water

MDPI

Singh et. al. (20xx) Supporting Information

Managing Water Quality in Premise Plumbing: Subject Matter Experts' Perspectives and a Systematic Review of Guidance Documents

Rajveer Singh [1,*,†], Kerry A. Hamilton [2,3,†], Md Rasheduzzaman [1,†], Zhao Yang [1,4,†], Saurajyoti Kar [1], Angelita Fasnacht [1,5], Sheldon V. Masters [6] and Patrick L. Gurian [1]

[1] Department of Civil, Architectural and Environmental Engineering, Drexel University, Philadelphia, PA, 19104, USA; mr3349@drexel.edu (M.R.); Zhao.Yang@ttu.edu (Z.Y.); sk3586@drexel.edu (S.K.); amf383@drexel.edu (A.F.); plg28@drexel.edu (P.L.G.)
[2] School of Sustainable Engineering and the Built Environment, Arizona State University; Tempe, AZ 85281, USA; kerry.hamilton@asu.edu
[3] The Biodesign Institute Center for Environmental Health Engineering, Arizona State University, Tempe, AZ, 85281, USA
[4] Department of Civil and Environmental Engineering, Texas Tech University, Lubbock, TX, 79430, USA
[5] Environmental Science and Policy Research Institute, Philadelphia, PA 19129, USA; smasters@esprinstitute.org
* Correspondence: rajs.iitk@gmail.com; Tel.: +1-215-895-2889
† Authors contributed equally to the manuscript.

Received: 13 December 2019; Accepted: 17 January 2020; Published: 26 January 2020

Subject Matter Experts (SMEs) Interview Protocol

The interview protocol consisted general open ended questions about building plumbing system operational and design parameters that have greatest impact on water quality, appropriate indicators of water quality in this context, existing sources of information and guidance, tools required for water quality monitoring and management, significant knowledge gaps, and other experts in the area. The interview was conducted to cover topics under following nine general questions:

1. Which building design components have the greatest impact on building water quality?
2. Which operational parameters have the greatest impact on building water quality? Prompt on tradeoffs: Energy use vs. killing *Legionella*, disinfectant tradeoffs for killing *Legionella* but not Mycobacteria, disinfectant/DBP tradeoffs
3. What are the most important indicators for building water quality?
4. What are the most significant knowledge gaps for building water quality?
5. What types of information would be valuable in a decision support tool? What types of tools are out there? What reports or sources of info do people use to get management info?
6. What are the most important literature sources that we should be aware of?
7. Are there any technical reports or other gray literature sources that are important but might be hard for us to find in the standard academic published literature?
8. Any tools available for practitioners to navigate these issues?
9. Are there any other people or research groups we should speak with that are influential in this field?

Table S1: List of all 54 guidance documents examined for building water quality management guidelines. (IGD = Important Guidance Document identified by process specified in Section 2.2 of text.)

SN	Guidance Documents
1.	ASHRAE. (2000). *ASHRAE Guideline 12-2000. Minimizing the Risk of Legionellosis Associated with Building Water Systems*. Retrieved from American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. website: http://www.techstreet.com/standards/guideline-12-2000-minimizing-the-risk-of-legionellosis-associated-with-building-water-systems?product_id=232891
2.	ASHRAE. (2018). *ANSI/ASHRAE Standard 188-2018 Legionellosis: Risk management for building water systems*. 24. (IGD) https://www.ashrae.org/technical-resources/bookstore/ansi-ashrae-standard-188-2018-legionellosis-risk-management-for-building-water-systems
3.	California Department of Public Health. (2000). *Use of recycled water for cooling 22 CCR § 60306*. Retrieved from https://govt.westlaw.com/calregs/Document/IF11A3B40D4B911DE8879F88E8B0DAAAE?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)
4.	CDC. (2003). *Guidelines for Environmental Infection Control in Health-Care Facilities: Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)*. Retrieved from https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf (IGD)
5.	CDC. (2016a). *2016 Annex to the model aquatic health code: Scientific rationale*. Retrieved from https://www.cdc.gov/mahc/pdf/2016-mahc-annex-final.pdf (IGD)
6.	CDC. (2018). The Model Aquatic Health Code (MAHC). Retrieved from: https://www.cdc.gov/mahc/pdf/2018-MAHC-Code-Clean-508.pdf
7.	CDC. (2017). *Developing a water management program to reduce Legionella growth & spread in buildings: A practical guide to implementing industry standards.* US Department of Health and Human Services: Atlanta, GA, USA. (p. 36). Retrieved from https://www.cdc.gov/legionella/downloads/toolkit.pdf (IGD)
8.	Centers for Medicare & Medicaid Services (CMS). (2018). *Requirement to Reduce Legionella Risk in Healthcare Facility Water Systems to Prevent Cases and Outbreaks of Legionnaires' Disease (LD) (revised 06.09.2017)*. Retrieved from https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Policy-and-Memos-to-States-and-Regions-Items/Survey-And-Cert-Letter-17-30-.html (IGD)
9.	Centre for Health Protection. (2015). *Scientific Committee on Emerging and Zoonotic Diseases: Consensus Summary of Recommended Strategy for Prevention and Control of Legionnaires' Disease in Hong Kong*. Hong Kong. Retrieved from https://www.chp.gov.hk/files/pdf/scezd_recommendations_on_ld_30_dec2015.pdf
10.	Department of Veterans Affairs. (2014). *VHA Directive 1061: Prevention of healthcare-associated Legionella disease and scald injury from potable water distribution systems*. (IGD)
11.	Department of Veterans Affairs. (2008). *VHA Directive 2008-010 Prevention of Legionella disease*. Washington, DC. (IGD)
12.	Division of Industry Services. (n.d.). *Application for General Plumbing Plan Review and Cross Connection Assembly Registration* (No. SBD-6154). Retrieved from

13.	Dutch Working Party Infection Prevention. (2002). *Prevention of infections through water and water-using equipment*. Retrieved from http://www.sld.cu/galerias/pdf/sitios/rehabilitacion-bal/water(1).pdf
14.	E Donegani, C Zotti, S Ditommaso, & MV Stefanetti. (2010). *Legionella in Mountain Huts. Recommendation for prevention and control of Legionella infections. The international Mountaineering and Climbing Federation; Official Standards of the UIAA Medical Commission* (No. Vol. 19). Retrieved from http://theuiaa.org/documents/mountainmedicine/Engl_UIAA_MedCom_Rec_No_19_Legionella_2010_V1-3.pdf
15.	European Guidelines Working Group. (2017). *European technical guidelines for the prevention, control and investigation, of infections caused by Legionella species*. Retrieved from https://ecdc.europa.eu/sites/portal/files/documents/Legionella%20GuidelinesFinal%20updated%20for%20ECDC%20corrections.pdf (IGD)
16.	Florida Department of Health. (2004). *Guidelines for the Surveillance, Investigation, and Control of Legionnaires' Disease in Florida*. Retrieved from http://www.floridahealth.gov/diseases-and-conditions/legionnaires-disease/_documents/gsi-legionella-update-final.pdf
17.	George K Morris, & Brian G. Shelton. (n.d.). *Legionella Bacteria in Environmental Samples: Hazard Analysis and Suggested Remedial Actions* (No. Technical Bulletin 1.5). Retrieved from PathCon Laboratories website: http://www.pathcon.com/wp-content/uploads/2016/11/tech_bulletin_15.pdf
18.	*Good practice guide 192: Designing energy efficient multi-residential buildings*. (2003). Retrieved from http://www.cibse.org/getmedia/7ef0dab3-6201-4650-8cc6-5be057c15047/GPG192-Designing-Energy-Efficient-Multi-Residential-Buildings.pdf.aspx
19.	Government of Western Australia, Department of Commerce, Department of Mines and Petroleum. (2010). *Code of practice: Prevention and Control of Legionnaires' disease 2010*. Retrieved from https://www.commerce.wa.gov.au/sites/default/files/atoms/files/legionnaires-code.pdf (IGD)
20.	Government of Western Australia Department of Health. (2006). *Environmental Health Guide: Legionnaires' Disease*. Retrieved from http://www.health.wa.gov.au/docreg/Education/Diseases/Communicable/Bacteria/HP008929_legionnaires_B.pdf
21.	Great Britain Department of Health, & Department of Health. (2006). *Water systems: Health technical memorandum 04-01 : the control of Legionella, hygiene, "safe" hot water, cold water and drinking water systems. Part B: Operational management*. London: Stationery Office.
22.	Health Protection Scotland. (2014). *Guideline on the management of Legionella cases, incidents, outbreaks and clusters in the community*. Retrieved from Health Protection Network, National Services Scotland, Health Protection Scotland, HSE website: http://www.hps.scot.nhs.uk/resourcedocument.aspx?id=2430
23.	Department of Health. (2016). *Health Technical Memorandum 04-01: Safe water in healthcare premises. Part A: Design, installation and commissioning*. (n.d.). 94. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524880/DH_HTM_0401_PART_A_acc.pdf
24.	HSE. (2007). *Controlling Legionella in nursing and residential care homes* (No. INDG253(rev1)). Sudbury, Great Britain: HSE Books.

25.	HSE. (2012a). *Legionnaires' disease A brief guide for duty holders* (No. INDG458). Retrieved from http://www.hse.gov.uk/pubns/indg458.pdf
26.	HSE. (2012b). *Legionnaires disease and humidifiers. What you need to know	Knowledge Hub*. Retrieved from https://www.condair.co.uk/knowledge-hub/legionnaires-disease-humidifiers-what-you-need-to-know
27.	HSE. (2013a). *Legionnaires' disease: Technical guidance Part 3: The control of Legionella bacteria in other risk systems* (No. HSG274 Part 3). Retrieved from http://www.hse.gov.uk/pubns/priced/hsg274part3.pdf
28.	HSE. (2013b). *Legionnaires' disease. The control of Legionella bacteria in water systems: Approved Code of Practice and guidance on regulations*. Retrieved from http://www.hse.gov.uk/pubns/books/l8.htm
29.	HSE. (2014). *Legionnaires' disease Part 2: The control of Legionella bacteria in hot and cold water systems* (No. HSG274 Part 2). Retrieved from http://thomsonwater.co.uk/wp-content/uploads/2015/09/hsg274part1-HSE.pdf
30.	Joint Commission. (2001). *Joint Commission ASHE Regulatory Advisory: Waterborne pathogens-compliance with JCAHO requirements*. Retrieved from https://pdfslide.net/documents/waterborne-pathogens-compliance-with-jcaho-waterborne-pathogens-compliance.html
31.	Marine Safety Forum. (2013). *Delivering quality potable water to offshore installations* (No. Issue 02-18th July 2013). Retrieved from https://www.marinesafetyforum.org/wp-content/uploads/2018/08/MSF-Guidance-Delivering-Quality-PotWater-to-Offshore-Installations-18th-July-2103.pdf
32.	Melinda Moore, & Shoshana Shelton. (2014). *Updated guidelines for the control of Legionella in Western Pennsylvania*. Allegheny County Health Department, Pittsburgh Regioneal Health Initiative. https://www.specialpathogenslab.com/perch/resources/2014finallegionellaguidelinesforwesternpa.pdf
33.	NASEM. (2019). *Management of Legionella in Water Systems*, The National Academies Press; National Academies of Sceinces, Engineering and Medicine: Washington, DC, 2019. (IGD). Retrieved from: https://www.nap.edu/catalog/25474/management-of-legionella-in-water-systems
34.	NSW Government. (2012). *Legionella control* (No. Information Sheet 5).
35.	Ontario Agency for Health Protection and Promotion (Public Health Ontario). (2014). *Legionella questions and answers*. Retrieved from http://www.floridahealth.gov/diseases-and-conditions/legionnaires-disease/_documents/legionella-guidelines.pdf
36.	OSHA. (1996). *Legionnaires' Disease: Section II: What water systems in workplaces are potential sources of Legionnaires' bacteria (LDB)?* (IGD)
37.	Rinnai. (2013). *Continuous flow direct water heating for potable hot water*. Retrieved from https://www.cibse.org/getmedia/c6194894-aba4-4ab3-888c-5973f0a29d83/TS2013-Session-15-Paper-1-b.pdf.aspx
38.	SSQC. (2014). *Legionella sampling and interpretation protocol*. Retrieved from: http://www.ssqc.co.uk/assets/template/PDFs/100c_Legionella_Sampling_and_Interpretation_1.0_16.07.14.pdf

39.	State of Maryland Department of Health and Mental Hygiene. (2000). *Report of the Maryland Scientific Working Group to Study Legionella in Water Systems in Healthcare Institutions*. Retrieved from https://phpa.health.maryland.gov/IDEHASharedDocuments/Legionella-Scientific-Working-Group-Guidance.pdf
40.	T Keane. (2005). *Guidelines for Control of Legionella in Ornamental Water Features*. Retrieved from Legionlla Risk Management, Inc.
41.	The Joint Commission. (2008). *Joint Commission Environment of Care Standard EC.02.05.01 The hospital manages risks associated with its utility systems*. Joint Commission Resources.
42.	Tonny Ng. (2011). *Legionnaires' disease – public health perspective*. SM&HO (Epidemiology Section), Surveillance and Epidemiology Branch, Center for Health Protection
43.	U.K. Department of Health. (2017). *Health Technical Memorandum 04-01: Safe water in healthcare premises. Part C: Pseudomonas aeruginosa – advice for augmented care units*. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524884/DH_HTM_0401_PART_C_acc.pdf (IGD)
44.	U.S. EPA. (1985). *Drinking Water Criteria Document For Legionella (Final Draft)* (No. EPA-600/X-85-051). Washington, D.C.: Environmental Criteria and Assessment Office. (IGD)
45.	U.S. EPA. (1987a). *Control of Legionella in plumbing systems* (No. PB87235586). Office of Drinking Water.
46.	U.S. EPA. (1987b). *Health advisories for Legionella and seven inorganics* (No. PB87-235586).
47.	U.S. EPA. (2000). *Legionella: Drinking water fact sheet* (No. Office of Water 4304). Retrieved from https://www.epa.gov/sites/production/files/2015-10/documents/legionella-factsheet.pdf
48.	U.S. EPA. (2001). *Legionella: Drinking water health advisory* (No. EPA-822-B-01-005). Retrieved from Office of Science and Technology, Office of Water website: https://www.epa.gov/sites/production/files/2015-10/documents/legionella-report.pdf
49.	VHA. (2013a). *Healthcare inspection: Legionnaires' disease at the VA Pittsburgh healthcare system Pittsburgh, Pennsylvania* (No. 13-00994–180). Retrieved from https://www.va.gov/oig/pubs/VAOIG-13-00994-180.pdf
50.	VHA. (2013b). *Healthcare Inspection: Prevention of Legionnaires' Disease in VHA Facilities* (No. 13-01189–267). Retrieved from Office of Inspector General website: https://www.va.gov/oig/pubs/VAOIG-13-01189-267.pdf
51	VHA. (2013c). *Prevention of Legionella disease* [IL 10-2013-006]. Retrieved from Department of Veterans Affairs website: https://www.armstronginternational.com/files/common/amber/va_2013/secretarysletter.pdf
52.	Wisconsin Department Safety and Professional Services. (n.d.). *Industry Services Division Plumbing Agent Municipalities*. Retrieved from http://dsps.wi.gov/Documents/Industry%20Services/Forms/Plumbing/Industry%20Services%20Division%20Plumbing%20Agent%20Municipalities.pdf
53.	World Health Organization. (2007). *Legionella* and the prevention of legionellosis; Bartram, J., Chartier, Y., Lee, J.V., Pond, K., and Surman-Lee, S., Eds.; World Health Organization: Geneva, ISBN 978-92-4-156297-3. (IGD)
54.	World Health Organization. (2011). *Water safety in buildings*, Cunliffe, D., Bartram, J., Briand, E., Charier, Y., Colbourne, J., Drury, D., Lee, J., Schaefer, B., and Surman-Lee, S. Geneva: World Health Organization. (IGD)

Table S2: List of 50 Keywords relevant to the topics of water quality concerns in premise plumbing systems used for searching guidance documents to screen Important Guidance Documents (IGDs) of high topic coverage of water quality concerns.

Design factors	Operational factors
1. Building codes	28. Ambient temperature
2. Construction material OR pipe material	29. Biofilm/sediments
3. Decorative water features	30. Buffering/pH control
4. Demand	31. (Cleaning OR disinfection) AND (frequency for spas)
5. Dental water lines	32. Corrosion control
6. Design flow- plumbing system	33. Disinfectant residual level
7. Evaporative condensers	34. Exposure route
8. Eyewash station	35. Heat disinfection OR heat shock
9. Flow rate	36. Monitoring
10. Fountains	37. Nutrients
11. Hot tubs OR spas OR whirlpools	38. Low disinfectant residual
12. Humidifiers	39. Tradeoffs *Legionella* vs. scalding
13. Ice machines	
14. Low flow	Indicators Parameters
15. Number of fixtures per person	40. Conductivity
16. Shower	41. Disinfectant byproducts OR DBPs
17. Sinks	42. Disinfectant residual or chlorine
18. Thermostatic mixing valves OR TMVs	43. Heterotrophic Plate Count OR HPCs
19. Water age OR stagnation OR household residence time	44. pH
20. Water conservation	45. Turbidity
21. Water fixture design OR shower heads, faucets	
22. Water main OR service lines	Solutions
23. Water recirculation	46. Chlorination
24. (Water reuse systems integrated with) AND (groundwater OR rainwater OR recycled water)	47. Flushing
25. Water storage tanks AND rainwater collection	48. Education
	49. HACCP
Other factors	50. Standards or Guidelines
26. Source water	
27. Amoeba	