24: 191-194	assessing the risk of infection, no mention of rinse water
Langlay, A. M. D., et al. (2013). Transmission of multidrug-resistant organisms via contaminated duodenoscopes. Gastrointestinal Endoscopy 77(5 SUPPL. 1): AB394.	conference abstract
Larson JL, Lambert L, Stricof RL, Driscoll J, McGarry MA, Ridzon R. Potential nosocomial exposure to *Mycobacterium tuberculosis* from a bronchoscope. Infect Control Hosp Epidemiol 2003;24:825-30.	exposure to contaminated endoscopes, no

	mention of rinse water
Leiss, O., et al. (2002). Reprocessing of flexible endoscopes and endoscopic accessories - An international comparison of guidelines. Zeitschrift fur Gastroenterologie 40(7): 531-542.	not primary data
Leiss, O., et al. (2008). Five years of the Robert Koch Institute guidelines for reprocessing of flexible endoscopes. a look back and a look forward. Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz 51(2): 211-220.	not primary data
Leung J, Vallero R, Wilson R. Surveillance cultures to monitor quality of gastrointestinal endoscope reprocessing. Am J Gastroenterol 2003;98:3- 5.	not primary data
Lines, L. and P. Moncur (2010). Improving endoscopy decontamination processes to minimise service disruption due to water test failures. Journal of Hospital Infection 76(SUPPL. 1): S37.	conference abstract
Lisgaris MV. The occurrence and prevention of infections associated with gastrointestinal endoscopy. Curr Infect Dis Rep 2003;5:108-113	not primary data
Lo Passo C, Pernice I, Celeste A et al. Transmission of Trichosporon asahii oesophagitis by a contaminated endoscope. Mycoses 2001; 44: 13–21	assessing the risk of infection, no mention of rinse water
Loo VG, Poirier L, Miller MA, et al. (2005) A predominantly clonal multi-institutional outbreak of *Clostridium difficile* associated diarrhoea with high morbidity and mortality. N Engl J Med 353: 2442–2449	not endoscopes
Lubowski DZ, Newstead GL. Rigid sigmoidoscopy: a potential hazard for cross-contamination. Surg Endosc. 2006;20:812–4	assessing the risk of infection, no mention of rinse water
Lupse Recurrent infective endocarditis of the native aortic valve due to ESBL producing *Escherichia coli* (*E. coli*) after therapeutic ERCP J Gastrointestin Liver Dis 2012	outbreak, no mention of rinse water
Ma GK Pegues DA Kochman ML et al. Implementation of a systematic culturing program to monitor the efficacy of endoscope reprocessing: outcomes and costs. Gastrointest Endosc. 2018; 87 (09.e3): 104	surveillance of endoscopes, no data on rinse water
Machado AP, Pimenta ATM, Contijo PP, Geocze S, Fischman O. Microbiologic profile of flexible endoscope disinfection in two Brazilian hospitals. Arq Gastroenterol 2006;43:255-8.	evaluation of disinfection process, no data on rinse water
MacKay, W. G., et al. (2002). Water, water everywhere nor any a sterile drop to rinse your endoscope. Journal of Hospital Infection 51(4): 256-261.	not primary data
Mansour W, Bouallegue O, Said H et al. Outbreak of *Pseudomonas aeruginosa* infections associated with contaminated water in a university hospital in Tunisia. Infect Control Hosp Epidemiol 2008; 29: 378–380	outbreak, no mention of rinse water
Marsh JW Krauland MG Nelson JS et al. Genomic epidemiology of an endoscope associated outbreak of *Klebsiella pneumoniae* carbapenemase (KPC)-producing *K. pneumoniae.* PLoS One. 2015; 10: e0144310	outbreak, no mention of rinse water
Martiny H, Floss H, Zuhlsdorf B. The importance of cleaning for the overall results of processing endoscopes. J Hosp Infect 2004;56: S16-22.	not primary data
Martiny, H. and H. Floss (2001). Residuals on medical devices following reprocessing. Journal of Hospital Infection 48(SUPPL. A): S88-S92.	not primary data

McCafferty CE, Abi-Hanna D, Aghajani MJ, Micali GT, Lockart I, Vickery K, et al. The validity of adenosine triphosphate (ATP) measurement in detecting endoscope contamination. J Hosp Infect. 2018	detection method, no mention of rinse water
McCafferty, C. E., et al. (2018). An update on gastrointestinal endoscopy-associated infections and their contributing factors. Annals of Clinical Microbiology and Antimicrobials 17(1): 36.	not primary data
McDonald LC, Killgore GE, Thompson A, et al. (2005) An epidemic, toxin gene – variant strain of *Clostridium difficile*. N Engl J Med 353:2433–2441	not endoscopes
Mean M, Mallaret MR, Bichard P, Shum J, Zarski JP: Gastrointestinal endoscopes cleaned without detergent substance following an automated endoscope washer/disinfector dysfunction. Gastroenterol Clin Biol 2006; 30: 665–668.	exposure to contaminated endoscopes, no mention of rinse water
Mehta, A. C. and L. F. Muscarella (2020). Bronchoscope-Related Superbug Infections. Chest 157(2): 454-469.	not primary data
Mikhail NN, Lewis DL, Omar N, et al. Prospective study of cross-infection from upper- GI endoscopy in a hepatitis C-prevalent population. Gastrointest Endosc 2008;65:584-8.	assessing the risk of infection, no mention of rinse water
Miner, N., et al. (2012). Rinsability of orthophthalaldehyde from endoscopes. Diagnostic and Therapeutic Endoscopy: 853781.	not focused on rinse water quality but describes that OPA does not rinse well
Morris J, Duckworth GJ, Ridgway GL. Gastrointestinal endoscopy decontamination failure and the risk of transmission of blood-borne viruses: A review. J Hosp Infect 2006;63:1-13.	not primary data
Moses F.M. Lee J.S. Surveillance cultures to monitor quality of gastrointestinal endoscope reprocessing. Am J Gastroenterol. 2003; 98: 77-81	surveillance of endoscopes, no data on rinse water
Moses FM, Lee JS. Current GI endoscope disinfection and QA practices. Dig Dis Sci 2004;49:1791-1797.	not primary data
Mughal, M. M., et al. (2004). Reprocessing the bronchoscope: The challenges. Seminars in Respiratory and Critical Care Medicine 25(4): 443-449.	not primary data
Muscarella LF. Automatic flexible endoscope reprocessors. Gastrointest Endosc Clin N Am 2000;10(2):245-57	not primary data
Muscarella LF. Evaluation of the risk of transmission of bacterial biofilms and *Clostridium difficile* during gastrointestinal endoscopy. Gastroenterol Nurs 2010;33:28-35.	not primary data
Muscarella LF. Is gastrointestinal endoscopy a risk factor for Whipple's disease? Infect Control Hosp Epidemiol 2004; 25: 453-454	not primary data
Muscarella LF. Risk of transmission of carbapenem-resistant Enterobacteriaceae and related “superbugs” during gastrointestinal endoscopy. World J Gastrointest Endosc 2014; 6: 457 – 474	not primary data
Muscarella LF.The importance of monitoring rinse water used during endoscope reprocessing. Endo Nurse. 2001;1(2):22.	not available
Muscarella LF: The study of a contaminated colonoscope. Clin Gastroenterol Hepatol 2010, 8:577–580. e1.	evaluation of disinfection

	process, no data on rinse water
Muscarella, L. F. (2002). Application of environmental sampling to flexible endoscope reprocessing: The importance of monitoring the rinse water. Infection Control and Hospital Epidemiology 23(5): 285-289.	not primary data
Muscarella, LE. Déjà vu… all over again? The importance of instrument drying. Infect Control Hosp Epidemiol 2000;21:628–629	not primary data
Muscarella, LE. Disinfecting endoscopes immediately before the first patient of the day. AORN J 2001;73:1159–1163	not primary data
Muscarella, LF. Limited surveillance in the endoscopic setting: has its time arrived? Am J Infect Control 2002;30:66–67	not primary data
Naas T, Cuzon G, Babics A, Fortineau N, Boytchev I, Gayral F, et al. Endoscopy-associated transmission of carbapenem-resistant *Klebsiella pneumoniae* producing KPC-2 beta-lactamase. J Antimicrob Chemother. 2010;65(6):1305–6.	outbreak, no mention of rinse water
Nelson D.B. Barkun A.N. Block K.P. et al. Transmission of infection by gastrointestinal endoscopy. Gastrointest Endosc. 2001; 54: 824-828	no primary data
Nelson, D. B. and L. F. Muscarella (2006). Current issues in endoscope reprocessing and infection control during gastrointestinal endoscopy. World Journal of Gastroenterology 12(25): 3953-3964.	not primary data
Nelson, D. B., et al. (2004). Multi-society Guideline for Reprocessing Flexible Gastrointestinal Endoscopes. Diseases of the Colon and Rectum 47(4): 413-421.	not primary data
Neves MS da Silva MG Ventura GM et al. Effectiveness of current disinfection procedures against biofilm on contaminated GI endoscopes. Gastrointest Endosc. 2016; 83: 944-953	evaluation of disinfection process, no data on rinse water
Nürnberg M, Schulz HJ, Rüden H, Vogt K. Do conventional cleaning and disinfection techniques avoid the risk of endoscopic *Helicobacter pylori* transmission? Endoscopy 2003; 35: 295-299	surveillance of endoscopes, no data on rinse water
O'Horo JC, Farrell A, Sohail MR, Safdar N. Carbapenem-resistant Enterobacteriaceae and endoscopy: an evolving threat. Am J Infect Control. 2016;44(9):1032–6.	not primary data
Ofstead C.L. Heymann O.L. Quick M.R. et al. Residual moisture and waterborne pathogens inside flexible endoscopes: Evidence from a multisite study of endoscope drying effectiveness. Am J Infect Control. 2018	evaluation of disinfection process, no data on rinse water
Ofstead C.L. Wetzler H.P. Heymann O.L. et al. Longitudinal assessment of reprocessing effectiveness for colonoscopes and gastroscopes: Results of visual inspections, biochemical markers, and microbial cultures. Am J Infect Control. 2017; 45: e26-e33	surveillance of endoscopes, no data on rinse water
Ofstead CL Quick MR Wetzler HP Eiland JE Heymann OL Sonetti DA et al. Effectiveness of reprocessing for flexible bronchoscopes and endobronchial ultrasound bronchoscopes. Chest. 2018; 154: 1024-1034	evaluation of disinfection process, no data on rinse water
Ofstead CL Wetzler HP Doyle EM Rocco CK Visrodia KH Baron TH et al. Persistent contamination on colonoscopes and gastroscopes detected by biologic cultures and rapid indicators despite reprocessing performed in accordance with guidelines. Am J Infect Control. 2015; 43: 794-801	surveillance of endoscopes, no data on rinse water
Ofstead CL, Dirlam Langlay AM, Mueller NJ, Tosh PK, Wetzler HP. 2013. Re-evaluating endoscopy-associated infection risk estimates and their implications. Am J Infect Control 41:734–736	not primary data

Ofstead CL, Wetzler HP, Snyder AK et al. Endoscope reprocessing methods: a prospective study on the impact of human factors and automation. Gastroenterol Nurs 2010; 33: 304–311	evaluation of disinfection process, no data on rinse water
Ofstead, C. L., et al. (2016). Practical toolkit for monitoring endoscope reprocessing effectiveness: Identification of viable bacteria on gastroscopes, colonoscopes, and bronchoscopes. American Journal of Infection Control 44(7): 815-819.	surveillance of endoscopes, no data on rinse water
Ofstead, C. L., et al. (2020). Challenges in achieving effective high-level disinfection in endoscope reprocessing. American Journal of Infection Control 48(3): 309-315.	not primary data
Oh, H. J. and J. S. Kim (2015). Clinical Practice Guidelines for Endoscope Reprocessing. Clinical Endoscopy 48(5): 364-368.	not primary data
Orsi GB, Bencardino A, Vena A, Carattoli A, Venditti C, Falcone M, Giordano A, Venditti M. Patient risk factors for outer membrane permeability and KPC-producing carbapenem-resistant *Klebsiella pneumoniae* isolation: results of a double case-control study. Infection. 2013;41:61–7.	assessing the risk of infection, no mention of rinse water
Osborne S. Reynolds S. George N. et al. Challenging endoscopy reprocessing guidelines: a prospective study investigating the safe shelf life of flexible endoscopes in a tertiary gastroenterology unit. Endoscopy. 2007; 39: 825-830	evaluation of disinfection process, no data on rinse water
Oumokhtar, B., et al. (2008). Residual microbiological contamination of digestive endoscopes. Acta Endoscopica 38(5): 483-492.	not in English
Pajkos A, Vickery K, Cossart EY. Is biofilm accumulation on endoscope tubing a contributor to the failure of cleaning and contamination? J Hosp Infect 2004; 58:224-9.	evaluation of disinfection process, no data on rinse water
Parohl, N., et al. (2012). Cleansing control of endoscopes by use of adenosine triphosphate. Hygiene + Medizin 37(6): 238-240.	not in English
Parr A, Querry A, Pasculle A, et al. Carbapenem-resistant *Klebsiella pneumoniae cluster* associated with gastroscope exposure among surgical intensive care unit patients at University of Pittsburgh Medical Center. Open Forum Infect Dis. 2016;3(suppl 1):248.	conference abstract
Peaper DR, Havill NL, Aniskiewicz M, Callan D, Pop O, Towle D, Boyce JM: Pseudo-outbreak of *Actinomyces graevenitzii* associated with bronchoscopy. J Clin Microbiol 2015; 53: 113–117.	pseudo-outbreak, no mention of rinse water
Petersen BT. Duodenoscope reprocessing: risk and options coming into view. Gastrointest Endosc 2015; 82: 484 – 486	not primary data
Petersen, B. T., et al. (2011). Multisociety guideline on reprocessing flexible gastrointestinal endoscopes: 2011. Gastrointestinal Endoscopy 73(6): 1075-1084.	not primary data
Petersen, B. T., et al. (2016). Infection Using ERCP Endoscopes. Gastroenterology 151(1): 46-50.	not primary data
Phillips, M. S. and C. F. Von Reyn (2001). "Nosocomial infections due to nontuberculous mycobacteria." Clinical Infectious Diseases 33(8): 1363-1374.	not primary data
Prabaker K., Muthiah C., Hayden M.K., Weinstein R. A., Cheerala J., Scorza M.L., et al. (2015). Pseudo-outbreak of *Mycobacterium gordonae* following the opening of a newly constructed hospital at a Chicago Medical Center. Infect. Control. Hosp. Epidemiol. 36, 198-203	not endoscopes
Pynnonen, M. A. and J. Whelan (2019). Reprocessing Flexible Endoscopes in the Otolaryngology Clinic. Otolaryngologic Clinics of North America 52(3): 391-402.	not primary data

Qiu L, Zhou Z, Liu Q, Ni Y, Zhao F, Cheng H. Investigating the failure of repeated standard cleaning and disinfection of a *Pseudomonas aeruginosa*- infected pancreatic and biliary endoscope. Am J Infect Control. 2015;43(8):e43–6.	outbreak, no mention of rinse water
Quan E. Mahmood R. Naik A. et al. Use of adesnosine triphosphate to audit reprocessing of flexible endoscopes with an elevator mechanism. Am J Infect Control. 2018; 46: 1272-1277	detection method, no mention of rinse water
Ramakrishna, B. S. (2002). Safety of technology: Infection control standards in endoscopy. Journal of Gastroenterology and Hepatology (Australia) 17(4): 361-368.	not primary data
Ramsey AH, Oemig TV, Davis JP et al. An outbreak of bronchoscopy-related *Mycobacterium tuberculosis* infections due to lack of bronchoscope leak testing. Chest 2002; 121: 976 – 981	outbreak, no mention of rinse water
Ranjan P Das K Ayyagiri A et al. A report of post-ERCP *Pseudomonas aeruginosa* infection outbreak. Indian J Gastroenterol. 2005; 24: 131-132	not available
Ransjo U, Engstrom L, Hakansson P, Ledel T, Lindgren L, Lindqvist A, et al. A test for cleaning and disinfection processes in a washer-disinfector. APMIS 2001;109:299-304	detection method, no mention of rinse water
Rauwers AW Troelstra A Fluit AC Wissink C Loeve AJ Vleggaar FP et al. Independent root cause analysis of contributing factors, including dismantling of 2 duodenoscopes, to an outbreak of multidrug-resistant *Klebsiella pneumoniae*. Gastrointest Endosc. 2019; 90: 793-804	outbreak, no mention of rinse water
Rauwers, A. W., et al. (2016). Outbreaks related to contaminated duodenoscopes: Causes and solutions. Nederlands Tijdschrift voor Geneeskunde 160(44): D458.	not in English
Reddick E Investigation of salmonellosis outbreak following a hospital endoscopy: a public health case study. Can J Infect Control. 2017; 32: 156-159	outbreak, no mention of rinse water
Reiner S. Investigation of a cluster of genomically identical *Pseudomonas aeruginos*a blood isolates following endoscopic retrograde cholangiopancreatography in a gastroenterology laboratory. Am J Infect Control. 2008;36(5):E198.	conference abstract
Rejchrt S. Cermak P. Pavlatova L. et al. Bacteriologic testing of endoscopes after high-level disinfection. Gastrointest Endosc. 2004; 60: 76-78	evaluation of disinfection process, no data on rinse water
Rex DK Sieber M Lehman GA et al. A double-reprocessing high-level disinfection protocol does not eliminate positive cultures from the elevators of duodenoscopes. Endoscopy. 2017	evaluation of disinfection process, no data on rinse water
Richards, J., et al. (2002). Rinse water for heat labile endoscopy equipment. Journal of Hospital Infection 51(1): 7-16.	not primary data
Riebe, O., et al. (2015). HYGENDA 2013 hygiene in endoscope reprocessing: A study on the reprocessing of flexible endoscopes in hospitals and private practices. Hygiene + Medizin 40(3): 88-96.	surveillance of endoscopes, no data on rinse water
Roberts, C. G. (2013). The role of biofilms in reprocessing medical devices. American Journal of Infection Control 41(5 SUPPL.): S77-S80.	not primary data
Ross, A. and M. Gluck (2019). Optimizing flexible endoscope reprocessing. Techniques in Gastrointestinal Endoscopy 21(4): 150627.	not primary data

Rubin, Z. A. and R. K. Murthy (2016). Outbreaks associated with duodenoscopes: New challenges and controversies. Current Opinion in Infectious Diseases 29(4): 407-414.	not primary data
Rubin, Z. A., et al. (2018). Safely reprocessing duodenoscopes: current evidence and future directions. The Lancet Gastroenterology and Hepatology 3(7): 499-508.	not primary data
Rutala W.A. Weber D.J. How to assess risk of disease transmission to patients when there is a failure to follow recommended disinfection and sterilization guidelines. Infect Control Hosp Epidemiol. 2007; 28: 146-155	not primary data
Rutala, W. A. and D. J. Weber (2016). Outbreaks of carbapenem-resistant Enterobacteriaceae infections associated with duodenoscopes: What can we do to prevent infections? American Journal of Infection Control 44(5 Supplement): e47-e51.	not primary data
Rutala, W.A. & Weber, D.J. (2013). New developments in reprocessing semicritical items. American Journal of Infection Control, 41, 560-566.	not primary data
Rutala, W.A. & Weber, D.J. (2014). Gastrointestinal endoscopes: A need to shift from disinfection to sterilization? Journal of the American Medical Association, 312(14), 1405-6.	not primary data
Rutala, W.A. & Weber, D.J. (2016). Disinfection and sterilization in health care facilities: An overview and current issues. Infectious Diseases of North America, 30, 609-637.	not primary data
Saliou P Le Bars H Payan C Narbonne V Cholet F Jezequel J et al. Measures to improve microbial quality surveillance of gastrointestinal endoscopes. Endoscopy. 2016; 48: 704-710	evaluation of disinfection process, no data on rinse water
Saludes V, Esteve M, Casas I, et al. Hepatitis C virus transmission during colonoscopy evidenced by phylogenetic analysis. J Clin Virol 2013;57:263-6.	not endoscopes
Sanderson R Braithwaite L Ball E Ragan P Eisenstein L An outbreak of carbapenem-resistant *Klebsiella pneumoniae* infections associated with endoscopic retrograde cholangiopancreatography (ERCP) procedures at a hospital. Am J Infect Control. 2010; 38 (abstr 178).: e141	conference abstract
Saviuc P, Picot-Guéraud R, Shum Cheong Sing J, et al. Evaluation of the Quality of Reprocessing of Gastrointestinal Endoscopes. Infect Control Hosp Epidemiol 2015; 36(9): 1017-23.	evaluation of disinfection process, no data on rinse water
Schelenz S, French G. An outbreak of multidrug resistant *Pseudomonas aeruginosa* infection associated with contamination of bronchoscopes and an endoscope washer-disinfector. J Hosp Infect 2000;46:23-30.	outbreak, no mention of rinse water
Schuetz AN, Hughes RL, Howard RM, et al. Pseudo-outbreak of *Legionella pneumophila* serogroup 8 infection associated with a contaminated ice machine in a bronchoscopy suite. Infect Control Hosp Epidemiol 2009; 30(5): 461-6.	pseudo-outbreak, no mention of rinse water
Sciortino Jr, C. V., E. L. Xia, et al. (2004). "Assessment of a Novel Approach to Evaluate the Outcome of Endoscope Reprocessing." Infection Control and Hospital Epidemiology 25(4): 284-290.	detection method, no mention of rinse water
Seoane-Vazquez E, Rodriguez-Monguio R, Visaria J, Carlson A. Exogenous endoscopy-related infections, pseudo-infections, and toxic reactions: clinical and economic burden. Curr Med Res Opin 2006; 22(10): 2007-21.	not primary data
Seoane-Vazquez E, Rodriquez-Monguio R, Visaria J, Carlson A. Endoscopy related infections and toxic reactions: an international comparison. Endoscopy 2007;39:742-6.	not primary data

Sethi S, Huang RJ, Barakat M et al. Adenosine triphosphate bioluminescence for bacteriologic surveillance and reprocessing strategies for minimizing risk of infection transmission by duodenoscopes. Gastrointest Endosc 2017; 85: 1180 – 1187	detection method, no mention of rinse water
Shellnutt, C. (2016). Advances in Endoscope Reprocessing Technology and Its Impact on Pathogen Transmission. Gastroenterology nursing : the official journal of the Society of Gastroenterology Nurses and Associates 39(6): 457-465.	not primary data
Shenoy ES Pierce VM Walters MS Moulton-Meissner H Lawsin A Lonsway D et al. Transmission of mobile colistin resistance (*mcr-1*) by duodenoscope. Clin Infect Dis. 2018; 68: 1327-1334	outbreak, no mention of rinse water
Shin, J. E., et al. (2019). Updates on the Disinfection and Infection Control Process of the Accredited Endoscopy Unit. Clinical Endoscopy 52(5): 443-450.	not primary data
Smith ZL Dua A Saeian K et al. A novel protocol obviates endoscope sampling for carbapenem-resistant enterobacteriaceae: experience of a center with a prior outbreak. Dig Dis Sci. 2017; 62: 3100-3109	tests the use of ETO for sterilisation
Smith ZL, Yuong SO, Saeian K et al. Transmission of carbapenem-resistant Enterobacteriaceae during ERCP: time to revisit the current reprocessing guidelines. Gastrointest Endosc 2015; 81: 1041 – 1045	outbreak, no mention of rinse water
Smith, A., et al. (2010). Contamination of a purified water system by *Aspergillus fumigatus* in a new endoscopy reprocessing unit. Journal of Hospital Infection 76(SUPPL. 1): S24.	duplicate, see Khalsa, 2014
Snyder GM Wright SB Smithey A Mizrahi M Sheppard M Hirsch EB et al. Randomized comparison of 3 high-level disinfection and sterilization procedures for duodenoscopes. Gastroenterology. 2017; 153: 1018-1025	evaluation of disinfection process, no data on rinse water
Soares JB, Gonçalves R, Banhudo A, Pedrosa J. Reprocessing practice in digestive endoscopy units of district hospitals: results of a Portuguese National Survey. Eur J Gastroenterol Hepatol 2011;23:1064-1068.	survey of practice, no mention of rinse water
Son, B. K., et al. (2017). Korean Society of Gastrointestinal Endoscopy Guidelines for Endoscope Reprocessing. Clinical Endoscopy 50(2): 143-147.	not primary data
Sorin M, Segal-Maurer S, Mariano N, Urban C, Combest A, Rahal JJ: Nosocomial transmission of imipenem-resistant *Pseudomonas aeruginosa* following bronchoscopy associated with improper connection to the Steris System 1 processor. Infect Control Hosp Epidemiol 2001; 22: 409–413.	outbreak, no mention of rinse water
Srinivasan A, Wolfenden LL, Song X, et al. Bronchoscope reprocessing and infection prevention and control: bronchoscopy specific guidelines are needed. Chest. 2004;125(1):307-314.	survey of endoscopists' knowledge
Steinmann J, Kaase M, Gatermann S, Popp W, Steinmann E, Damman M, Paul A, Saner F, Buer J, Rath P. Outbreak due to a *Klebsiella pneumoniae* strain harbouring KPC-2 and VIM-1 in a German university hospital, July 2010 to January 2011. Euro Surveill. 2011;16:19944	not endoscopes
Sugiyama T, Naka H, Yachi A, Asaka M. Direct evidence by DNA fingerprinting that endoscopic cross-infection of *Helicobacter pylori* is a cause of post-endoscopic acute gastritis. J Clin Microbiol 2000; 38: 2381-2382	outbreak, no mention of rinse water
Thaker A.M. Muthusamy V.R. Sedarat A. et al. Duodenoscope reprocessing practice patterns in U.S. endoscopy centers: a survey study. Gastrointest Endosc. 2018; 88: 316-322	survey of practice, no mention of rinse water
Thornhill G, Bommarito M, Morse DJ. Monitoring the manual cleaning of flexible endoscopes with an ATP detection system. Am J Infect Control. 2012;40:e184-e5.	conference abstract

Tokar, J. L., et al. (2015). Getting to Zero: Reducing the risk for duodenoscope-related infections. Annals of Internal Medicine 163(11): 873-874.	not primary data
Tosh PK, Disbot M, Duffy JM, Boom ML, Heseltine G, Srinivasan A, et al. Outbreak of *Pseudomonas aeruginosa* surgical site infections after arthroscopic procedures: Texas, 2009. Infect Control Hosp Epidemiol 2011;32:1179-86.	not endoscopes
Valderrama S, Miranda CJL, Rubio ÁPG, Gualtero S, Fraile GCC, Escobar Y, et al. Successful Control of an Endoscopic Retrograde Cholangiopancreatography–Associated Nosocomial Outbreak Caused by *Klebsiella pneumoniae* Carbapenemase Producing Klebsiella pneumoniae in a University Hospital in Bogota, Colombia. Open Forum Infectious Diseases. 2016;3(suppl_1)	conference abstract
Valeriani F, Agodi A, Casini B, et al; GISIO Working Group of the Italian Society of Hygiene, Preventive Medicine, and Public Health. Potential testing of reprocessing procedures by real-time polymerase chain reaction: A multicenter study of colonoscopy devices. Am J Infect Control 2018; 46(2): 159-64.	detection method, no mention of rinse water
Vanhems P, Gayet-Ageron A, Ponchon T, Bernet C, Chayvialle JA, Chemorin C, Morandat L, Bibollet MA, Chevallier P, Ritter J, Fabry J: Follow-up and management of patients exposed to a flawed automated endoscope washer-disinfector in a digestive diseases unit. Infect Control Hosp Epidemiol 2006; 27: 89–92.	exposure to contaminated endoscopes, no mention of rinse water
Verbaan H, Molnegren V, Pentmo I, et al. Prospective Study of Nosocomial Transmission of Hepatitis C in a Swedish Gastroenterology Unit. Infect Control Hosp Epidemiol 2008;29:83-5	exposure to contaminated endoscopes, no mention of rinse water
Verfaillie CJ, Bruno MJ, Voor in ’t holt AF et al. Withdrawal of a novel design duodenoscope ends outbreak of a VIM-2-producing *Pseudomonas aeruginosa*. Endoscopy 2015; 47: 493 – 502	outbreak, no mention of rinse water
Vijayaraghavan, R., Chandrashekhar, R., Sujatha, Y. & Belagavi, C. S. (2006). Hospital outbreak of atypical mycobacterial infection of port sites after laproscopic surgery. J Hosp Infect 64, 344– 347.	not endoscopes
Visrodia K Hanada Y Pennington KM Tosh PK Topazian MD Petersen BT Duodenoscope reprocessing surveillance with adenosine triphosphate testing and terminal cultures: a clinical pilot study. Gastrointest Endosc. 2017; 86: 180-186	surveillance of endoscopes, no data on rinse water
Visrodia, K. and B. T. Petersen (2017). Echoing concerns related to endoscope reprocessing. Gastrointestinal Endoscopy 85(2): 398-400.	not primary data
Wang P, Xu T, Ngamruengphong S, et al. Rates of infection after colonoscopy and osophagogastroduodenoscopy in ambulatory surgery centres in the USA. Gut. 2018;67(9):1626-1636	assessing the risk of infection, no mention of rinse water
Weber DJ and Rutala WA. Assessing the risk of disease transmission to patients when there is a failure to follow recommended disinfection and sterilization Guidelines. Am J Infect Control 2013; 41(5 Suppl): S67-71.	not primary data
Weber DJ, Rutala WA: Lessons learned from outbreaks and pseudo-outbreaks associated with bronchoscopy. Infect Control Hosp Epidemiol 2012; 33: 230–234.	not primary data
Wendorf K, Kay M, Baliga C et al. Endoscopic retrograde cholangiopancreatography- associated AmpC *Escherichia coli* outbreak. Infect Control Hosp Epidemiol 2015; 36: 634 – 642	outbreak, no mention of rinse water
Wendt C, Schutt S, Dalpke AH, Konrad M, Mieth M, Trierweiler-Hauke B, Weigand MA, Zimmermann S, Biehler K, Jonas D. First outbreak of *Klebsiella pneumoniae*	not endoscopes

carbapenemase (KPC)-producing K. pneumoniae in Germany. Eur J Clin Microbiol Infect Dis. 2010;29:563–70	
Wu H, Shen B. Health care-associated transmission of hepatitis B and C viruses in endoscopy units. Clin Liver Dis 2010;14:61-68	not primary data
Yu-Hsien L. Te-Li C. Chien-Pei C. et al. Nosocomial *Acinetobacter* genomic species 13TU endocarditis following an endoscopic procedure. Intern Med. 2008; 47: 799-802	outbreak, no mention of rinse water
Zhang X, Kong J, Tang P, et al. Current status of cleaning and disinfection for gastrointestinal endoscopy in China: a survey of 122 endoscopy units. Dig Liver Dis 2011;43:305-308.	survey of practice, no mention of rinse water
Zhou ZY, Hu BJ, Qin L, et al. Removal of waterborne pathogens from liver transplant unit water taps in prevention of healthcare-associated infections: a proposal for a cost-effective, proactive infection control strategy. Clin Microbiol Infect 2014;20:310-4.	not endoscopes
Zlojtro M., Jankovic M., Samarzija M., Zmak L., Jankovic V.K., Obrovac M., Zlojtro I., Jakopovic M. (2015). Nosocomial pseudo-outbreak of *Mycobacterium gordonae* associated with a hospital's water supply contamination: a case series of 135 patients. J. Water Health. 13, 125-130	not endoscopes
Zong Z Biliary tract infection or colonization with *Elizabethkingia meningoseptica* after endoscopic procedures involving the biliary tract. Intern Med, (1):11-15 2015	outbreak, no mention of rinse water
Zuhlsdorf B, Martiny H. Intralabortory reproducibility of the German test method of prEN ISO 15883-1 for determination of the cleaning efficacy of washer-disinfectors for flexible endoscopes. J Hosp Infect 2005;59:286-91.	detection method, no mention of rinse water
Zühlsdorf B. Floss H. Martiny H. Efficacy of 10 different cleaning processes in a washer disinfector for flexible endoscopes. J Hosp Infect. 2004; 56: 305-311	evaluation of disinfection process, no data on rinse water
Zweigner J, Gastmeier P, Kola A, Klefisch FR, Schweizer C, Hummel M. A carbapenem-resistant *Klebsiella pneumoniae* outbreak following bronchoscopy. Am J Infect Control 2014;42:936-7.	outbreak, no mention of rinse water

Appendix 3 – Quality appraisal

a. Checklist used for quality appraisal

JBI checklist for case series

Question	Possible answers
1. Were there clear criteria for inclusion in the case series? The authors should provide clear inclusion (and exclusion criteria where appropriate) for the study participants. The inclusion/exclusion criteria should be specified (e.g., risk, stage of disease progression) with sufficient detail and all the necessary information critical to the study.	Yes No Unclear n/a
2. Was the condition measured in a standard, reliable way for all participants included in the case series? The study should clearly describe the method of measurement of the condition. This should be done in a standard (i.e. same way for all patients) and reliable (i.e. repeatable and reproducible results) way.	Yes No Unclear n/a
3. Were valid methods used for identification of the condition for all participants included in the case series? Many health problems are not easily diagnosed or defined and some measures may not be capable of including or excluding appropriate levels or stages of the health problem. If the outcomes were assessed based on existing definitions or diagnostic criteria, then the answer to this question is likely to be yes. If the outcomes were assessed using observer reported, or self-reported scales, the risk of over- or under-reporting is increased, and objectivity is compromised. Importantly, determine if the measurement tools used were validated instruments as this has a significant impact on outcome assessment validity.	Yes No Unclear n/a
4. Did the case series have consecutive inclusion of participants? Studies that indicate a consecutive inclusion are more reliable than those that do not. For example, a case series that states 'we included all patients (24) with osteosarcoma who presented to our clinic between March 2005 and June 2006' is more reliable than a study that simply states 'we report a case series of 24 people with osteosarcoma.'	Yes No Unclear n/a
5. Did the case series have complete inclusion of participants? The completeness of a case series contributes to its reliability (1). Studies that indicate a complete inclusion are more reliable than those that do not. A stated above, a case series that states 'we included all patients (24) with osteosarcoma who presented to our clinic between March 2005 and June 2006' is more reliable than a study that simply states 'we report a case series of 24 people with osteosarcoma.'	Yes No Unclear n/a
6. Was there clear reporting of the demographics of the participants in the study? The case series should clearly describe relevant participant's demographics such as the following information where relevant: participant's age, sex, education, geographic region, ethnicity, time period, education.	Yes No Unclear n/a
7. Was there clear reporting of clinical information of the participants? There should be clear reporting of clinical information of the participants such as the following information where relevant: disease status, comorbidities, stage of disease, previous interventions/treatment, results of diagnostic tests, etc.	Yes No Unclear n/a
8. Were the outcomes or follow-up results of cases clearly reported? The results of any intervention or treatment should be clearly reported in the case series. A good case study should clearly describe the clinical condition post-intervention in terms of the presence or lack of symptoms. The outcomes of management/treatment when presented as images or figures can help in conveying the information to the reader/clinician. It is important that adverse events are clearly documented and described, particularly a new or unique condition is being treated or when a new drug or treatment is used. In addition, unanticipated events, if any that may yield new or useful information should be identified and clearly described.	Yes No Unclear n/a
9. Was there clear reporting of the presenting site(s)/clinic(s) demographic information? Certain diseases or conditions vary in prevalence across different geographic regions and populations (e.g. women vs. men, sociodemographic variables between countries). The study sample should be described in sufficient detail so that other researchers can determine if it is comparable to the population of interest to them.	Yes No Unclear n/a

10. Was statistical analysis appropriate? As with any consideration of statistical analysis, consideration should be given to whether there was a more appropriate alternate statistical method that could have been used. The methods section of studies should be detailed enough for reviewers to identify which analytical techniques were used and whether these were suitable.	Yes No Unclear n/a

b. Quality appraisal results

authors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Bajolet, 2013[9]	🟢	🟢	🟢	🟡	🟡	🟢	🟢	🟢	🟢	⚪
Bou, 2006[10]	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Cetre, 2005[11]	🟢	🟢	🟡	🟡	🟡	🔴	🔴	🟡	🟢	⚪
Chang, 2013[12]	🟢	🟢	🟢	🟢	🟢	🔴	🔴	🟡	🟢	⚪
Guy, 2016[13]	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Kumarage, 2019[14]	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🟢	🟢	⚪
Levy, 2003[15]	🟢	🟢	🟢	🟡	🟡	🟢	🟢	🟢	🟢	🟢
Robertson, 2017[16]	🟢	🟢	🟢	🟢	🟢	🔴	🔴	🟢	🟡	⚪
Shimono, 2008[17]	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🟡	🟢	⚪
Srinivasan, 2003[18]	🟢	🟢	🟢	🟡	🟡	🔴	🔴	🟢	🟢	⚪
Wedelboe, 2007[19]	🟡	🟢	🟢	🟡	🟡	🔴	🔴	🔴	🟡	🟢
Imbert, 2005[20]	⚪	🟢	🟢	⚪	⚪	🟢	🟢	🟢	🔴	⚪

Appendix 4 – Evidence tables

a. Characteristics of the included studies

Author, Year	**Study Design**	**Country**	**Type of procedure/ scope**	**Type of disinfection**	**Rinse water tested**	**Microorganisms involved**
Bajolet, 2013[9]	Outbreak report	France	Gastroscopy	Automated	Yes	*Pseudomonas aeruginosa*
Bou, 2006[10]	Outbreak report	Spain	Bronchoscopy	Both	No	*Pseudomonas aeruginosa*
Cetre, 2005[11]	Outbreak report	UK	Bronchoscopy	Manual	Yes	Enterobacteraceae
Chang, 2013[12]	Outbreak report	Taiwan	Ureteroscopy	Manual	Yes	*Enterobacter cloacae*
Guy, 2016[13]	Outbreak report	France	Bronchoscopy	Automated	Yes	*Pseudomonas aeruginosa* *Stenotrophomonas maltophilia*
Kumarage, 2019[14]	Outbreak report	UK	Ureteroscopy	Automated	Yes	*Pseudomonas aeruginosa*
Levy, 2003[15]	Outbreak report	France	Transoesophageal echocardiography	Manual	Yes	*Legionella pneumophila*
Robertson, 2017[16]	Outbreak report	UK	ERCP (w/ duodenoscope)	Automated	Yes	*Salmonella enteritidis*
Shimono, 2008[17]	Outbreak report	Japan	Bronchoscopy	Automated	Yes	*Pseudomonas aeruginosa*
Srinivasan, 2003[18]	Outbreak report	USA	Bronchoscopy	Automated	Yes	*Pseudomonas aeruginosa*
Wedelboe, 2007[19]	Outbreak report	USA	Cystoscopy	Manual	Yes	*Pseudomonas Aeruginosa*

Imbert, 2005[20]	Case study	France	ERCP	Automated	Yes	*Methylobacterium mesophilicum*
Abdolrasouli, 2021[21]	Pseudo-outbreak report	UK	Bronchoscopy	Automated	Yes	*Rhinocladiella similis*
Botana-Rial, 2016[22]	Pseudo-outbreak report	Spain	Bronchoscopy	Automated	Yes	*Pseudomonas putida* *Stenotrophomonas maltophilia*
Campos-Gutierrez, 2020[23]	Pseudo-outbreak report	Spain	Bronchoscopy	Automated	Yes	*Mycobacterium fortuitum*
Chroneou, 2008[24]	Pseudo-outbreak report	USA	Bronchoscopy	Automated	No	*Mycobacterium chelonae*
Falkinham, 2010[25]	Pseudo-outbreak report	USA	Bronchoscopy	Automated	Yes	*Mycobacterium avium* *Mycobacterium intracellulare*
Gillespie, 2000[26]	Pseudo-outbreak report	UK	Bronchoscopy	Automated	Yes	*Mycobacterium chelonae*
Guimaraes, 2016[27]	Pseudo-outbreak report	Brazil	Gastroscopy Bronchoscopy	Automated	NR	*Mycobacterium abscessus* subsp *bolletii*
Kirschke, 2003[28]	Pseudo-outbreak report	USA	Bronchoscopy	Automated	Yes	*Pseudomonas aeruginosa* *Serratia marcescens*
Levy, 2016[29]	Pseudo-outbreak report	Israel	Bronchoscopy	Automated	Yes	*Fusarium solani*
Rosengarten, 2010[30]	Pseudo-outbreak report	Israel	Bronchoscopy	Automated	Yes	*Burkholderia cepacia*
Rossetti, 2002[31]	Pseudo-outbreak report	Italy	Bronchoscopy	Automated	Yes	*Mycobacterium gordonae*
Scorzolini, 2016[32]	Pseudo-outbreak report	Italy	Bronchoscopy	Automated	Yes	*Mycobacterium gordonae*

Seidelman, 2018[33]	Pseudo-outbreak report	USA	Bronchoscopy	Automated	No	*Mycobacterium avium*
Seidelman, 2021[34]	Pseudo-outbreak report	USA	Bronchoscopy	Not reported	Not reported	Adenovirus
Silva, 2003[35]	Pseudo-outbreak report	Brazil	Bronchoscopy	Manual	Yes	*Pseudomonas aeruginosa* *Serratia marcescens*
Stigt, 2015[36]	Pseudo-outbreak report	Netherlands	Ultrasound endoscopes bronchoscopes	Automated	Yes	*Stenotrophomonas maltophilia*
Waite, 2016[37]	Pseudo-outbreak report	UK	Bronchoscopy	Manual	Yes	*Stenotrophomonas maltophilia*
Zhang, 2020[38]	Pseudo-outbreak report	China	Bronchoscopy	Both	Yes	*Pseudomonas aeruginosa*
Bissett, 2006[39]	Environmental survey	Australia	Gastroscopes Colonoscopes	Automated	No	Any microorganism
Khalsa, 2014[40]	Environmental survey	UK	ENT scopes Bronchoscopes Gastroscopes, Duodenoscopes, Colonoscopies	Automated	Yes	*Aspergillus fumigatus*
Lu, 2012[41]	Environmental survey	China	Gastroscopes Colonoscopy	Both	Yes	Anaerobic bacteria Aerobic bacteria *Mycobacterium tuberculosis*
Marek, 2014[42]	Environmental survey	UK	Endoscopy reprocessing units	Automated	Yes	Any microorganism
Pang, 20023[43]	Environmental survey	Australia	Gastroscopy	Automated	Yes	Any microorganism
Parnell, 2001[44]	Environmental survey	UK	Bronchoscopes GI scopes	Automated	Yes	*Mycobacterium chelonae* *Acremonium*

Paula, 2015[45]	Environmental survey	Austria	Duodenoscopes Choledoscope Baby endoscope Endoscoping ultrasound	Automated	Yes	Any microorganism
Tschudin-Sutter, 2011[46]	Environmental survey	Switzerland	Bronchoscopy Duodenoscopes Colonoscopy Gastroscopy	Automated	Yes	*Pseudomonas aeruginosa*
Tunuguntla, 2004[47]	Environmental survey	USA	Gastroscopes	Automated	No	*Pseudomonas aeruginosa*
Willis, 2006[48]	Environmental survey	UK	Not reported	Automated	Yes	Any microorganism
Cottarelli, 2020[49]	Environmental survey	Italy	Gastroscopes Colonoscopes Bronchoscopes Laryngoscopes	Automated and manual	Yes	*Pseudomonas aeruginosa* *Klebsiella pneumoniae* *Escherichia coli* Other Enterobacteriaceae Other Gram-negative nonfermentant
Decristoforo, 2018[50]	Environmental survey	Austria	Gastroscopes	Automated	Yes	Enterococci Enterobacteriaceae (E coli and others) *Pseudomonas aeruginosa* Gram-negative non-fermenters *Staphylococcus aureus* Alpha-haemolytic streptococci
Ji, 2020[51]	Environmental survey	China	Gastroscopes	Automated and manual	Yes	Any bacteria
Obee, 2005[52]	Environmental survey	UK	GI scopes	Automated	Yes	Any microorganism
Ren-Pei, 2014[53]	Environmental survey	China	Endoscopes, types not reported	Both	No	Any microorganism

Ribeiro, 2012[54] Ribeiro, 2013[55]	Environmental survey	Brazil	Colonoscopes Gastroscopes	Manual	No	Any microorganism
de Vos, 2006[56]	Laboratory experiment	Belgium	Gastroscopes	Automated	Yes	Fungi

b. Summary of findings tables

Outbreaks

Author, Year	**Country**	**Type of procedure/ scope**	**Microorganisms involved**	**Type of disinfection**	**No of affected patients**	**Rinse water used**	**Results of rinse water testing**
Bajolet, 2013[9]	France	Gastroscopy	Pseudomonas aeruginosa	Automated	4	Filtered	Negative
Bou, 2006[10]	Spain	Bronchoscopy	Pseudomonas aeruginosa	Automated or manual	17	Filtered	Negative
Cetre, 2005[11]	UK	Bronchoscopy	Enterobacteraceae	Manual	2*	Filtered	Negative
Chang, 2013[12]	Taiwan	Ureteroscopy	Enterobacter cloacae	Manual	15	Sterile	Negative
Guy, 2016[13]	France	Bronchoscopy	Pseudomonas aeruginosa Stenotrophomonas maltophilia	Automated	10	Not reported	Negative
Kumarage, 2019[14]	UK	Ureteroscopy	Pseudomonas aeruginosa	Automated	14	Not reported	Negative
Levy, 2003[15]	France	Transoesophageal echocardiography	Legionella pneumophila	Manual	3	Filtered	Positive

Robertson, 2017[16]	UK	ERCP	Salmonella enteritidis	Automated	4	Not reported	Negative
Shimono, 2008[17]	Japan	Bronchoscope-assisted thoracic surgery	Pseudomonas aeruginosa	Automated	7	Sterile	Negative
Srinivasan, 2003[18]	USA	Bronchoscopy	Pseudomonas aeruginosa	Automated	39	Not reported	Negative
Wedelboe, 2007[19]	USA	Cystoscopy	Pseudomonas aeruginosa	Manual	23	Tap	Positive
Imbert, 2005[20]	France	ERCP	Methylobacterium mesophilicum	Automated	1	Not reported	Negative
Total:	France: 4 UK: 3 USA: 2 Japan: 1 Spain: 1 Taiwan: 1	Bronchoscopy: 4 ERCP: 2 Ureteroscopy: 2 Gastroscopy: 1 Cystoscopy: 1 BATS: 1 TOE: 1	P aeruginosa: 7 S maltophilia: 1 M mesophilicum: 1 S enteritidis: 1 L pneumophila: 1 E cloacae: 1 Enterobacteraceae: 1	Automated: 7 Both: 1 Manual: 4	139	Sterile: 2 Filtered: 4 Tap: 1 NR: 5	Negative: 10 Positive: 2

Pseudo-outbreaks

Author, Year	**Country**	**Type of procedure/ scope**	**Microorganisms involved**	**Type of disinfection**	**No of cases**	**Rinse water used**	**Results of rinse water testing**
Abdolrasouli, 2021[21]	UK	Bronchoscopy	Rhinocladiella similis	Automated	9	NR[I]	Negative
Botana-Rial, 2016[22]	Spain	Bronchoscopy	Pseudomonas putida Stenotrophomonas maltophilia	Automated	39	Filtered	Positive[II]
Campos-Gutierrez, 2020[23]	Spain	Bronchoscopy	Mycobacterium fortuitum	Automated	9	Tap	Positive

Chroneou, 2008[24]	USA	Bronchoscopy	Mycobacterium chelonae	Automated	9	Filtered	Positive
Falkinham, 2010[25]	USA	Bronchoscopy	Mycobacterium avium Mycobacterium intracellulare	Automated	9	Filtered + UV treated	Negative[iii]
Gillespie, 2000[26]	UK	Bronchoscopy	Mycobacterium chelonae	Automated	2	NR	Positive
Guimaraes, 2016[27]	Brazil	Gastroscopy Bronchoscopy	M abscessus subsp bolletii	Automated	5	Filtered	Positive[iv]
Kirschke, 2003[28]	USA	Bronchoscopy	Pseudomonas aeruginosa Serratia marcescens	Automated	20 (PA) +6 (SM)	Filtered	Negative
Levy, 2016[29]	Israel	Bronchoscopy	Fusarium solani	Automated	5	Filtered	Positive[v]
Rosengarten, 2010[30]	Israel	Bronchoscopy	Burkholderia cepacia	Automated	3	Filtered	Positive
Rossetti, 2002[31]	Italy	Bronchoscopy	Mycobacterium gordonae	Automated	16	Filtered	Positive
Scorzolini, 2016[32]	Italy	Bronchoscopy	Mycobacterium gordonae	Automated	7	Tap	Negative[vi]
Seidelman, 2018[33]	USA	Bronchoscopy	Mycobacterium avium	Automated	173	Filtered	Positive[vii]
Seidelman, 2021[34]	USA	Bronchoscopy	Adenovirus	Not reported	10	NR	NR[viii]
Silva, 2003[35]	Brazil	Bronchoscopy	Pseudomonas aeruginosa Serratia marcescens	Manual	7	Filtered	Positive
Stigt, 2015[36]	Netherlands	Ultrasound endoscopes Bronchoscopes	Stenotrophomonas maltophilia	Automated	3	NR	Negative

Waite, 2016[37]	UK	Bronchoscopy	Stenotrophomonas maltophilia	Manual	13	Sterile	Negative
Zhang, 2020[38]	China	Bronchoscopy	Pseudomonas aeruginosa	Both	NR	Filtered	Positive[ix]
Total:	USA: 5 UK: 3 Spain: 2 Brazil: 2 Israel: 2 Italy: 2 Netherlands: 1 China: 1	Bronchoscopy: 18 Ultrasound: 1 Gastric: 1	NMT: 8 P aeruginosa: 3 S maltophilia: 3 Fungi: 2 S marcescens: 2 P putida: 1 B cepacia: 1 Adenovirus: 1	Automated:14 Manual: 2 Both: 1 NR: 1	-	Tap: 2 Filtered: 10 Filtered + UV:1 Sterile: 1 NR: 4	Positive: 11 Negative: 6 NR: 1

Surveillance studies

Author, Year	Type of water used	Type of sampling	Duration	Frequency	Benefit	Criteria for failed quality
Bissett, 2006[39]	Filtered	Endoscopes	80 weeks	Not reported	Reported no benefit**	Any bacterial growth
Khalsa, 2014[40]	Filtered	Final rinse water	Not reported	Weekly & quarterly	Reported benefit	*Pseudomona*s spp., NTM, *Legionella* >0 cfu/100 mL), endotoxin >0.25 unit/mL
Lu, 2012[41]	Purified by reverse osmosis	AERs	5 years	Monthly	Reported benefit	Any bacterial growth
Marek, 2014[42]	Purified by reverse osmosis	Final rinse water	5 years	Weekly	Reported benefit*	TVC: cfu/100ml >10. *Pseudomonas*, NTM or *Legionella* >0cfu, endotoxin >25EU/ml
Pang, 20023[43]	Filtered	Final rinse water	5 years	Weekly	Reported benefit	TVC: cfu/100ml >100
Parnell, 2001[44]	Filtered	Final rinse water	1 year	Weekly	Reported benefit	Any bacterial growth
Paula, 2015[45]	Not reported	Final rinse water	10 years	1x year	Reported benefit	Growth of anything other than skin contaminants

Tschudin-Sutter, 2011[46]	Filtered	Final rinse water	10 years	2x week	Reported benefit	Growth of *P. aeruginosa*
Tunuguntla, 2004[47]	Not reported	Store water	10 years	4-monthly	Reported benefit	Not reported
Willis, 2006[48]	Filtered + disinfected	Final rinse water	4 months	NR	Reported benefit	Any bacterial growth

* reported benefit of monitoring but also mentioned that current criteria of <10cfu/100ml unrealistic; ** authors did not use monitoring but opted for more frequent changes of filters, reported that this action made monitoring unnecessary

Environmental surveys

Author, Year	Type of procedure	Microorganisms involved	Type of disinfection	Sample type	Total samples	Contaminated samples	Reviewer's comments
Cottarelli, 2020[49]	Gastroscopes Colonoscopes Bronchoscopes Laryngoscopes	Pseudomonas aeruginosa Klebsiella pneumoniae Escherichia coli Other Enterobacteriaceae Other Gram-negative nonfermentant	Both	Final rinse water	25	15 (60%)	11 endoscope suites 3 used sterile water (1 automatic and 2 manual), 5 used demineralised water (all automatic) and 3 did not use rinsing (all manual). 92/143 (64.3%) of endoscopes were free of indicator microorganisms. Endoscopes contaminated with indicator organisms: 47/102 (46.1%) of GI gastroscopes, 4/41 (9.8%) of broncho/laryngoscopes. Endoscopes with <1 cfu/ml: 45/130 (34.6%), 1-20 cfu/ml 36/130 (27.7%), >20 cfu/ml: 49/130 (37.7%). Authors reported that no standard procedures for reprocessing were implemented
Decristoforo, 2018[50]	Gastroscopes	Enterococci Enterobacteriaceae (E coli and others) Pseudomonas aeruginosa gram-negative nonfermenters Staphylococcus aureus	Automated	Final rinse water	Phase 1: 51 Phase 2: 52	Phase 1: 1 (2%) Phase 2: 6 (11.5%)	A total of 29 centres participated in the study with 51 AERs in phase 1 and 54 in phase 2. Phase 1: organism was *P. oleovorans* which resulted in one contaminated endoscope, there were further eight AERs which failed but these had -ve rinse water and endoscopes were not contaminated. Phase 2: organism was *P.aeruginosa* (n=5) and *P.oleovorans (*n=1) which

		alpha-hemolytic streptococci					caused with 3/6 contaminating the sampled endoscope.
Ji, 2020[51]	Gastroscopes	All bacteria	Both	Final rinse water	180	114 (63.3%)	114/180 (63.3%) samples contaminated, with up to 91,000 cfu/100ml, considered contaminated if >20cfu. No difference in contamination rate based on AER vs manual cleaning, significant difference based on type of water used.
Obee, 2005[52]	GI scopes	Any microorganism	Automated	Different locations including rinse water			Reported results of environmental survey undertaken in two endoscopy units in two different hospitals, where 63 GI endoscopes routinely processed in AERs were evaluated. Sampling also included different locations which authors considered important for potential disinfection failures, including the rinse water from AERs. Endoscopes and the locations were assessed using two methods: dipslides and ATP. The number of rinse water samples was not provided but authors reported that according to dipslides results, 4% of the samples were contaminated in unit A and 0% in unit B. According to ATP testing, none of the samples were contaminated. Authors concluded that the rinse water was of good quality in both units using both assessment methods and unlikely to be a source of contamination for the endoscopes in this study.
Ren-Pei, 2014[53]	Endoscopes, types not reported	Any microorganism	Reports the results of sampling the endoscopes from 66 hospitals and using SEM to assess the biofilm formation. All hospitals provided data on reprocessing procedures. 48/66 (72%) of hospitals used manual cleaning. A total of 36/66 (54.6%) of endoscopes had biofilm visible under SEM. when comparing endoscopes with and without biofilm, those which had biofilm had higher proportion of hospitals where manual cleaning was used (91.7%, 33/36 vs 50.0%, 15/30, $p<0.001$). There was no difference in the use of sterile water for rinsing between the hospitals which had endoscopes with and				

			without biofilm: (61.1%, 22/36 vs 60.0%, 18/30, p=0.927). Other significant factors for biofilm formation were: use of biofilm removal detergent, repeated use of detergent and drying with alcohol.
Ribeiro, 2012[54] Ribeiro, 2013[55]	Colonoscopes Gastroscopes	Any microorganism	37 GI endoscopy services participated in the survey where endoscopes were tested for contamination and services were asked to complete the questionnaire about their decontamination procedures. All centres used manual cleaning, 33/37 rinsed endoscopes after cleaning (89%). Of those which used rinsing 1/33 (3%) used bi-distilled water, 6/33 (18.2%) used filtered water for rinsing, and 26/33 (78.8%) used tap water. Authors also questioned the adequacy of using the tap for rinsing stating that the narrow channels of endoscopes would hinder the flow of water inside them. There were also other breaches in disinfection procedures. In 34/37 services (91%), at least one endoscope was contaminated. 33/39 of colonoscopes were contaminated mostly with Gram -ve bacteria, 50/62 gastroscopes contaminated with mostly intestinal flora.

Laboratory experiment

Author, Year	Type of procedure	Microorganisms involved	Type of disinfection	Sample type	Total samples	Contaminated samples	Reviewer's comments
de Vos, 2006[56]	Gastroscopes	Fungi	Automated	Final rinse water	10	4 (40%)	Laboratory experiment to establish whether solid phase cytometry was reliable in detecting fungi in water. Among other water samples, authors collected ten rinse water specimens from AER. No fungi detected on plates, 4 detected via solid phase cytometry with very low counts (2-5 cfu)

Appendix 5 – GRADE table

Number of studies	Quality assessment						Results		Effect		Quality of evidence
	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Exposed	Control	Relative RR [95%CI]	Absolute	
Outcome: risk of infection from contaminated rinse water											
12	Case series[9-20]	Serious[i]	No serious inconsistency	No serious indirectness	Serious imprecision[ii]	n/a	32/NR	NR	n/a	3/12 studies reported that infection occurred following exposure to a contaminated endoscope	Low
Outcome: presence of microorganisms in patient specimens											
18	Pseudo-outbreak reports[21-38]	Serious[iii]	No serious inconsistency	Serious indirectness[iv]	Serious imprecision[ii]	n/a	268/NR	NR	n/a	11/18 studies reported that rinse water was the reason for contamination of patient specimens	Moderate
Outcome: benefit of routine monitoring of rinse water											
10	Case series[39-48]	Serious[v]	No serious inconsistency	No serious indirectness	Serious imprecision[ii]	n/a	NR	NR	n/a	9/10 studies reported benefit of rinse water monitoring	Moderate
Outcome: relationship between rinse water quality and contamination of endoscopes											

6	Case series[49-56]	Serious[v]	No serious inconsistency	No serious indirectness	Serious imprecision[ii]	n/a	NR	NR	n/a	6/6 studies reported that sufficient rinse water quality results in less endoscopes contaminated	Very low
Outcome: presence of other micro-organisms in final rinse water											
1	Case series[57]	Serious[v]	No serious inconsistency	No serious indirectness	Serious imprecision[ii]	small quantities detected, not possible to know if clinically important	4/10	NR	n/a	1/1 studies showed other micro-organisms could be present which would not be detected by currently recommended process	Low

i – due to study design, all were case studies/series (outbreak studies), which are considered very low quality on the hierarchy of the evidence; ii – serious imprecision due to study design (no control group); iii – due to study design, all were pseudo-outbreak reports, which are considered very low quality on the hierarchy of the evidence; iv – all reported procedures were bronchoscopy; v – due to study design, all were environmental surveys, which are considered very low quality on the hierarchy of the evidence;

Appendix 6 – Summary of data from excluded outbreak studies

Author, Year	Country	Type of procedure	Microorganisms involved	No of patients affected	Type of disinfection	Reason for outbreak and comments
Alipour, 2017[57]	Turkey	Bronchoscopy	Pseudomonas aeruginosa	15/NR	Manual	Outbreak of MDR-PA in outpatient bronchoscopy unit, bronchoscopes processed manually, rinsed with sterile water. Total of 15 cases identified. Bronchoscope contaminated, with biofilm, but no lapses to procedures. Outbreak ended after ETO sterilisation. Authors reported taking environmental swabs including rinse water but they did not report the results of the testing. Concluded that disinfection according to protocol was still not sufficient and that sterilisation is required.
Alrabaa, 2013[58]	USA	ERCP	Klebsiella pneumoniae	7/NR	Automated	Patients identified in two hospitals (A, B) which previously had no cases of CRKP, all patients had ERCP done in another facility (C) which also received patients from another hospital (X). Reported that the ERPC scope was not disinfected according to manufacturer's instructions. Biodebris were found inside the implicated endoscope which was also contaminated with CR E coli. Hospital X also reported not to isolate Gram -ve MDRO. Further 3 cases in addition to the 7 were found infected with CR organisms. Facility C instructed to manually clean the elevator. All admissions from C and X pre-emptively isolated and screened – no further cases of CRO occurred in hospitals A and B.
Aumeran, 2010[59]	France	ERCP	Klebsiella pneumoniae	16/NR	Automated	Hospital outbreak of ESBL-KP which involved only patients who underwent ERCP.

						Environmental sampling found no contamination in AERs and surveillance of endoscopes repeatedly showed negative results. Eventually one duodenoscope found contaminated after a flush-brush-flush method was used. Evaluation of practice showed that manual cleaning before disinfection and drying were inadequate. Correction of these practices ended an outbreak.
Carbonne, 2010[60]	France	Duodenoscopy	Klebsiella pneumoniae	7	Automated	Outbreak involving 13 cases including an index case – 9 were colonisations and 4 were infections, seven (2 infections) were following endoscopy with duodenoscope contaminated from an index case. Authors reported that all disinfection procedures were appropriate but drying was not.
Corne, 2005[61]	France	Bronchoscopy	Pseudomonas aeruginosa	10/NR	Manual	Bronchoscopes were reported to be cleaned manually and disinfected using peracetic acid and rinsed using sterile water. 10 patients infected, further 12 transiently colonised. Authors reported no lapses in procedures. Also mentioned that tap water was tested but no results reported and tap water was not used for rinsing. Two bronchoscopes were found to be contaminated due to defective biopsy forceps.
DiazGranados, 2009[62]	USA	Bronchoscopy	Pseudomonas aeruginosa	2	NR	11/20 exposed to one bronchoscope had positive BAL samples. There was another positive sample but it was a different strain. 2 patients had evidence of clinical infection. Bronchoscope samples found positive and matched BAL isolates. Removal of bronchoscope ended an outbreak. No lapses in procedures were identified, the only

						environmental sample positive for *P.aeruginosa* was a sink drain. Bronchoscope was regularly maintained and leak testing was performed. Engineering evaluation by the manufacturer revealed multiple defects (associated with the use) which resulted in insufficient disinfection. The earliest case where this strain was isolated was co-infected with TB and was most likely an index case which contaminated a bronchoscope (not included as case patient).
Epstein, 2014[63]	USA	ERCP	Escherichia coli	35	Automated	New Delhi Metallo-β-Lactamase–Producing Carbapenem-Resistant EC linked to ERCP. Scopes were manually cleaned and reprocessed in AER according to manufacturer's instructions, the only deviations were using a different enzymatic cleaner and brushes compatible but not produced by the manufacturer. Overall, 39 cases of which 35 had had ERCP. Procedure changed from automated to ethylene gas sterilisation. No lapses and no damage to endoscopes identified.
Fraser, 2004[64]	USA	ERCP	Pseudomonas aeruginosa	4	NR	Four isolates of MDR-PA from patients after ERCP triggered outbreak investigation. Five cases identified. 4/5 patients exposed to a same duodenoscope (for one not possible to identify), which was on loan from manufacturer and as with other endoscopes was subject to quarterly surveillance (negative a month earlier). One of 5 patients considered an index case, endoscope possibly contaminated due to inadequate disinfection. Source of an outbreak not investigated.

Galdys, 2019[65]	USA	Bronchoscopy	Pseudomonas aeruginosa Klebsiella pneumoniae	18+8	Automated	Outbreak of MDRPA and CRKP identified in ICU. A total of 33 patients undergoing bronchoscopy were identified. 23 were exposed to implicated bronchoscope, 19 infected with MDRPA (one considered an index case and 18 became infected) and 11 (2 considered index cases, one infected by genetically distinct isolate, total 8 infected) with CRKP. There were further six cases not exposed to bronchoscopes and most likely infected horizontally in ICU. All bronchoscopes were sampled and only one was positive. Both microorganisms were isolated from the implicated bronchoscopes which was also found to have a defective lumen containing biodebris. Authors reported no breaches in re-processing.
Humphries, 2017[66]	USA	ERCP	Klebsiella pneumoniae	16	Automated	Carbapenem- Resistant KP outbreak linked to ERCP. One case triggered an investigation which identified an index patient. Overall 50 cases infected with CR-KP of whom 16 patients (9 infected and 7 colonised) affected by one of two duodenoscopes. Investigation found no breaches in practice, endoscopes processed manually and disinfected in AERs. All endoscopes were <1year (except one which was eventually not implicated in an outbreak), were adequately maintained and passed leak tests. Implicated two endoscopes which consistently tested negative – permanently removed from service. All scopes now sterilised using ethylene gas.
Jimeno, 2016[67]	Spain	Cystoscopy	Salmonella spp.	4/NR	NR	All patients had UTI due to *Salmonella* spp. One patient was an index case who was later found

						to have urine positive for *Salmonella* but no clinical infection at the time of cystoscopy. No Salmonella found in environmental samples which were taken to investigate an outbreak. No further cases occurred after a more intense protocol for endoscope disinfection was implemented.
Jorgensen, 2016[68]	Norway	Bronchoscopy	Klebsiella pneumoniae	5	Automated	Heat-resistant, extended-spectrum b-lactamase-producing KP. Hospital had an established programme for surveillance of microorganisms in ICU. Increased number of BAL specimens positive for KP initiated an investigation which was linked to a contaminated bronchoscope. No breaches in practice except a small than recommended brush used in manual cleaning (suspected biofilm formation as a result) and no environmental samples positive. Bronchoscope persistently contaminated and no damage or design issues found.
Katsinelos, 2002[69]	Greece	ERCP	P aeruginosa	2/NR	Automated	Two cases of *P aeruginosa* infection occurred 48 hrs after ERCP was conducted. Patient developed septicaemia and hepatic abscesses. Duodenoscope washer and bottled water used for irrigation were negative but authors concluded that duodenoscope must have remained contaminated following disinfection.
Kola, 2015[70]	Germany	ERCP	Klebsiella pneumoniae	6/19	Automated	Outbreak of CRKP with a total of 12 patients. Four patients were found infected following ERCP using the same duodenoscope. Follow up of 19 patients who underwent ERCP with the same scope and were available for follow up (further 3 were not available) revealed two

						additional cases. All 12 cases strongly related. No CRKP isolated from implicated duodenoscope and environmental samples all negative. Authors concluded duodenoscope must have been initially contaminated but since it underwent several disinfection cycles no CRKP were recovered. Also reported that no lapses in disinfection but enterococci were found on duodenoscopes which indicates that re-processing may not have been adequate in some cases.
Kovaleva, 2009[71]	Netherlands	ERCP	Pseudomonas aeruginosa	3/36 (8.3%)	Automated	Two cases of MDR-PA sepsis after ERCP triggered outbreak investigation. Endoscope persistently contaminated despite HDL and negative samples of environment. A record of 36 patients who underwent ERCP revealed one additional case. Scope eventually decontaminated after ETO sterilisation but re-contaminated 4 months later (with different strains). Manufacturer's investigation revealed that endoscope appeared undamaged but that there were some structures in an inner channel suggesting biofilm, inner channel replaced
Lo Passo, 2001[72]	Italy	Gastro-oesophageal endoscopy	Trichosporon asahii	2/NR	NR	Two cases of *T asahii* associated with contaminated endoscope. Authors did not attempt to find a source but aimed to link two retrospective cases to endoscope. No mention of rinse water.
Lupse, 2012[73]	Romania	ERCP	Escherichia coli	1/NR	NR	A case study of transmission of ESBL Producing EC following ERCP. Authors did not attempt to find a source of contamination
Mansour, 2008[74]	Tunisia	Ureteroscopy	Pseudomonas aeruginosa	12	Manual	Outbreak following ureteroscopy, due to contaminated water used for bladder irrigation

						– tap water contaminated. The irrigation water was UV disinfected but the process failed to destroy PA. Rinse water for endoscopes not tested.
Marsh, 2015[75]	USA	ERCP	Klebsiella pneumoniae	37	NR	Carbapenemase producing KP outbreak following ERCP. Potential index case was identified which suggested failure in scope reprocessing. Three scopes were contaminated, WGS was performed to assess the relatedness. Authors reported a few clusters of KP infection linked to endoscope use, providing evidence that isolates from endoscopes and clinical samples were identical. No attempt to identify a source, no mention of rinse water.
Naas, 2010[76]	France	Gastroscopy	Klebsiella pneumoniae	6/10	Automated	Outbreak of three CRKP infections in one unit triggered an investigation. One of the cases was a patient who underwent gastroscopy few days previously, nosocomial transmission occurred to other patients. Another patient also infected following gastroscopy, cases two weeks apart but same endoscope used. Further analysis identified an index patient who was positive for CRKP during gastroscopy two months previously. In total, following the index patient, 17 patients underwent gastroscopy with the same scope. 6/10 of those available for follow up were colonised (n=4) or infected (n=2, those previously identified). Cross-transmission occurred in the above unit and in another hospital. Authors reported that there was a delay in re-processing and inadequate drying of the endoscopes which likely were the reasons for an outbreak. Authors also reported that

						changing from glutaraldehyde to peracetic acid (to prevent CJD) may have damaged the endoscope. Longer reprocessing ended an outbreak and surveillance of endoscopes is more frequent than 2x/year.
Qiu, 2015[77]	China	ERCP	Pseudomonas aeruginosa Klebsiella pneumoniae Escherichia coli	3/NR	NR	Outbreak after ERCP. Two patients infected with all three organisms, one infected only with *P aeruginosa*. Investigation showed that the same scope was used in all patients. Scope tested positive persistently despite disinfections and sterilisation with epoxyethane. Only negative after tubing inside was replaced. No mention of rinse water.
Ramsey, 2002[78]	USA	Bronchoscopy	Mycobacterium tuberculosis	10	NR	Outbreak occurred in 1999. 10/19 tested positive after bronchoscopy. 4 patients had evidence of infection and 6 seemed to be colonised with no symptoms. 9/10 patients had bronchoscopy with the same scope which was later found to have a hole, leak testing was not routinely performed.
Rauwers, 2019[79]	Netherlands	ERCP	Klebsiella pneumoniae	25	Automated	MDR-KP outbreak linked to two duodenoscopes. Cultures found persistent contamination of both scopes with identical microorganisms. Also found a range of other pathogenic microorganisms. All ERCP patients invited for screening of whom 81 accepted and 27 found infected or colonised, 2 of whom were considered index cases. 10 patients developed an active infection. Review of practice showed small lapses: e.g. cleaning with a newly designed brush recommended by manufacturer not implemented, no protocol that said to move forceps elevator to upright

						position for cleaning, leak test not performed. Also, duodenoscopes were found damaged and inappropriately repaired by the manufacturer.
Reddick, 2017[80]	Canada	Colonoscopy	Salmonella enteritidis	3/27	Automated	Two cases of salmonellosis following colonoscopy triggered an investigation. Four cases in total were identified and three had colonoscopy in the same hospital using the same scope. Scopes decontaminated manually, leak tested and then processed in AER. Authors reported that the unit was short of one hook for endoscope storage and as a result one of the endoscopes remained in AER after reprocessing. 24 further patients were identified who underwent colonoscopy with the same endoscope around the same time but no cases were identified. Implicated endoscope was negative for *Salmonella* – suggested that scope was disinfected many times since infections and no longer contaminated. Source not identified, no mention whether environmental samples were taken.
Schelenz, 2000[81]	UK	Bronchoscopy	Pseudomonas aeruginosa	10	Automated	Outbreak of MDR-PA associated with bronchoscopy, most likely due to contaminated AER. A cluster of PA cases (two strains) in ICU triggered an outbreak investigation. Bronchoscopes were manually scrubbed and processed in AER with a sterile water used for final rinse. Samples were taken from AER but no mention if this included rinse water. 11 cases identified, all with one of two isolates, one was index patient who had PA and S aureus pneumonia – all cases underwent bronchoscopy. 2/3 bronchoscopes

						contaminated with matching isolates. All environmental samples negative except AER – where 20/21 samples were contaminated (no mention of rinse water or filters), although only one grew PA. authors mentioned that manufacturer's instructions for AER maintenance were not followed.
Shenoy, 2018[82]	USA	ERCP	Klebsiella pneumoniae	5	Automated	Colistin-resistant KP. Index patient underwent ERCP, second case had ERCP done with the same duodenoscope 10 days later. Reported that scopes were processed according to manufacturer's instructions and additionally: had a second HLD in AER, had a bioburden check between manual clean and HDL and were periodically tested. Index case infected 8 patients, 5 were exposed to duodenoscope. One of these patients infected further 15 in the ward before they were isolated. No breaches in IPC were identified, duodenoscope tested negative after each reprocessing and same results were obtained by an independent laboratory. CDC obtained low levels of E coli and K pneumoniae from the scope but KP without colistin resistance. Manufacturer evaluation of the duodenoscope identified an area at the distal tip where adhesive had peeled off and where foreign materials were found.
Smith, 2015[83]	USA	ERCP	Escherichia coli	4/27	NR	Three patients with New Delhi metallo-b-lactamase EC infection following ERCP with the same scope triggered an outbreak investigation. Scope was tested and was negative – suspected eradicated by the time of

						testing. Decision was made to sterilise with ETO before use again. Index patient was identified as a person who was previously hospitalised in India and underwent ERCP, his biliary specimen matched the isolates obtained from his blood a month earlier. Investigation identified 27 patients exposed to the duodenoscope following the index. Further case was identified. No lapses in reprocessing were identified.
Sorin 2001[84]	USA	Bronchoscopy	Pseudomonas aeruginosa	18	Automated	Historical outbreak which occurred in 1998. All bronchoscopes were cleaned in dedicated endoscopy suite, all underwent manual cleaning and HDL in AER. Cases appeared immediately after an installation of a new reprocessor. 18 cases identified, all linked to bronchoscopy, 3 developed clinical infection. All environmental samples were negative. Authors mentioned sampling tap water, but this was used for rinsing before HDL in AER. AER seemed to be functioning but there were faulty connections between the AER and bronchoscopes which likely resulted in insufficient amount of disinfectant being injected into the channels. Correction ended an outbreak.
Sugiyama, 2000[85]	Japan	Upper Gastrointestinal Endoscopy	Helicobacter pylori	1	Manual	A case study of two patients who underwent gastroscopy and was *H pylori* positive following the procedure (negative before). Authors obtained isolates from patient's stomach as well as an isolate from previous patients who underwent gastroscopy being HP positive. Fingerprinting using gel electrophoresis showed

						that the isolate pairs matched for both cases. Authors concluded that fibergastroscopes were not decontaminated sufficiently between patients (no mention of rinse water)
Verfaille, 2015[86]	Netherlands	ERCP	Pseudomonas aeruginosa	22	NR	A total of 30 patients were identified. 22 patients underwent ERCP with the same duodenoscope. Investigation revealed that the scope design made the cleaning of endoscope difficult to decontaminate.
Wendorf, 2015[87]	USA	ERCP	Escherichia coli	32/NR	Automated	Outbreak of AmpC–producing *Escherichia coli*. Public health laboratory identified three cases of previously unknown isolate, increased to 7 cases later in a year. All cases underwent ERCT in the same hospital. Endoscopes and AERs tested, reprocessing procedures reviewed. A total of 32 cases identified, all had ERCP. Endoscope manufacturer confirmed all reprocessing procedures were above the standard and no lapses were observed. Of eight endoscopes sent for evaluation, seven had a defect not identified at the facility. Overall, of 60 endoscopes, 4 were contaminated, 2 with the AmpC EC. All environmental samples negative. Routine sampling revealed contamination on some endoscopes despite adequate processing – authors concluded that routine maintenance may be required.
Yu-Hsien, 2008[88]	Taiwan	Panendoscopy	Acinetobacter spp 13TU	1	NR	A case study of one patient who developed AB bacteraemia and endocarditis shortly after endoscopic procedure. Authors concluded that this procedure was most likely the reason for infection, no attempt to identify a source and

						speculated that the scope was contaminated from HCWs' hands. No mention of rinse water
Zong, 2015[89]	China	ERCP Endoscopic nasobiliary drainage	Elizabethkingia meningoseptica	20	NR	Report of 20 cases who had EM isolated from their bile samples. All cases underwent either ERCP or ENBD prior EM isolation which were concluded to be a significant risk factor for EM acquisition. No attempts were made to identify the sources, no mention of rinse water.
Zweigner, 2014[90]	Germany	Bronchoscopy	Klebsiella pneumoniae	3/NR	Automated	CR- KP outbreak in one hospital. A total of eight cases identified, three infected via bronchoscopy. Two bronchoscopes tested and both yielded heavy growth of CRKP. Environmental sampling done, including AER (no mention of rinse water) and all samples negative. All procedures according to manufacturer's instructions and guidelines, no lapses identified. Observed defects to the channels of instruments.

Appendix 7 – Summary of methodology recommended by different guidance for the monitoring of the final rinse water quality

Standard	Recommendation	Comment
Frequency of TVC test	Weekly[A1-A3] or weekly until established that water supply is consistently within spec and at more extended intervals thereafter.[A4]	Samples should continue to be collected weekly even if the TVC is within specification as outliers may be missed. Trending of the results will provide an indication of whether the results are satisfactory or whether there are areas of concern
Incubation temp	28 – 32°C	This incubation temperature will also culture potentially clinically relevant bacteria.
Incubation period	Examine after 48 hours and report if positive[A1-A4] Continue to incubate for 5 days for final report. [A1-A4]	It will be preferable to examine the culture plates and report after 48 hours to allow an early detection of the presence of clinically important bacteria that could affect patients. In addition, it is necessary to continue the incubation up to 5 dates and report the final results as described in BS EN ISO 15883-1:2009+A1:2014.[A4] This may help to detect environmental bacteria which could persist and subsequently form a biofilm within EWD.
Culture media	R2A [A1-A4]	Standard methods for the enumeration of heterotrophic bacteria in water have traditionally used nutritionally rich media, such as Plate Count Agar, with incubation at 35°C.[A5] It has been acknowledged that organisms isolated under these conditions may represent only a small percentage of the bacteria present in the sample.[A6] R2A Agar developed by Reasoner and Geldreich[A6] is a nutritionally reduced medium. It was demonstrated that using this medium and incubating for longer at lower temperatures resulted in the enhanced recovery of stressed and chlorine-damaged bacteria from treated waters, resulting in higher bacterial counts. This culture medium is commercially available in the UK in dehydrated form as well as ready-poured plates
Volume sampled	100 ml in duplicate [A1-A4]	Duplicate samples will increase the sensitivity of recovery.
Neutralizer in sample container	For example - 0.5% Sodium thiosulphate [A1-A4]	Residual chemicals e.g., disinfectants in the sample will inhibit the growth of bacteria. The neutralizer should be capable of neutralizing chemical residues without being inhibitory to possible contamination. The test laboratory should carry out validation of the neutralizer to confirm effective neutralization each time a new batch is prepared
Sample transport	Process within 4 hours or transport at 2-5°C and process within 48 hours [A1-A4]	This will reduce the possibility of microbial proliferation during transport. If the sample arrives out of specification, this should be reported within the results.
Acceptable limit	<10 cfu/100ml [A1-A4]	

Further advice	Tests for other organisms of clinical significance may need to be performed	It is advisable to determine the type of contamination as this may have an impact on the action taken e.g., Gram positive or Gram-negative bacteria.
Testing for indicator micro-organisms	*Pseudomonas spp.*[A1-A4] *Mycobacteria spp.*[A1,A2,A4] *Legionella spp.*[A2] *Enterobacteriaceae spp*.[A4] Endotoxins[A2,A4]	Test for the presence of *Pseudomonas* spp. and *Mycobacteria* spp. is considered mandatory and should be performed quarterly by all endoscope reprocessing units. The inclusion of other microorganisms (e.g. *Legionella spp.* or *Enterobacteriaceae spp.*) will depend on local circumstances. The inclusion of a test, as per the methods described in HTM 04-018,[A7] specifically for *P. aeruginosa* is recommended in HTM 01 06. Although this is recommended as a quarterly test, in areas of high prevalence weekly testing may be more beneficial.
Molecular detection methods	Not mentioned by either guidance[A1-A4]	Molecular detection methods, e.g., PCR test are an acceptable alternative method for detection of indicator micro-organisms such as *Pseudomonas* spp*., Mycobacteria* spp*., Legionella* spp*.* or *Enterobacteriaceae* spp.). There are currently no acceptable alternatives to TVC, testing must still be performed using the culture-based method.

Reference list for Table A7

A1 Department of Health. Health Technical Memorandum 01-06: Decontamination of flexible endoscopes. Part E: Testing methods. Department of Health, 2016.

A2 NHS Wales Shared Partnership. Welsch Health Technical Memorandum 01-06: Decontamination of flexible endoscopes. Part E: Testing methods. NHS Wales Shared Partnership, 2017.

A3 Health Protection Scotland. NHS Scotland Guidance for the interpretation and clinical management of endoscopy final rinse water. Health Protection Scotland, 2019.

A4 British Standards Institute. BS EN ISO 15883-1:2009+A1:2014: Washer-disinfectors. General requirements, terms and definitions and tests. British Standards Institute, 2009.

A5 American Public Health Association. *Standard Methods for the Examination of Drinking Water and Waste Water. 23rd Ed. APHA, Washington DC., 2017*

A6 Reasoner D.J., Geldreich E.E. A new medium for the enumeration and subculture of bacteria from potable water. Appl Environ Microbiol, 1985; 49(1):1-7

A7 Department of Health. Health Technical Memorandum 04-01: Safe water in healthcare premises. Department of Health, 2021.

Appendix 8 Other considerations for the final rinse water quality

Problems with water supplies and remedial actions

Water quality management can be difficult to understand and control for decontamination processes as there are many areas that contribute to poor water quality results. Users need to be fully aware of the water supply and distribution system and how the quality is managed at the point of use. Problems can manifest themselves within the EWD or within the water treatment equipment in the vicinity of the washroom as opposed to the actual incoming water supply. Regular monitoring and testing are required so that users can determine that standards are being maintained to provide safe water for patients.

Trend analysis of microbiological results assists in the management of the water quality and graphically analysing the results can assist with identifying recurring themes or issues. This can be demonstrated in the case study of one hospital which experienced increasing water counts that were due to a section of supply hose which was not achieving sufficient water temperature during a thermal self-disinfection regime for an EWD installation and hence resulted in microbial growth. At week 25, the hospital routinely changed the supply hose and avoided the high counts that always occurred if they left the hose unchanged. Many increases in results can be found from the hose example given, due to poor water (including rinse water), sample collection methods, filter changes and ineffective system cleaning. Hence there is an advantage of using trending as a tool to ensure that the microbial water quality is within specification.

The water quality supplied to the decontamination equipment requires an ongoing risk assessment within the water safety plan implemented by the wider decontamination team and water safety group and any remedial actions or treatment required needs to be agreed so that compliance can be maintained. It is necessary to understand the source of the water supply, i.e., whether the mains supply is directly fed to units or is from a water cistern / tank. It is also essential that the supply meets the requirements of the local water byelaws.[93] However, compliance with the byelaws can, in some cases, add problems to the service supplies because grade A air gaps must be fitted either in the supply to the EWD, or at the EWD's themselves to prevent backflow. Some decontamination equipment purchased from outside of the UK will require grade A air gaps to be fitted and this will need to be assessed at the procurement stage.

Where ball valve tank systems have to be fitted in line with the water supply, this will lead to oxygenation of the water in the cistern which has been shown to result in microbial growth. Care and monitoring are required by the water safety group to assess the quality of the water at this stage.

Typically the volume of cold water stored should be minimized and only a nominal 12 h on-site storage is recommended.[93] Multiple cold water storage cisterns require care in the connecting pipework to ensure that the water flows through each of the cisterns to avoid stagnation in any one cistern. Water from these cisterns may have been chlorinated and may be in storage for longer times than with previous designs, but again this needs to be monitored and assessed.

Cold water cisterns should be:

- Fitted with close fitting lids s which comply with the Water Regulations and insect screens fitted to any pipework open to the atmosphere, e.g. the overflow pipe and vent should be in a good condition and be intact.
- Sited in a cool place and protected from extremes of temperature by thermal insulation which should be in a good condition. Piping should be insulated and kept away from hot ducting and other hot piping to prevent excessive temperature rises in the cold-water supply; typically, not more than 2°C increase should be allowed. The pipework should be easy to inspect so that the thermal insulation can be checked to see that it is in position and has remained undisturbed.

- Fed with a water supply at one side of the cistern with the water outlet at the other side and close to the bottom of the tank. Cisterns have areas within them that will form biofilms on their surfaces which can then contaminate the distribution systems; the water outlet is usually on the side of a cistern and not directly from the bottom surface. Users should find out if, and when the cistern cleaning processes are carried out. The dosing system and records should also be made available for inspection to the decontamination team/WSG.
- Inspected on an annual basis to check the condition of the inside of the cistern and the water within it. The water surface should be clean and shiny, and the water should not contain any debris or contamination.
- Cleaned, disinfected and faults rectified, if considered necessary. If debris or traces of vermin are found, then the inspection should be carried out more frequently.

It is recommended that water for the EWD is taken from a mains supply that is continually flowing. This will provide water of an appropriate quality that can be more easily managed. Dump valves can be used to maintain constant flows if required when no frequently used sinks or other water outlets are fitted to the same supply.

Design and materials of construction of cisterns, pipework, valves, and pumps should not support microbial growth and plastic materials should be WRAS approved[95]. Dead legs should be eliminated where possible. Plastics can encourage biofilms to develop, and alternative materials that do not encourage the growth of *Legionella pneumophilia* should be used. The WRAS water fittings and materials directory should be consulted to identify approved products. Design of systems should ensure that all tanks, pipework, fittings, pumps etc. are free draining where possible.

Some designs and types of joints in the pipework can also be a cause of biofilm build-up e.g.- push fit type joints may contain pockets of un-flushed water areas. Some joints of this design have rubber/neoprene joint rings that allow the biofilm to grow. The systems can be flushed through and chlorinated, but after a time the microbiological results can increase due to re-growth. In many cases, established biofilms may be inaccessible or tolerant to disinfectants and hyperchlorination and in such circumstances replacement of affected parts or sections of pipework should be considered.

Biofilm build up will occur in most EWD designs. Where factory testing has been carried out and incomplete draining and disinfection has taken place then biofilms may have become established and may be present in the EWD on delivery. Consider whether factory testing of EWDs is necessary when purchasing against a European Standard such as BS EN ISO 15883. Anecdotal evidence from engineers indicates that chemical self-disinfect machines and water systems are more likely to be prone to biofilm build up than thermal type systems. Where manufacturers have factory tested equipment prior to delivery on site they should provide certification of decontamination and assurance that the components do not contain microbial contamination that would see the EWD.

The interface between the EWD and any water treatment system is often a problem; particularly the length of flexible pipework between the treatment system loop and the EWD. If the disinfection regimes of the treatment system and the EWD do not allow water or chemical to pass through this section of flexible hose, then biofilm may develop. In such circumstances where biofilm has established on the flexible hoses then regular replacement may be the only answer to long standing biofilm problems (bear in mind that other surfaces associated with this pipe, both up- and down-stream, will also have biofilm present, which will need to be treated). In designing a system or reengineering an existing one, attempts should be made to limit the length of flexible hoses by taking the water treatment flow and return points (or the continuous loop) as close to the EWD as possible. It is recommended that hoses are kept as short as possible and be able to naturally drain. Alternatively, the system should be (re)designed such that it does not incorporate flexible hoses. To address remedial problems and to prevent the microorganisms being present in the final rinse water,

additional ultra-filtration (bacterial retention filters) may be needed near the point of use or internally within the EWD.

To facilitate problem solving and tracing of pipework routes, a schematic diagram provides a simplified but accurate illustration of the layout of the water system, including parts temporarily out of use. While providing only an indication of the scale, it is an important tool as it allows any person who is not familiar with the system to understand quickly and easily their layout, without any specialised training or experience. These are not formal technical drawings but show what the systems comprise, illustrating plant and equipment, including servicing and control valves, any components potentially relevant to the *Legionella* risk, including outlets, strainers and filters or parts that are out of use. These should comply with BS 1710:2014 Specification for identification of pipelines and services and be updated when changes are made that impact on the risk assessment. Below is a check list that can assist in analysing the systems if high levels of microbial growth are measured in rinse water results (Table 5).

Table 5: Check list of points to investigate following high microbial counts in the final rinse water.

Checkpoint	Answer
Water Supply and Pipework (including Distribution Rings):	
• Confirm if the water supply prior to the EWD is tank fed or mains water supply?	
• Is there a water softener fitted to the main hospital supply? • If so, is this being maintained properly with appropriate backwash and cleaning regime? • Is it still in circuit and not bypassed and acting as a large dead end? *It is recommended that a test point for water sampling is fitted at the softener if required for further investigations. Note: They can often be a source of growth if not managed correctly?*	
• Are there any dead legs in the system? How many? Can they be removed? *Note: They may be hidden in the ceiling space or walls etc.*	
• Has there been any water supply or distribution system changes in the hospital water network that could have affected the water quality supply to the endoscopy decontamination unit? *Note: This could include treatment changes, pipework replacement, tank cleaning or treatment, water softener changes etc*	
• Is there a pattern to the microbiology results? Have the results been graphed from the r spreadsheet.	
• Has any remedial work been carried out in the building by contractors or estates staff that could have caused the problems? • Have any sinks, bath, showers, or toilet outlets changed or been removed in the vicinity of the decontamination facility but leaving a dead leg? • Any additional or replacement sections of pipework been installed? *Note: It can be helpful to examine past results and look for spikes that correlate with work undertaken*	
• Check the pipework materials. Are they copper, stainless steel or plastic?	

Checkpoint	Answer
• What type of joints and fittings are in use as some types or designs can promote growth? • Are all water fittings to WRAS standards? • Are there problems and growth in any nearby water outlets such as mixing valves if fitted, especially joints/O rings etc	
Supply/Rinse Water Treatment (either supplied to the EWD or those supplied with(in) the EWD):	

• Identify what type of water treatment plant is being used?
  • Softened?
  • High level filtration?
  • Reverse Osmosis (RO) plant?
  • Water scavenging plant?
  • Water dosing system directly into the pipework system to machines?	

• Check the maintenance records of whatever treatment plant is fitted	
Local Softening:(if required after carrying out tests) • Is there a requirement for softening? • Has the water supply been tested and checked for hardness? • Does the Hardness value comply with both guidance and machine\process chemical requirements? • Examine the maintenance records for proper housekeeping. • Is the backwash regime functioning properly? • Is the correct salt being used and is it being replenished? • Is it still in circuit and not bypassed and acting as a large dead leg? • Check the materials as used for the supply pipework to any further treatment plant.	
High level filtration and water scavenging units (If required) • Examine the maintenance records for filter changes. • When filters were changed, were the seals changed or disinfected? • Were the filter housings cleaned out before the new elements were fitted? • Check the materials as used for the filter housings and systems. • Are pressure gauges fitted to enable an indication of filter failures and blockages that may be causing problems? • Are the gauges checked periodically for function and comparison readings against a known source? *Note: More scavenging systems may be required in the future as tanked chlorinated water supplies increase*	
Reverse Osmosis (If required): • Is it thermal or chemical self-disinfect? • Examine the maintenance records for membrane changes. • When membranes were changed, were the seals changed or disinfected? • Were the membrane housings cleaned out before the new membranes were fitted? • Check the materials as used for the filter housings and systems. • What is the pH of the rinse water? Low pH may indicate carbonic acid carryover and membrane problems.	

Checkpoint	Answer

Water Sampling
• Ensure water sampling techniques are correct by random audit and checking of procedures against HTM/WHTM guidance 01-06 and HTM 04-01.
• Instigate more detailed trending Including:
  o who takes the sample,
  o time of day when samples are taken,
  o machine stage when samples are taken,
  o pick up time for transport
  o delivery time to laboratory
  o time between delivery and analysis
  o the laboratory used
  o review of laboratory standard operating procedures
• Ensure the correct collection bottles are being used and they are clean.
• Ensure water collection – storage and delivery are to the requirements of the guidance and that of the testing laboratory being used.
Note: If in doubt, check the logistics chain from the moment the sample is taken to the time it arrives at the laboratory. Is it sat waiting at the post room or for a taxi? Is it still within temperature when reaching the laboratory?
• In order to investigate high or unusual microbiological results additional water samples may have to be taken to identify the potential source of the contamination:
  o Take additional samples from earlier in the distribution system.
  o Sample any treatment plant before and after major treatment points such as membranes, filters, softeners etc
  o Sample the quality of the tank or mains supply water. Remember that if using RO plant, it is a percentage reduction method not an absolute barrier to contamination. It cannot deal with levels of contamination in the supply water that are higher than its design criteria.
• The water test points must be managed correctly and cleaned/disinfected prior to use.
Note: Sanitary, stainless-steel types can help prevent inadvertent contamination of samples.	

• If the EWD has two independent chambers, is there a biofilm build up or high counts on one side only? • Has any work or changes been made to one side only? *Note This could be indicating that an alternative disinfection such as a longer thermal time or a different chemical is required to treat that side only. Or a change of pump or pipes on the one side can often improve the situation.*	

Good teamwork with the decontamination team and WSG is essential to monitor, control and investigate the issues of water management. Include all the relevant people and professions that can have an influence on the results and system. Ensure the results obtained are within the desired NHS guidance and standards for use.

Non-Microbial Water Contaminants

Aside from microbial contamination, there are other water contaminants that can cause concern or require monitoring. Water quality varies in different parts of the UK and can also vary depending on the level of the water table, and the source of water as determined by the various Water Boards to ensure adequate quantity of supplies to meet our needs. There are limits for contaminants in various European standards and NHS guidance of the UK. However, it is worth remembering that a full chemical analysis, while no longer an absolute requirement in most parts of the UK can still be of benefit. Both the HTM[3] and WHTM[4] documents refer to this as a subsequent test when conductivity levels are high, and it is often the only reliable method of determining the purity of rinse water for substances other than dissolved ions. Figure 4 demonstrates corrosion from water inside a valve seat on an EWD. Testing the conductivity of the water did not show any abnormal results as no dissolved ions were present in the water.

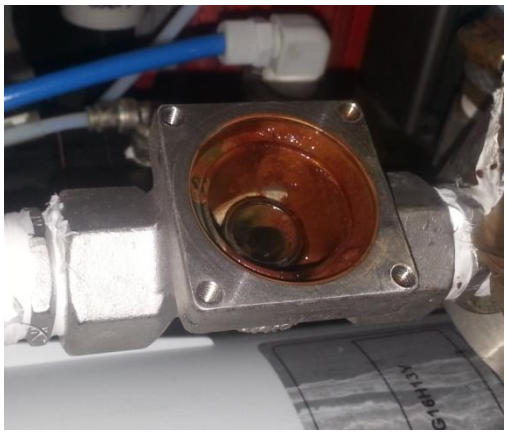


Figure A8.1: Internal corrosion inside a valve seat in an EWD

Some of the more contentious and problematic water contaminants are discussed below:

Hardness

Often the forgotten parameter and taken for granted. Hard water is caused by the presence of dissolved salts of alkaline earth metals, principally calcium, magnesium, barium, and strontium, which have low solubilities. These can then be released when heated to form limescale. All the UK health guidance has the following statement:

"*Using hard water in the final rinse stages of an EWD cycle is one of the major causes of deposits on load items. These deposits are not only unsightly and an unwelcome contaminant but act as a focus for soiling and recontamination of the item in use. Such deposits may seriously impair the utility of the endoscope, particularly the optical system. Hard water may cause scaling on the edges of spray nozzles*

even when fed with only cold water. Detergent formulations intended for use only with soft water may give rise to precipitation if used with hard water. If these products are used diluted with hard water in an EWD, serious damage to endoscopes may result."

A Ministry of Health Report on Water Softening identified that 0.5 mm of hard scale increases fuel costs by 9.4%. Similar evidence is cited in more recent studies that reconfirmed this by stating that 0.8 mm scale increases fuel costs by 10%. Detergent use is also increased with increases in hardness. Disinfectant efficacy can also be impaired.

If using RO water treatment, hardness also has an impact as it causes fouling of the membrane resulting in less membrane space for the water to pass through, leading to:

- More water pressure being required
- Higher energy use
- Increase of the cleaning frequency
- Shorter life span of the membranes

Hardness is easily controlled using a water softener. However, softeners require maintenance, back washing and salt dosing and are an essential component of water treatment.

Chlorides and Ionic Contaminants

To prevent corrosion, water used in decontamination processes should have a chloride concentration of less than 120 mg/L chlorine. Chloride concentrations greater than 240 mg/L can cause pitting of some stainless steel and plastic components. The SHTM2030 and the current HTM 01 guidance requires a final rinse water chloride level of no higher than 10 mg/L chloride and the WHTM states a similar level is required only if RO is used to treat final rinse water. This concentration stems from the limits in sterile water for irrigation. and is far below the levels needed to prevent corrosion. With the WHTM accepting a much higher level for non-reverse osmosis derived rinse water then it is difficult to see a need for such a low level for treated rinse water. Chloride levels can be reduced using a carbon filter. If an EWD that uses a chlorine compound additive in the final rinse water is used, then these limits for chloride concentration will be exceeded if measured in that final rinse water. As discussed earlier ionic contamination (and hence chloride levels) of water can be measured by conductivity but if it is suspected that specific chemicals may contaminate the water source then this may not be detected by such means.

Silicates

Silicates (minerals with silicon) are found in water that is taken from sandy locations. Many years ago, high numbers of silicate contaminants were restricted to a few geographical areas. However, the increased sharing of water supplies in the UK means that this may be a wider problem. Deposits on the instruments are opaque at first and turn dark blue when the layers grow thicker. However much of this is cosmetic. More a cause for concern is when silicates interact with a high chloride level to increase pitting and crevice corrosion. Silicates can act as suspended solids on metals creating a crevice in which the chloride ions can concentrate. High silicates combined with high chlorides is much more of a concern than high silicates alone. If high silicates are a concern (for instance in combination with high chlorides) then they can be reduced either by twin pass RO (e.g., two RO plants in series) or by polishing filters. If utilising the latter, then careful control of microbiological contamination of the polishing filter is needed.

Good Practice Points for Final Rinse Water Treatment Plant Procurement

- Measure the quality of the raw water that will be supplying the plant before purchasing a water treatment or water-using decontamination equipment.
- Examine the results and copy to the prospective water treatment plant suppliers and then instruct them to do their own subsequent testing via another laboratory to confirm the results.
- Request information from the local Estates officer for the Healthcare Facility in question on the regular water test results as given by the local Water Board as a base line measure. These tests should be carried out at least annually.
- Find out the likely fouling index of the water and fit adequate pre-treatment!
- If silicates are important to the quality of the output water, inform the prospective suppliers and measure the existing level. Remember that most forms of water treatment (especially RO) are reduction and not an absolute barrier.
- Identify any filtration system that is needed to deal with particulates and water flow for the installation.
- Consider single point of failures and whether Duplex or Simplex type pump/filtration plant as required with run/standby pumps or filters to maintain the system as desired.
- Identify critical spares that need to be held.
- Calculate the worst-case demand for use for full flow when all EWD's are running at the same cycle stage
- If a rinse water treatment system requires periodic self-disinfection, then decide upon the method required (e.g., thermal or chemical self-disinfect).

- Consider how the water treatment plant will interface with the EWD.
- Request that there are multiple sample points and that they are all of a sanitary stainless-steel type.
- Ensure that the staff involved in and responsible for using equipment within and associated with the decontamination suite are trained and competent in the required areas.