THE STATUS OF WATER, SANITATION AND HYGIENE IN HEALTH CARE FACILITIES IN THE WHO EUROPEAN REGION

Lauren Kelly Joca

A technical report submitted to the faculty at the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Science in Public Health in the Department of Environmental Science and Engineering in the Gillings School of Global Public Health.

Chapel Hill

2018

Approved by:

Jamie Bartram

Jacqueline MacDonald Gibson

John Tomaro

ABSTRACT

Lauren Kelly Joca: The status of water, sanitation and hygiene in health care facilities in the WHO European Region
(Under the direction of Jamie Bartram)

Adequate water, sanitation, and hygiene (WaSH) infrastructure is an essential component of effective healthcare facilities (HCF). However, researchers have not adequately studied the status of WaSH in HCF in the World Health Organization European Region (WHO Euro). A systematic literature review and a qualitative questionnaire were used to begin characterization of WaSH in HCF in WHO Euro. The review revealed common deficiencies in WaSH, disease outcomes and cost implications of deficient WaSH, disease reservoirs in HCFs, and effective infection management (IM) techniques. The questionnaire provided an understanding of the legal framework, implementation strategies, and monitoring structures that allow for the adequate provision of WaSH in HCF. The two components of the project revealed significant gaps between knowledge and practice. Future policies should address these gaps: adequate WaSH to improve IM, enhanced treatment of hospital waste, and the impact of emerging issues (e.g. AMR, *Legionella*, and climate change resiliency) in HCFs.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AMR	Antimicrobial Resistance
CPE	Carbapenemase-producing Enterobacteriaceae
HCF	Health Care Facility
HCW	Health Care Worker
ICU	Intensive Care Unit
IPC	Infection Prevention and Control
KAP	Knowledge, Attitudes, Practices
LTC	Long Term Care
MRSA	Methicillin-resistant *Staphylococcus aureus*
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SDDT	Selective disinfection of the digestive tract
UNICEF	United Nations Children's Fund
WaSH	Water Sanitation and Hygiene
WHO	World Health Organization
WI	Water Institute

1. Introduction

Access to water, sanitation, and hygiene (WaSH) infrastructure is vital for health and well-being. The provision of adequate and safe WaSH infrastructure within healthcare facilities (HCF) is of particular importance, where it represents an essential component of environmental health. In turn, environmental health in HCF has been identified as one of the six core functions of the health system (Rehfuess et al. 2009). HCF contain a high concentration of pathogens within a space that also houses vulnerable populations. WaSH infrastructure is necessary to treat patients and to prevent disease transmission between patients, as well as between patients and staff. Therefore, without adequate WaSH infrastructure, basic quality of care in HCF cannot be achieved.

In essence, an HCF without proper WaSH is not an HCF at all. Deficiencies in WaSH infrastructure can lead to several problems, including nosocomial infections, longer hospital stays, increased cost of care, and increased burden of infection caused by antimicrobial-resistant (AMR) pathogens (Defez et al., 2008). Adverse outcomes due to deficient use and functionality of WaSH infrastructure can extend outside of HCF into the surrounding environment, contributing pharmaceuticals, AMR genes, and infectious agents into the ecosystem through wastewater and solid waste (Blanch et al., 2002; Yilmaz et al., 2016).

Despite the importance of WaSH services in HCF settings, a recent study covering 78 low- and middle-income countries found that 50% of HCF lack piped water, 33% lack improved sanitation, 39% lack handwashing soap, 39% lack adequate infectious waste disposal, 73% lack sterilization equipment (Cronk and Bartram, 2018). Importantly, the majority of data used to determine WaSH coverage in HCF were derived from studies based in Asia, Africa and Latin America and the Caribbean. Only four of the 78 countries represented in the analysis were in the WHO European Region (WHO Euro) (Cronk and Bartram, 2018).

WHO Euro consists of 53 member nations: one low-income country, five lower-middle income countries, 14 upper-middle income countries, and 33 high-income countries. There has been a concerted effort to characterize and correct WaSH deficiencies since the ratification of the Sustainable Development Goals in 2015 (Goal 6), with a growing interest in WaSH infrastructure in HCF. However, the countries in WHO Euro remain poorly represented in existing data (Cronk & Bartram, 2018). Moreover, the existing large-scale studies that consider WaSH-related outcomes in WHO Euro focus on burden of disease attributable to multiple risk factors, rather than specific WaSH-related shortcomings (Lim et al., 2012; Lopez et al., 2006). Therefore, a significant data gap exists related to the status of WaSH in HCF across all of WHO Euro.

2. Objectives

The objective of this study is to fill the data gap on the status of WaSH in HCF throughout WHO Euro through two means: a systematic literature review and a questionnaire analysis. The systematic literature review was designed to collect existing data on the relationship between WaSH infrastructure in HCF and health or environmental outcomes. A questionnaire was developed to complement the systematic literature review and administered to nineteen WHO Euro member countries at a regional meeting in September 2017. The questionnaire was designed using previous bottleneck analyses by the WHO and was intended to construct a picture of the “enabling environment” in each country. Through the

qualitative synthesis of data obtained through these two methods, this project characterizes the status of WaSH across a region that has not before been analyzed in this way.

3. Methods

In order to create a comprehensive picture of the current status of WaSH in HCF in WHO Euro, this study used a systematic literature review protocol and analyzed data collected through a questionnaire.

3.1. Systematic Literature Review

The goal of the systematic review was to obtain existing literature that addressed WaSH in HCFs of WHO Euro countries.

3.1.1. Search Strategy

This review followed the PRISMA protocol for study search and selection, requiring the construction of a search string and identification of inclusion and exclusion criteria. The search string was organized into five sections: environmental factor, factor outcome, health impact, hospital, and country terms (Appendix 1).

- Environmental factors included the terms for water, sanitation, and hygiene, as well as related infrastructure terms for ventilation, waste, and Washing.
- Factor outcome terms included the management of the environmental factors, like waste management, wastewater treatment, and infection prevention.
- Health impact terms focused on the outcomes of insufficient WaSH infrastructure, such as outbreak, healthcare acquired infection, or nosocomial infections.
- The hospital terms were included to narrow results to the health care facility setting.
- All 53 member states of the WHO European Region were included in the country terms, as well as regional terms (i.e. Europe or Europ*).

The search string was adapted for use in the PubMed, Ebsco Global Health, Embase, and Web of Science databases. The search was conducted in January 2017.

A grey literature search was conducted between December 2016 and January 2017. Databases searched for the grey literature search strategy included: the government websites of all EU and non-EU countries within the WHO European Region; the databases of entities that specialize in WaSH, including the UNICEF Water and Sanitation Publications, WHO: Water Sanitation Health, and World Bank: Water and Sanitation databases; the Conference Proceedings Citation Index; Google Scholar; and the Open Grey database. Across the grey literature sources, only English-language information was selected for further review.

Authors manually searched the government websites and repositories of international agencies specialized in WaSH to find relevant literature. A search of the Conference Proceedings Citation Index, Google Scholar, and Open Grey required modified search strings adapted from the string used in the peer-reviewed literature search (Appendix 2).

3.1.2. Study selection

The peer-reviewed literature and grey literature were aggregated in the systematic review software Covidence (Veritas Health Innovation) so that all literature could be scrutinized with the same inclusion and exclusion criteria.

During title and abstract screening, non-English language studies, duplicates, reviews, and studies published in or before 1991 were excluded. Additionally, studies were excluded if they did not mention a WaSH issue (e.g. water quality, wastewater disposal, sanitation systems, hygiene, or infection prevention strategies), were not set in a healthcare facility, or were based in a non-European country. If the origin of the study was not clear (i.e. it could have been based in a European country), but the study was set in a healthcare facility and mentioned a WaSH issue, then it was moved to full text review. Two authors completed the title and abstract screening process separately and conferred on the results.

In the full text review, editorials (e.g. opinion pieces, letters to the editors, articles, etc.) and non-English language studies (e.g. those studies with an English abstract and a foreign language body) were excluded. If full text of a study was unavailable (e.g. full text could not be acquired or the study was only available in abstract form), it was also excluded at this stage. Studies were moved from full text review and included in the data extraction stage if they were based in a European nation, were set in a healthcare facility, and accomplished one or more of the following:

1) Examined water quality, wastewater disposal, sanitation systems, hygiene, or infection prevention strategies;
2) Related healthcare facility infrastructure to environmental health;
3) Related WaSH infrastructure or environmental health to patient outcome;
4) Analyzed the relationship between healthcare facility waste and community/ ecological health;
5) Related structural/systemic factors to WaSH provision;
6) Concerned healthcare facilities, including infrastructure, policy, etc.

The same authors that completed the title and abstract screening completed the full text review, reviewing each text individually and conferring on any conflicts between the studies that were selected for synthesis or excluded.

3.1.3. Data extraction

The data extraction protocol assigned the selected studies to one of seven categories that were defined before full text review began. These categories allowed the authors to extract the pertinent information from each type of study, with different set of information extracted according to the categorization (Table 1). Abbreviated tables can be found in Appendix 3. The seven categories comprised: Coverage; Disease Outcomes Related to Deficient WaSH; Impact on the Natural Environment; Prevention and Management of Infections in the Healthcare Facility; Role of the Healthcare Worker; Environmental Management of the Healthcare Facility; and Governance resources.

- Coverage: assess the water access or quality within a healthcare facility, the sanitation facilities of a healthcare facility, or hygiene measures, including handwashing compliance and infection control/prevention strategies used within a facility. When these studies entered data extraction, the WaSH dimension and the key findings were recorded.
- Disease Outcomes Related to Deficient WaSH: consider the result (e.g. antimicrobial resistant infection, mortality) of certain process deficiencies (e.g. inadequate infection control and prevention, cross-contamination, inadequate sterilization, mismanagement of waste) within a healthcare facility.

- Impact on the Natural Environment: consider the impact on the environment of healthcare facilities. Specifically, the studies examine the pollutant load and destination of wastewaters or solid waste from healthcare facilities. They may connect inadequate treatment of healthcare facility waste and contribute to the presence of micropollutants or infectious agents in the environment.
- Three facets of WaSH-related management within the healthcare facility setting:
    - Prevention and Management of Infections in the Healthcare Facility: includes studies that evaluate surveillance of nosocomial infections, the functionality of disinfection tools, and the effectiveness of infection control protocols, among others.
    - Role of the Healthcare Worker: consider the impact that knowledge, behavior, and attitude of the healthcare worker has on compliance with WaSH guidelines, as well as patient outcomes.
    - Environmental Management of the Healthcare Facility: examine how patient outcomes and infection rate(s) are impacted by environmental factors, including healthcare facility infrastructure and the presence of fomites that have the potential to spread disease.
- Governance: consider the results achieved from applying national or regional standards or policies to prevent WaSH-related issues in healthcare facilities (e.g. the impact of region-wide AMR surveillance, the implementation of WHO guidelines in European healthcare facilities, a comparison of different countries' WaSH standards). They could also answer administration-level questions on the impact of WaSH-related issues (e.g. the cost to the healthcare facility of AMR infections; the cost per patient of in-facility outbreaks; a cost-benefit analysis of different types of infection control/prevention measures).

Table 1: Example data extraction template

All Studies	
Information	**Data Extracted**
Title	e.g. Situation Report on the status of coverage, health outcomes and management practices associated with water, sanitation and hygiene in health care facilities
First author, Year	e.g. Doe et al., 2018
Publication type	e.g. Peer-reviewed, grey literature
Study design	e.g. cross-sectional, longitudinal,
Setting (i.e. healthcare facility type)	e.g. Hospital, Dental Clinic, Tertiary Care Center, Specialized clinic
"Coverage" only	
Level	e.g. district, regional, national
WaSH Dimension	e.g. Water access, Water quality, Handwashing, Sanitation, Hygiene, Healthcare waste management
Description	e.g. microbial assessment of drinking water system
Key Findings	e.g. Water samples resulted in XX CFU of Legionella
"Disease Resulting from Deficient WaSH" only	
Study population	e.g. ICU
Source of exposure	e.g. dental tools
Infectious agent	e.g. *Enterobacter* cloacae, *Acinetobacter* baumannii, etc.
Process Deficiencies	e.g. contaminated water supply, inadequate sanitation
No. infected/ No. exposed	e.g. patients presenting disease/all patients in department
Health outcomes	e.g. sepsis, mortality, etc.
Strategies for prevention or management	e.g. isolation, hygiene monitoring, etc.
"Impacts on the Natural Environment" only	
Sample type	e.g. untreated surface water
Environmental outcome	e.g. AMR genes in waterway
Strategies for prevention or management	e.g. effluent pretreatment
"Prevention and Management of Infections in Healthcare Facilities," "Role of the Healthcare Worker," and "Environmental Management of the Healthcare Facility"	
Objective	e.g. to investigate effectiveness of current hygiene guidelines
Infection mitigation method	e.g. increased hand hygiene compliance
Methods	e.g. monitoring
Outcomes	e.g. greater compliance, lower rates of HAI-acquisition
"Governance" only	
Objective	e.g. to determine effectiveness of new national program
Methods	e.g. pre- and post-test analysis
Outcome	e.g. greater compliance, lower rates of HAI-acquisition

3.1.4. Data Synthesis

After data were extracted from the individual studies, the newly created database was reviewed as a whole to identify common themes present across extraction categories. The information was qualitatively synthesized to report these significant themes and important relevant conclusions from the literature.

3.2. Questionnaire Development and Analysis

To fill in data gaps identified in the literature search, a questionnaire developed by the WHO Europe Regional Office was administered to officials from nineteen WHO Euro member countries that were participating in a regional meeting in September 2017.

3.2.1. Description

The questionnaire was based on previous work WHO and UNICEF had completed on the enabling environment, *The Status of WaSH in Schools in the Pan-European Region*. Respondents provided data on the national regulations, standards, and programs present in their respective countries that concern WaSH in HCF (Table 2). For the purposes of this analysis, the enabling environment includes governance, monitoring, and human resources directed to the WaSH sector and the factors influencing progress on the delivery of services.[1]

[1] World Health Organization. (2018). Defining competent maternal and newborn health professionals: background document to the 2018 joint statement by WHO, UNFPA, UNICEF, ICM, ICN, FIGO and IPA: definition of skilled health personnel providing care during childbirth.

Table 2: Questionnaire

1.	**Are there national regulations or standards addressing WaSH in health care facilities, and/or healthcare waste management, in your country? *Please note that water, sanitation and hygiene may be covered each under different regulations.***
	If yes, please briefly summarize their scope and key requirements and provide reference to relevant documents (if not available online, please provide us with hard or electronic copies). Please provide your answer in the box below by using maximum 150 words.
2.	**Are there any targeted programs in your country which aim at improving WaSH conditions in health care facilities?**
	If yes, please briefly summarize their scope and key requirements and provide reference to relevant documents (if not available online, please provide us with hard or electronic copies). Please provide your answer in the box below by using maximum 150 words.
3.	**Are there any targeted programs in your country aiming at improving environmental sustainability of health care facilities (e.g. safe wastewater disposal, reduction or better management of healthcare waste, water use etc.)?**
	If yes, please briefly summarize the scope of such programs and provide reference to relevant documents (if not available online please provide us with hard or electronic copies). Please provide your answer in the box below by using maximum 150 words.
4.	**In your country, how are responsibilities spread among national, regional and/or local agencies involved in providing and maintaining WaSH services in health care facilities and/or in monitoring WaSH conditions in health care facilities? *Please note that water, sanitation and hygiene may be covered each under different areas of responsibility.***
	Please briefly summarize respective responsibilities in the box below by using maximum 150 words.
5.	**Do you have an overview on the situation of WaSH in health care facilities in your country (e.g. based on findings from ongoing national monitoring programs and/or targeted one-off surveys or assessments)?**
	If yes, please provide a brief summary of the situation and provide details on the information basis (e.g. routine monitoring, one-off assessments). If possible, please differentiate between water, sanitation and hygiene conditions. Please provide reference to relevant documents (if not available online please provide us with hard or electronic copies). Please provide your answer in the box below by using maximum 150 words.
6.	**Do you have requirements for routine surveillance by national authorities of WaSH conditions in health care facilities?**
	If yes, please briefly describe these requirements in terms of thematic focus, frequency, coverage, and enforcement mechanism and actors. Please provide your answer in the box below by using maximum 150 words.

3.2.2. Data Analysis

The results of six countries were analyzed: Georgia, Hungary, Italy, The Republic of Moldova, Serbia, and Tajikistan. This subgroup was selected from the nineteen countries that completed the questionnaire because each country represented a distinct region of Europe and showed an expressed interest in participating in further analyses (Table 3).

Table 3: Rationale for the selection of the Champion Country subset[2]

Country	Region	Rationale
Georgia	Western Asia	Co-leads priority area on WASH in HCF under the 2017-2019 programme of work of the Protocol. Since 2016 the MoH is monitoring the infection control system in inpatient medical institutions integrating relevant indicators for WASH in HCF.
Hungary	Eastern Europe	Co-leads priority area on WASH in HCF under the 2017-2019 programme of work of the Protocol. Hungary prioritised WASH in HCF on the national agenda and is about to scale-up a pilot survey on WASH in HCF.
Italy	Southern Europe	The country has been recently strengthening the national prevention and surveillance of nosocomial infections, integrating WASH/IPC with quality health care.
Republic of Moldova	Eastern Europe	Co-leads priority area on WASH in HCF under the 2017-2019 programme of work of the Protocol. MoH expressed interest in conducting a national survey on WASH in HCF in 2018, and requested support by WHO.
Serbia	Southern Europe	The country chairs the Protocol in the triennium 2017-2019. Country has set an example in the Region for coordinated work towards progressive implementation of Regional commitments. National targets for WASH in HCF are under development and an inspection methodology has been updated in line with the 2017 global WASH in HCF indicators.[3]
Tajikistan	Central Asia	Besides an already ongoing project on developing water safety plans, MoH expressed interest to pilot the WHO approach WASH FIT for improvement at the facility level with the support of WHO.[4]

First, the answers were characterized based on whether the country had a program, regulation, or standard referenced, as well as the number of policies, the scope of the policies, and the WaSH dimension covered in each policy.

Then, components of the enabling environment and the challenges within the policy environment that may discourage adequate WaSH in health care facilities were identified based on dimensions and indicators previously used by WHO and UNICEF in bottleneck analyses (Table 4). Enablers appear when the information collected from the countries reflect the indicators defined by WHO/UNICEF (i.e. the indicator is true). Challenges include the reasons for why an indicator may only be partially true (e.g. there is a regulation, but it does not consider one of the WaSH dimensions), as well as indicators that do not reflect the data collected from the countries (i.e. the indicator is false).

[2] WHO Concept Note, WASH in HCF Deep Dive Preparation March 3, 2018

[3] WHO/UNICEF Joint Monitoring Programme on Water, Sanitation and Hygiene, 2017. Core questions and indicators for monitoring WASH in health care facilities. https://WaSHdata.org/report/jmp-2016-core-questions-and-indicators-monitoring-winhcf

[4] WHO/UNICEF, 2015. Water and Sanitation for Health Facility Improvement Tool (WASH FIT): A practical guide for improving quality of care through water, sanitation, and hygiene in health care facilities. http://www.WaSHinhcf.org/fileadmin/user_upload/documents/WASH-FIT_Oct2016_forknowledgeportal.pdf

Table 4: Dimensions and Indicators of the Enabling Environment for WaSH in HCF[5]

Dimensions	*Indicators*
Legal framework	A legal framework exists
	Policy and Regulations, containing national service norms, is approved
	Policy and Regulations are comprehensive of all dimensions of WaSH (Water, Sanitation, Hygiene and Waste management)
	Requirements are in line with the WHO standards
	Requirements are legally binding
	Requirements incorporate emerging issues (e.g. Legionella, AMR, HAIs and sepsis)
Implementation	Institutional roles are clearly defined
	Interdepartmental and/or intergovernmental (local, district, federal, etc.) cooperation are in place
	Roles are clearly defined at the local level
	The national authorities oversee the work of the local authorities for WaSH in health care facilities (e.g. local utilities, onsite management by HCF)
	There is a person in charge of WaSH at the facility level
	Enforcement mechanisms are regulated/in place
	There is a specific financial plan/budget line for WaSH in place
	There is an ongoing national or sub-national plan/program targeted at implementing and improving compliance with the law for WaSH in health care facilities
	WaSH is reflected as a component in programs targeted at quality health care, health care sustainability, etc.
	Targets under the protocol on WaSH in HCF are drafted or approved
Sector and service monitoring	Monitoring systems are in place
	Monitoring is regular
	Monitoring comprehensive of all WaSH dimensions
	Monitoring measures availability and functionality
	Monitoring is nation-wide
	Monitoring reflects international indicators (WHO/UNICEF Joint Monitoring)

4. Results

4.1. Literature search results

A total of 3,119 studies were found in the peer-reviewed literature search. The results were combined with 112 studies identified in the grey literature search, for a total of 3,231 studies. After duplicates were removed, 2595 studies remained for title and abstract screening. After screening, 728 studies entered full text review. After full text review, 90 were selected for data extraction and synthesis (Figure1).

[5] Developed based on ccorrespondence with WHO Euro office April 30, 2018

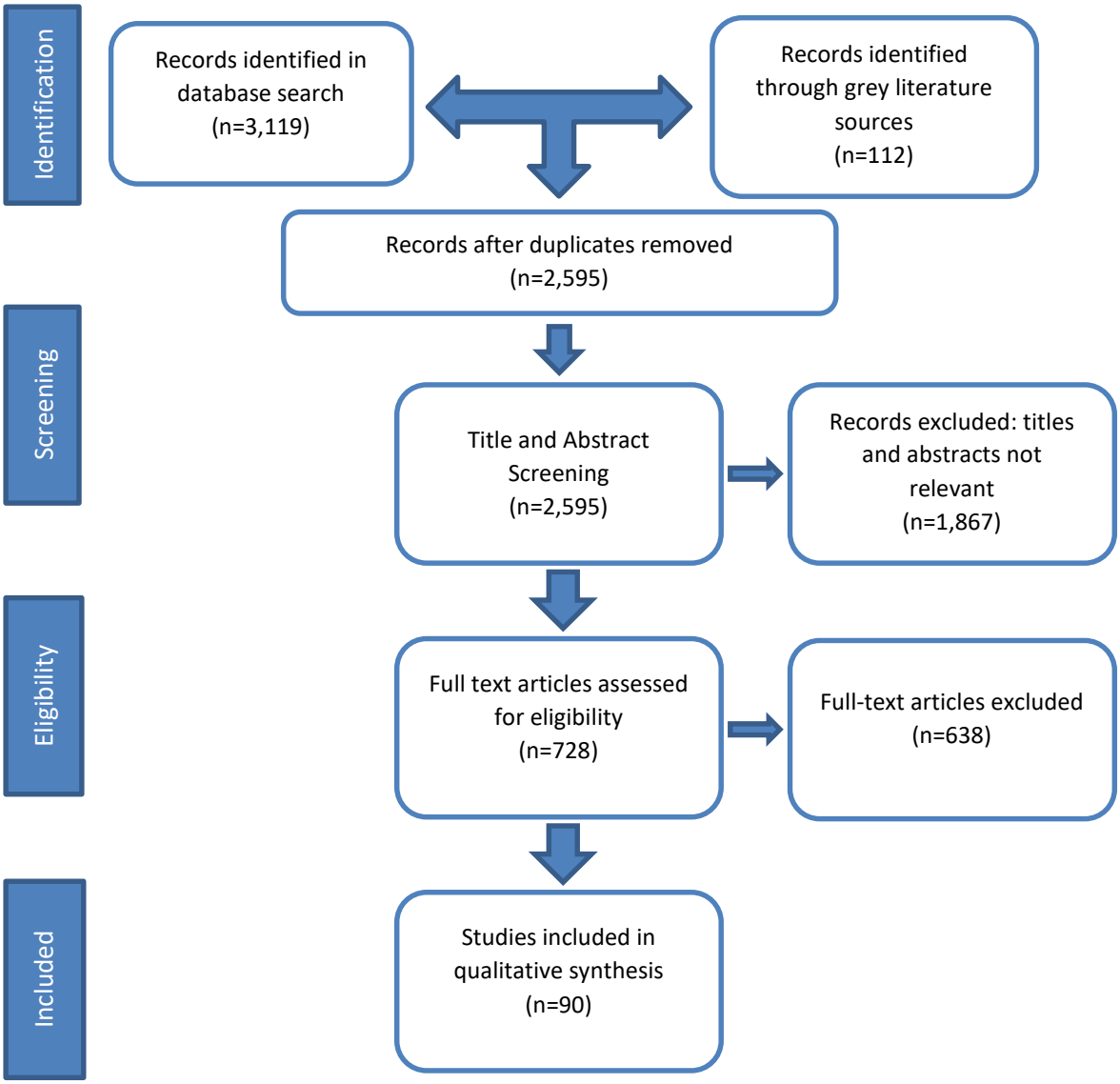

Figure 1: PRISMA Literature Search Flow Diagram

4.2. Literature characteristics

The selected studies came from 20 countries and included three larger, European-scale surveys. When broken down by country of origin, the United Kingdom (England, Wales, Scotland, and Northern Ireland) prepared the largest number of studies (24 out of 90, 26.6%), followed by France, the Netherlands, and Turkey (Table 5).

The largest number of studies (19 out of 90, 21%) were assigned to "Environmental Management of the Healthcare Facility", The number of studies in each category ranged from 7 to 19 (Table 6).

Table 5: The literature search results disaggregated by region and country according to the country represented in each study

Sub-Regions	Country	Studies Identified
Western Asia	Cyprus	1
	Turkey	8
	Albania	1
Eastern Europe	Hungary	2
	Poland	1
	Czech Republic	1
Northern Europe	Denmark	1
	Ireland	7
	Sweden	3
	United Kingdom	24
	England	2
Southern Europe	Greece	1
	Italy	6
	Portugal	2
	Spain	3
Western Europe	France	12
	Germany	8
	Netherlands	9
	Luxembourg	1
Central Asia	Turkmenistan	1
	Kazakhstan	1

Table 6: literature search results by extraction category (Appendix 3)

Extraction Category	Studies Identified
Coverage	7
Disease Outcomes Resulting from Deficient WaSH	15
Impacts on the Natural Environment	15
Prevention and Management of Infections in HCF	14
Role of the healthcare worker	7
Environmental Management of the Healthcare Facility	19
Governance	13
Total	90

4.3. Data Synthesis

Several themes are present in the literature that represent commonly addressed WaSH topics in WHO Euro. These themes comprised common deficiencies related to WaSH, pathogens of concern, environmental reservoirs of disease, infection management techniques, important specialized healthcare settings, and cost implications of deficient WASH.

4.3.1. Common Deficiencies Related to WaSH

Surveys were used in both the U.K. and Germany to determine if variations in infection control practices exist and identify deficiencies that could impact a healthcare facility's ability to respond to an outbreak (Inglis et al. 1992; Peters et al. 2014). Survey results did show that noncompliant infection control procedures were a threat to safe health care. (Inglis et al. 1992).

Two evaluations of the amount of waste generated and the safety of its disposal were conducted in Turkey. Both found that the medical waste management in Turkey needed to improve its separation and handling of waste during disposal, including separation of hazardous waste in health institutions and municipal waste storage areas and establishing sterilization units for infectious waste within healthcare facilities (Soysal et al. 2010; Goren et al. 2011).

One study of healthcare facilities in Portugal revealed that compliance with waste generation and management laws was poor and education about the laws had a significant impact on compliance (Botelho 2012). Also in Portugal, risk perception associated with waste handling was low compared to risk perception in patient care, but was improved through education (Ferreira and Teixeira 2010).

The first country-wide assessment of infection control practices in Ireland revealed several deficient areas, including the number of hospitals with an on-site microbiologist (47%), an infection control nurse (85%), and an occupational health physician (29%). Additionally, only 73% of hospitals had an infection control committee and, on average, there was one isolation room for every 16 beds (Cunney, Humphreys, and Murphy 2006).

4.3.2. Pathogens of Concern

Across the literature, a common concern for European healthcare facilities was the ability to control and prevent the spread of AMR infections. Nosocomial outbreaks were often connected to resistant strains of *Staphylococcus aureus, Staphylococcus epidermidis, Enterobacter cloacae*, *Acinetobacter baumannii, Escherichia coli,* and *Klebsiella pneumoniae.*

WaSH-related deficiencies also propagated nosocomial infections that were not resistant strains. For example, the spread of *Serratia murcescens*, influenza, norovirus*,* and *Clostridium dificile* between patients was linked to ineffective infection control protocols within healthcare facilities.

Outbreaks of both *Legionella pneumophilia* and *Pseudomonas aeruginosa* originated from the drinking water systems of hospitals in Greece, Hungary, and Cyprus. In Cyprus, health officials documented the first hospital outbreak of *L. pneumophilia* to occur in their country (Yiallouros et al. 2013). Water system analyses conducted in Greece revealed that the risk associated with hospital water systems begins within the facility with the growth of *L. pneumophilia*, but also that a monitoring program may allow hospital staff to identify contamination before it spreads to patients (Velonakis et al. 2012). *Legionella pneumophilia* was also identified in the drinking water distribution system of a hospital in Hungary, where it and *Pseudomonas aeruginosa* posed a health risk to those who came into contact with the drinking water (Felföldi et al. 2010). These pathogens were infrastructure-related and eradication required interventions that improved water quality.

4.3.3. Environmental Reservoirs of Disease

The literature revealed important environmental reservoirs that must be considered within and outside of healthcare facilities to adequately prevent the spread of healthcare-associated infections. Within healthcare facilities, several fomites were identified that could contribute to the spread of nosocomial infections. These included endoscopes, dental tools, dialysis units, ultrasound equipment, cell phones, and clothing. Fomite analyses were conducted in the U.K. and reviewed non-disposable tourniquets (Elhassan and Dixon 2012), reusable surgical tools (Bagg et al. 2007; Vassey et al. 2011; Lipscomb, Sihota, and Keevil 2006), and mobile phones (Brady et al. 2011). The reported cleaning procedures of these items were insufficient to prevent the spread of infection. Due to MRSA contamination, it was recommended that healthcare facilities use disposable tourniquets (Elhassan and Dixon 2012). Guidelines and education on the proper handling and disinfection of mobile phones were recommended to protect patients and staff from cross-contamination (Brady et al. 2011). Finally, the cleaning standards for reusable dental surgical (Bagg et al. 2007; Vassey et al. 2011) and general surgical (Lipscomb, Sihota, and Keevil 2006) equipment were deficient in the removal of proteins prior to use, indicating that pathogens could still be present after cleaning. In general, infection control protocols specific to this equipment, like requiring the use of automatic sterilizing equipment instead of manual cleaning, were required to limit their potential to spread infection.

Healthcare facilities threaten the integrity of nearby waterways. The literature shows that hospital effluent contributed AMR organisms into water resources because standard wastewater treatment was unable to sufficiently remove these pathogens. For example, treatment systems in metropolitan areas of France were unable to remove vancomycin- and erythromycin-resistant Enterococci (Novais et al. 2005; Blanch et al. 2003), as well as carbapenemase-resistant *Klebsiella pneumoniae* (Perilli et al. 2013). Additionally, data from Turkey showed that hospital wastewaters present a risk due to chemical toxicants that wastewater treatment currently in use is also insufficient (Yilmaz et al. 2017). Together, the literature suggests that advanced wastewater treatment may be necessary to reduce the risk posed by AMR-genes and chemical toxicants present in hospital wastewater.

4.3.4. Infection Management Techniques

The literature revealed management techniques that were effective in curbing the spread of AMR and other healthcare-associated infections, as well as areas of hospitals that require greater vigilance. For example, many interventions were centered around increasing hand hygiene compliance among healthcare workers. A study examining hand hygiene behavior identified three areas that, if addressed, could increase hand hygiene compliance among nurses at a teaching hospital in England: the attitudes of the staff about hand hygiene, the perceived control over their own behavior, and the level of personal responsibility associated with hygiene (Jenner et al. 2010).

Two studies from the Netherlands examined approaches to infection management that were not seen elsewhere, including an electronic surveillance system (Kaiser et al. 2014) and the selective decontamination of the oropharynx and the digestive tract (Houben et al. 2014). The automated electronic system described in the literature increased surveillance in the hospital while decreasing cost and workload (Kaiser et al. 2014). Selective disinfection of the digestive tract (SDDT) was explored in the literature as an infection control measure to prevent the spread of AMR organisms, but its efficacy is unclear. Results suggested that SDDT may not be suitable infection management techniques due to possible propagation of antibiotic resistance (Houben et al. 2014).

Interventions like HCF surveillance of nosocomial infections and building the capacity for database management served an important role in infection control and prevention practices by identifying the most common infections and areas most likely to harbor these infections. An 8-year country-wide surveillance study of primary bloodstream infection rates and lower respiratory tract

infections in Germany found that participation in the surveillance system and monitoring of country-level risk data is associated with lower incidence of healthcare-associated infections (Schröder et al. 2015). In a surveillance study of incidence and prevention of sternal surgical site infections in a cardiac unit, adherence to hand hygiene guidelines and preoperative antibiotic administration were associated with decreased incidence of surgical site infections (Beckmann et al. 2011).

Finally, outbreaks were often department specific and adherence to strong infection control and prevention policies was particularly important in neonatal units, ICU's, and in post-operative patients, representing populations with particularly vulnerable physical states (O'Connor et al. 2017; Neylon et al. 2010; Bou et al. 2004; Lambert et al. 2011).

4.3.5. Important Specialized Healthcare Settings

Hospital settings are the most prominent HCFs described in the literature, with 78% of identified literature based in a hospital. However, other important HCF-types were identified that also struggled with ensuring adequate WaSH. Dental practices, long-term care facilities, and nursing homes experience difficulties in controlling exposure to infections for reasons related to WaSH infrastructure deficiencies.

Long-term care facilities and nursing homes had difficulty controlling the spread of AMR infections within their patient populations and represent a potential source for AMR outbreaks in HCF (Barret et al., 2015; Szabó et al., 2015). Care facilities for the elderly are of particular importance because these facilities need to meet the demands of an especially-vulnerable population.

Water quality problems and inadequate sterilization and disinfection of equipment put patients in dental facilities at risk of healthcare associated infections. In Italy, an assessment of dental hygienists found that long-practicing hygienists and those who attended continuing education programs were more likely to apply correct disinfection or sterilization techniques than those who did not attend continuing education (Angelillo et al. 2001). Dentists were also surveyed in Turkey about their knowledge of cross-infection control procedures and revealed poor knowledge of pathogens associated with insufficient hand hygiene and cross infection (Yüzbasioglu et al. 2009)

4.3.6. Cost Implications of Deficient WaSH

Disease outcomes related to deficient IPC procedures are a serious economic burden. Four studies offered cost analyses of nosocomial outbreaks in the Netherlands, England, and France. A review of seven nosocomial outbreaks between 2012 and 2014 in the Netherlands resulted in total additional costs reaching up to €350,000, with cost dependent on the type of infection (Dik et al. 2016). The lowest cost outbreak-cause was norovirus (€10 per patient per day), while the highest cost outbreak-cause was EBSL-positive *Klebsiella pneumonia* (€1,368.92 per patient per day). In another Dutch tertiary care facility, an outbreak of *Clostridium dificile* ribotype O27 infection cost €1.33 million with increased cost associated with missed revenue due to increased length of stay of the *C. dificile* patients, the closure of beds to enable contact isolation of *C. dificile* patients, extra surveillance, and activities of the infection control department (van Beurden et al. 2017). In England, an outbreak of Carbapenemase-producing Enterobacteriaceae (CPE) resulted in a total cost of over €1.1 million over a 10-month period, with the highest cost factor being missed revenue (Otter et al. 2017). In France, the total additional costs of nosocomial infections due to increased medical costs and the costs associated with an extended length of stay were estimated to be €3.2 million per year for a single hospital (Defez et al. 2008).

4.4. Questionnaire Results

The majority of countries provided an answer (either yes or no) to each question in the questionnaire (Table 7). Tajikistan and Italy were unable to completely describe the division of roles and responsibilities related to the provision, maintenance, and monitoring of WaSH. Tajikistan was unable to provide a description of the scope of the program in the country that is targeted at improving WaSH.

Additionally, each country was unable to provide complete parameters for the requirements of routine surveillance (Table 7).

Table 7: Response to the county briefs: yes (number of programs or policies), or no

	Country					
Outcome	Georgia	Hungary	Italy	The Republic of Moldova	Serbia	Tajikistan
National Standards and Regulations	Yes (5)	Yes (4)	Yes (4)	Yes (4)	Yes (9)	Yes (5)
Targeted Programs to improve WaSH	No	Yes (2)	Yes (2)	Yes (1)	Yes (4)	Incomplete (1)
Targeted Programs to improve sustainability	No	Yes (2)	Yes (1)	Yes (2)	Yes (1)	Yes (3)
Division of responsibilities of provision, maintenance, and monitoring of WaSH	Yes	Yes	Incomplete	Yes	Yes	Incomplete
Overview on the situation of WaSH in HCF	No	Yes	Yes	Yes	Yes	Yes
Requirements for routine surveillance by national authorities of WaSH conditions	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete

Overall, the scope of national regulations and standards, as well as targeted programs to improve WaSH, covered: WaSH Infrastructure, water supply/quality, sanitary facilities, handwashing/hygiene, medical waste management, surveillance of nosocomial infections, staff training/behavior, laundering, IPC, cleaning and disinfection, *Legionella spp*, wastewater, epidemiological rules to protect public health, and antimicrobial resistance (Appendix 4).

The scope of targeted programs to improve the environmental sustainability of healthcare facilities included energy efficiency, renewable energy, water use efficiency, conscientious consumption, medical waste reduction and/or management, wastewater treatment, access to safe water, and education measures.

The administrative framework that defined the division of responsibilities in the provision, maintenance, and monitoring of WaSH generally included national laws, but this was not always the case as described by individual countries. National, regional, or local agencies were often empowered with oversight of the bodies responsible for WaSH in HCF. In some cases, these agencies were the organizations responsible for the provision, maintenance, and monitoring of WaSH in HCF.

Overviews on the situation of WaSH in HCF was available in each country, but the scope and type of overview available varied between countries. Findings to inform an overview of WaSH were available from ongoing national monitoring programs or from one-off assessments. In very few cases, these overviews covered a wide range of WaSH dimensions; more often, the information available was not comprehensive.

Finally, the information available on the requirements for routine surveillance was incomplete for each country. In the case of Italy, no requirements for surveillance were reported at all. The other countries were missing one or several of the parameters including scope, frequency, enforcement mechanisms, and actors.

4.5. Enabling Environment

Following an examination of the combined questionnaire results, the enabling environment of each country was individually described.

4.5.1. Georgia

Aspects of the enabling environment identified in Georgia included the comprehensive national standards and regulations and the authority of national agencies to coordinate and oversee the provision, maintenance and monitoring of WaSH in HCF. Enforcement mechanisms were also in place to strengthen the requirements of routine surveillance (Table 8).

While ongoing monitoring included several WaSH dimensions, it did not include sanitation and wastewater. While the role of national agencies is well defined, the roles of local agencies and the responsibility of routine surveillance is not discussed in the country brief (Table 8).

Table 8: Enablers and challenges present in Georgia with respect to WaSH provision

Dimension	Enabler or Challenge	Related Indicator	Explanation
Legal Framework	Enabler	Policy and Regulations are comprehensive of all dimensions of WaSH	Comprehensive national standards and regulations
	Enabler	A legal framework exists	Provision and maintenance of WaSH defined by national law
Implementation	Enabler	The national authorities oversee the work of the local authorities for WaSH in health care facilities	Monitoring is coordinated by a national agency
	Enabler	Enforcement mechanisms are regulated/in place	Requirements for surveillance are strengthened with enforcement mechanisms
	Challenge	Institutional roles are clearly defined	Local roles in the provision, maintenance, and monitoring of WaSH are not clearly defined
	Challenge	Institutional roles are clearly defined	Actors responsible for surveillance are not clearly defined
Sector Service Monitoring	Enabler	Monitoring systems are in place	Ongoing monitoring of several WaSH dimensions
	Challenge	Monitoring comprehensive of all WaSH dimensions	Sanitation and wastewater are not included in ongoing monitoring

4.5.2. Hungary

Aspects of the enabling environment identified in Hungary included that the national standards and regulations consider emerging issues like *Legionella spp*. As seen in Georgia, the provision and maintenance of WaSH is defined by national law and the responsibilities of national and local agencies in the monitoring of WaSH are well defined. Unlike Georgia, the actors responsible for routine surveillance are also well defined (Table 9)

While hand hygiene is regularly monitored and assessed based on WHO standards, the national standards and regulations, as well as national monitoring, are not comprehensive. Additionally, the country does not have enforcement mechanisms for surveillance requirements (Table 9).

Table 9: Enablers and challenges present in Hungary with respect to WaSH provision

Dimension	Enabler or Challenge	Related Indicator	Enablers
Legal Framework	Enabler	Requirements are in line with emerging issues (e.g. Legionella, AMR, HAIs and sepsis)	National standards and regulations include Legionella
	Enabler	A legal framework exists	Provision and maintenance of WaSH defined by national law
	Enabler	Requirements are in line with the WHO Essential standards	Hand hygiene status determined based on WHO Framework
	Challenge	Policy and Regulations are comprehensive of all dimensions of WaSH	National standards and regulations do not include water supply/quality, wastewater, or medical waste management
Implementation	Enabler	Institutional roles are clearly defined	Responsibilities related to monitoring WaSH are defined at national and local level
	Enabler	Institutional roles are clearly defined	Actors responsible for surveillance are defined
	Challenge	Enforcement mechanisms are regulated/in place	Enforcement mechanisms for surveillance requirements are not defined
Sector and service monitoring	Enabler	Monitoring systems are in place	Ongoing monitoring of hand hygiene
	Challenge	Monitoring systems are in place	There is not comprehensive ongoing monitoring to inform an overview on the situation of WaSH in HCF
	Challenge	Monitoring comprehensive of all WaSH dimensions	WaSH is not the focus of surveillance in the country

4.5.3. Italy

Aspects of the enabling environment identified in Italy also included that the national standards and regulations considered emerging issues like *Legionella spp*. Moreover, Italy also assessed AMR in situational overviews of WaSH (Table 10)

While the role of local agencies in the provision, maintenance, and monitoring of WaSH was well defined, the role of national or regional agencies was not. Additionally, comprehensive standards and

regulations, as well as a comprehensive overview of WaSH dimensions are not available in the county. Finally, it is unclear if any routine surveillance is required in Italy (Table 10).

Table 10: Enablers and challenges present in Italy with respect to WaSH provision

Dimension	Enabler or Challenge	Related Indicator	Explanation
Legal Framework	Enabler	Requirements are in line with emerging issues (e.g. Legionella, AMR, HAIs and sepsis)	National standards and regulations include Legionella
	Enabler	Requirements are in line with emerging issues (e.g. Legionella, AMR, HAIs and sepsis)	Assessment on the situation of WaSH consider AMR
	Enabler	Policy and Regulations are comprehensive of all dimensions of WaSH	National standards and regulations do not consider sanitation
Implementation	Enabler	Roles are clearly defined at the local level	Responsibilities of provision and maintenance of WaSH defined at the local level
	Challenge	Institutional roles are clearly defined	Responsibility of monitoring WaSH conditions is not defined
	Challenge	Institutional roles are clearly defined	Role of national agencies in provision, maintenance, or monitoring of WaSH not defined
Sector and service monitoring	Challenge	Monitoring systems are in place	Comprehensive overview on the situation of WaSH not available
	Challenge	Monitoring systems are in place	Requirements for routine surveillance not available

4.5.4. The Republic of Moldova

Aspects of the enabling environment identified in The Republic of Moldova the requirements of routine surveillance for sanitation and hygiene, with enforcement mechanisms in place. Additionally, national standards and regulations consider WaSH, as well as medical waste management. Medical waste is assessed in ongoing monitoring programs (Table 11).

While they have a wider scope than the other countries, the national standards and regulations of Moldova do not consider wastewater. The overview of the situation of WaSH and routine surveillance are also limited in scope and do not comprehensively represent all WaSH dimensions (Table 11).

Table 11: Enablers and challenges present in the Republic of Moldova with respect to WaSH provision

Dimension	Enabler or Challenge	Related Indicator	Enablers
Legal framework	Enabler	A legal framework exists	National standards and regulations consider WaSH and medical waste
	Challenge	Policy and Regulations are comprehensive of all dimensions of WaSH	National standards and regulations do not consider wastewater
Implementation	Enabler	Institutional roles are clearly defined	Responsibility of national agencies in provision, maintenance, and monitoring of WaSH are defined
	Enabler	Enforcement mechanisms are regulated/in place	Enforcement mechanisms for the requirements of routine surveillance defined
	Challenge	Roles are clearly defined at the local level	Responsibility for provision, maintenance, or monitoring of WaSH not defined at the local level
Sector and service monitoring	Enabler	Monitoring systems are in place	Ongoing monitoring of water and medical waste management available
	Enabler	Monitoring systems are in place	Requirements for routine surveillance on sanitation and hygiene available
	Challenge	Monitoring systems are in place	Overview on the status of sanitation, hygiene, and wastewater not available
	Challenge	Monitoring comprehensive of all WaSH dimensions	Requirements for routine surveillance are not comprehensive of all dimensions of WaSH

4.5.5. Serbia

Aspects of the enabling environment identified in Serbia included well-defined responsibilities for the provision, maintenance, and monitoring of WaSH at the national and local level. Additionally, the country reported both ongoing monitoring of hygiene and requirements for routine surveillance of WaSH in HCF. The Actors responsible for this surveillance are also defined (Table 12).

While several WaSH dimensions are considered across policies and monitoring programs, national standards and regulations in Serbia do not consider hygiene, and an overview on the situation of water and sanitation is not available in the country. Enforcement mechanisms for surveillance requirements are undefined in Serbia (Table 12).

Table 12: Enablers and challenges present in Serbia with respect to WaSH provision

Dimension	Enabler or Challenge	Related Indicator	Enablers
Legal framework	Enabler	A legal framework exists	National standards and regulations consider water, sanitation, wastewater and medical waste management
	Challenge	Policy and Regulations are comprehensive of all dimensions of WaSH	Hygiene is not considered in national standards and regulations
Implementation	Enabler	Institutional roles are clearly defined	Responsibilities for provision, maintenance, and monitoring of WaSH defined at the national level
	Enabler	Roles are clearly defined at the local level	Responsibilities for provision, maintenance, and monitoring of WaSH defined at the local level
	Enabler	Institutional roles are clearly defined	Actors responsible for routine surveillance are defined
	Challenge	Enforcement mechanisms are regulated/in place	Enforcement mechanism for routine surveillance requirements are not defined
Sector and service monitoring	Enabler	Monitoring systems are in place	Ongoing monitoring of hygiene is available
	Enabler	Monitoring systems are in place	Overview of wastewater and medical waste management is available
	Enabler	Monitoring systems are in place	Requirements for routine surveillance of WaSH are defined
	Challenge	Monitoring systems are in place	Overview on the situation of water and sanitation is not available

4.5.6. Tajikistan

Aspects of the enabling environment identified in Tajikistan included that medical waste management is considered in both national standards and regulations, as well as surveillance systems. Importantly, the actors responsible for surveillance are defined in the policies. Ongoing monitoring of water and sanitation was also reported by the country, while water is additionally covered in its national standards and regulations (Table 13).

However, the national standards and regulations, as well as ongoing monitoring in Tajikistan, are not comprehensive of all WaSH dimensions. They do not consider hygiene or wastewater management. Additionally, the national or regional responsibilities related to the provision, maintenance, and monitoring of WaSH are not defined in national law. Finally, the enforcement mechanisms of surveillance systems are not defined (Table 13).

Table 13: Enablers and Challenges present in Tajikistan with respect to WaSH provision

Dimension	Enabler or Challenge	Related Indicator	Enablers
Legal framework	Enabler	A legal framework exists	National standards and regulations consider water supply and medical waste management
	Challenge	Policy and Regulations are comprehensive of all dimensions of WaSH	National standards and regulations are not comprehensive of all WaSH dimensions
Implementation	Enabler	Roles are clearly defined at the local level	Responsibility of the provision and maintenance of WaSH is defined at the local level
	Enabler	Institutional roles are clearly defined	Actors responsible for routine surveillance are defined
	Challenge	Institutional roles are clearly defined	Responsibility of monitoring WaSH conditions is not defined
	Challenge	Enforcement mechanisms are regulated/in place	Enforcement mechanisms of the responsibilities of routine surveillance not defined
Sector and service monitoring	Enabler	Monitoring systems are in place	Ongoing monitoring of water supply and sanitation available
	Enabler	Monitoring systems are in place	Requirements for routine surveillance of WaSH and medical waste management defined
	Challenge	Monitoring comprehensive of all WaSH dimensions	Overview on the status of wastewater, hygiene, and medical waste management is not available

5. Discussion

To our knowledge, this is the first attempt to characterize the status of water, sanitation and hygiene (WaSH), including infection control procedures, surveillance, and impacts of hospital wastewater effluent on the natural environment in healthcare facilities (HCF) throughout the WHO European Region using systematic literature review and questionnaire analysis methods.

The literature search revealed that WaSH-related deficiencies could propagate the spread of several infections in HCF. For example, the spread of *Serratia marcescens,* influenza, norovirus, *and Clostridium dificile* between patients was linked to ineffective infection control protocols within healthcare facilities. Outbreaks of both *Legionella pneumophilia* and *Pseudomonas aeruginosa* originated from the drinking water systems of hospitals in Greece and Hungary. These pathogens were infrastructure-related and outbreak control required interventions that improved water quality.

Across the literature, a common concern for European healthcare facilities was the ability to control and prevent the spread of AMR infections. Nosocomial outbreaks were often connected to resistant strains of *Staphylococcus aureus, Staphylococcus epidermidis, Enterobacter cloacae, Acinetobacter baumannii, Escherichia coli,* and *Klebsiella pneumoniae.* However, the literature also revealed management techniques that were effective in curbing the spread of AMR and other healthcare-associated infections. Increasing hand hygiene (HH) compliance among healthcare workers and implementing hospital surveillance systems were successful in stemming the spread of nosocomial infections, while techniques like SDDT had the potential to increase the prevalence of AMR pathogens in

HCF. Finally, we found that outbreaks were often department specific and adherence to strong infection control and prevention policies was particularly important in neonatal units, ICU's, and in post-operative patients, representing populations with particularly vulnerable physical states.

This was consistent with the findings of outside literature. The hands of healthcare workers have been identified as potential vehicles for the spread of infection from patient to patient (WHO, 2006), with a mechanism of action involving 5 critical steps (Pittet et al. 2006). Hand hygiene among health care workers interrupts these steps and stops the propagation of infection (Pittet et al. 2006). Indeed, in a review of the impact of HH compliance on healthcare associated infections (HCAI), 21 out of 24 HH interventions implemented in a hospital setting from 1977 to 2008 were able to reliably show sustained compliance and a temporal association with hygiene uptake and a decrease in HCAI prevalence (Allegranzi & Pittet, 2009). Despite the documented benefits of HH, compliance rates remain low at 40% in ICUs and between 50-60% in other departments, on average (Erasmus et al. 2010). While compliance rates in ICUs were lower than other departments, the majority of documented HH interventions took place in neonatal or adult ICUs, demonstrating that increasing compliance could improve outcomes for these especially-vulnerable patients (Allegranzi & Pittet, 2009).

Also important to controlling the spread of nosocomial infections was the identification of environmental reservoirs that had the potential to spread disease. Within HCFs, endoscopes, dental tools, dialysis units, ultrasound equipment, cell phones, and clothing were identified as fomites that contribute to the spread of nosocomial infections. The role of cell phones in the spread of nosocomial infections has been well documented, but, because these are personal items and not standard equipment of the HCF, they may not be subject to the same sterilization requirements as other potential fomites (Borer et al. 2005; Jeske et a. 2007; Karabay et al. 2007; Sadat-Ali et al. 2010). Therefore, there is a need for hygiene rules that include cell phone use and sterilization within the HCF. Outside, HCFs can threaten the integrity of surrounding waterways. The literature showed that hospital effluent contributed AMR organisms into waterways because municipal water systems were unable to sufficiently remove these pathogens through standard wastewater treatment. This phenomenon has been documented elsewhere (Varela et al. 2013), in which hospital wastewater has been shown to contribute not only AMR organisms, but also antibiotics and other pharmaceuticals into surrounding waterways (Boillot et al. 2008; Verlicchi et al. 2012). One hypothesis for the breakdown of traditional wastewater treatment is that the presence of antibiotics inactivates important bacteria in the treatment process (Al-Ahmad et al. 1998)

Finally, the HCF types that displayed particular trouble in controlling infections related to WaSH-deficiencies were dental practices, long-term care facilities, and nursing homes. Water quality deficiencies and inadequate sterilization and disinfection of equipment put patients in dental facilities at risk of healthcare associated infections. Long-term care facilities and nursing homes had difficulty controlling the spread of AMR infections within their patient populations and represent a potential source for AMR outbreaks in the healthcare system. Care facilities for the elderly are of particular importance because these facilities will need to meet growing demand from an especially vulnerable population.

The questionnaire was designed to complement this systematic literature review by filling in some of the gaps remaining after data synthesis. These gaps included country-specific data on the legal and monitoring framework surrounding WaSH in HCF, as well as the enabling environment that impacts the provision of adequate WaSH. Thus, the questionnaire collected data on national policies, programs, responsibilities, and monitoring tools related to WaSH in six WHO Europe member countries: Georgia, Hungary, Italy, The Republic of Moldova, Serbia, and Tajikistan.

While the literature revealed the impact on the natural environment that hospital effluent can have, national policies still largely focus on the solid waste leaving hospitals. Healthcare-associated infections, AMR genes, and chemical toxicants can enter water bodies from hospital effluent (Blanch et al., 2002; Yilmaz et al, 2016), but the national standards and regulations reported in the country briefs show a gap in wastewater-related policies. Serbia is the only country that reports a national standard or regulation for HCF wastewater. Conversely, all countries except Hungary report a national standard or regulation around solid medical waste management.

The questionnaire analysis also showed that the meaning or feasibility of "sustainability" is not consistent across countries. Several countries: Hungary, Italy, and Moldova, have national programs or strategies to reduce waste, increase energy efficiency, implement renewable energies, or reduce water usage. Georgia reported no programs aimed at sustainability at all. The remaining countries (Serbia and Tajikistan) reported policies that improve sanitation systems, implement medical waste management, and ensure a safe water supply for the means of protecting public health. This spectrum of the interpretation of "sustainability" could introduce a complex problem for policy- and decision-makers, who must define what sustainability means for their country. However, it could also signal an opportunity for innovation. "Leapfrogging" has long been discussed in terms of developing countries moving directly to renewable forms of energy (Goldemberg, 1998). There could also be an opportunity to leapfrog other WaSH technologies in countries like Tajikistan, which is still struggling to secure a safe water supply, and introduce sustainable water use.

Policy- and decision-makers must consider emerging threats when developing programs aimed at sustainability, but many countries did not appear to. In fact, Moldova was the only country to report a program with an explicit goal to increase resiliency in the face of climate change. The integration of resilience into sustainability programs has been successfully piloted in the United Kingdom where it lead to more comprehensive environmental management strategies (Achour et al., 2010). Successful environmental management in the face of climate change will also require cooperation at the national, regional, and local level, with clearly defined roles and responsibilities (Frumkin et al., 2011). This highlights the challenges many countries had with defining the responsibilities of providing and monitoring WaSH. Creating a comprehensive sustainability strategy and defining roles and responsibilities at all levels of government should be included in the discussion of sustainability in healthcare to create truly resilient facilities.

There were several limitations to this study, including that the peer-reviewed and grey literature is not equally distributed across all European countries. Our results came from 20 countries, leaving 33 member countries of the WHO European region. Areas like the U.K., France, Germany, and Southern Europe were well represented in our results, with few data from Eastern Europe, Central Asia, and Western Asia. This review excluded studies that were not in English, which could have led to the exclusion of relevant data and introduced bias into the dataset of selected studies. Finally, in the course of work, several additional terms were identified that merit inclusion in the systematic review search strings of future reports: disinfection, contamination, and decontamination.

6. Conclusion

This report represents the first attempt to characterize the status of WaSH in HCF throughout the entire WHO European region using a systematic literature review and questionnaire analysis. Together, these methods reveal gaps between literature and practice which highlight potential policy foci to improve the status of WaSH in HCF: recognizing that the provision of WaSH can improve IPC, improving

treatment of hospital waste, prioritizing emerging issues like AMR and *Legionella spp*, and ensuring climate change resiliency in HCFs. Based on the literature, future interventions should consider WaSH's integral role in IPC within healthcare facilities, unique environmental reservoirs and settings that can also impact healthcare provision, and the unique threat introduced by AMR infections and *Legionella spp* within and outside the healthcare-facility environment. Based on questionnaire, future assessments should examine the type and scope of wastewater policies, the presence of wastewater monitoring, and the scope of sustainability programs. Furthermore, more research is needed to determine whether existing policies or programs have been fully implemented and how the success of policies or programs is monitored over time.

Appendix 1: Search String

Environmental Factor Terms	water OR latrine OR toilet OR plumbing OR ventilat* OR handwashing OR hygiene OR Washing OR "WaSH basin" OR soap OR sanitation OR waste OR "infectious waste" OR "hazardous waste" OR "medical waste" OR "surface water" OR "water source" OR "hand rub" OR environmental pollution[MeSH] OR "hospital wastewater" OR "hospital effluent" OR infection control[MeSH]
Factor Outcome Terms	disposal OR pollut* OR "waste management" OR "hygiene management" OR "resource management" OR "emergency management" OR energy OR power OR electricity OR "cleaning products" OR "pharmaceuticals" OR "environmental health" OR "environmental quality" OR "wastewater treatment" OR "water treatment" OR "infection prevention"
Health Impact Terms	"antimicrobial resistance" OR "antibiotic resistance" OR "outbreak" OR "sterilization" OR "human health" OR "healthcare acquired infection" OR "hospital acquired infection" OR "nosocomial" OR "surgical site infection"
Hospital Term	hospital OR "health center" OR maternity OR dispensary OR clinic OR "health post" OR health policy[MeSH] OR "health officer" OR "healthcare facility" OR health facility[MeSH]
Country Terms	Europe[MeSH] OR Europe* OR Albania OR Andorra OR Armenia OR Austria OR Azerbaijan OR Belarus OR Belgium OR Bosnia and Herzegovina OR Bulgaria OR Croatia OR Cyprus OR Czech* OR Denmark OR Estonia OR Finland OR France OR Georgia OR Germany OR Greece OR Hungary OR Iceland OR Ireland OR Israel OR Italy OR Kazakhstan OR Kyrgyzstan OR Latvia OR Lithuania OR Luxembourg OR Malta OR Monaco OR Montenegro OR Netherlands OR Norway OR Poland OR Portugal OR Moldov* OR Romania OR Russia* OR San Marino OR Serbia OR Slovakia OR Slovenia OR Spain OR Sweden OR Switzerland OR Tajikistan OR Macedonia* OR Turkey OR Turkmenistan OR Ukraine OR "United Kingdom" OR "Great Britain" OR "Northern Ireland" OR Uzbekistan OR England OR Britain

Appendix 2: Adapted Search Strings

Database	Search String
Conference Proceedings Citation Index	Water OR sanitation OR hygiene OR waste OR "infection prevention" OR "infection control"
	hospital OR "health center" OR maternity OR dispensary OR clinic OR "health post" OR "health officer" OR "healthcare facility"
	Europe* OR Albania OR Andorra OR Armenia OR Austria OR Azerbaijan OR Belarus OR Belgium OR Bosnia and Herzegovina OR Bulgaria OR Croatia OR Cyprus OR Czech* OR Denmark OR Estonia OR Finland OR France OR Georgia OR Germany OR Greece OR Hungary OR Iceland OR Ireland OR Israel OR Italy OR Kazakhstan OR Kyrgyzstan OR Latvia OR Lithuania OR Luxembourg OR Malta OR Monaco OR Montenegro OR Netherlands OR Norway OR Poland OR Portugal OR Moldov* OR Romania OR Russia* OR San Marino OR Serbia OR Slovakia OR Slovenia OR Spain OR Sweden OR Switzerland OR Tajikistan OR Macedonia* OR Turkey OR Turkmenistan OR Ukraine OR "United Kingdom" OR "Great Britain" OR "Northern Ireland" OR Uzbekistan OR England OR Britain
Google Scholar	Europe
	hospital OR "health center" OR maternity OR dispensary OR clinic OR "health post" OR "health officer" OR "healthcare facility"
	Water OR sanitation OR hygiene OR waste OR "infection prevention" OR "infection control"
Open Grey	"water, sanitation, hygiene"
	"health care facilities"

Appendix 3: Study Summary tables

Appendix 3.1: Coverage

Coverage				
Citation	**Country**	**Setting**	**WaSH Dimension**	**Key Findings**
Rita Szabó, 2015	Hungary	Long-term care facilities;	Handwashing/ Hygiene	Median consumption of ABHR and antimicrobial soap was 15.5L per LTCFs, and 2.2 mL and 12.1 mL) per HCWs in 2013, respectively; 0.6 hygienic hand rub/ HCW per day and 2.4 hygienic handwashing/HCW per day
Smith et al., 2009	Scotland	dental practices; national	Sanitation	of 179 surgeries, 99% had hand pieces cleaned before disinfected or autoclaved; most manually cleaned by disinfectant impregnated cloth, then put in steam sterilizer
Inglis, 1991	U.K.	Hospital/ ICU	IPC	identify inappropriate procedures and suggest priorities for future infection control practice in the ICU
Peters, 2014	Germany	Nursing homes	IPC	Nursing homes were equipped to respond to multidrug-resistant organisms (MDROs), training and standards were in place. However, there were deficiencies in communication of information on infected residents with hospitals and general practitioners
Goren, 2011	Turkey	Healthcare facilities	Waste management	Recommendations were developed for improved waste separation, transportation and disposal
Soysal, 2010	Turkey	Healthcare facilities	Waste management	To provide a safe health-care waste management metropolitan municipality must provide hazardous waste separation in health institutions, establish sterilization units for infectious waste, and provide the last storage of medical waste in completely different, safe and special areas apart from the municipal waste storage areas.

Mehmet Emin Birpinar (2008)	Turkey	192 private and public hospitals in Istanbul metropolitan area	Waste management	This study showed that an estimate of around 22 tons'/day medical waste (0.63gk/bed-day) is generated in the Istanbul metropolitan area. Separation of recyclable reaches rates of up to 83% but approx. 25% of the hospitals still use inappropriate containers for medical waste collection. Almost 77% of the hospitals use appropriate equipment for collection personnel.

Appendix 3.2: Diseases related to deficient WaSH

Disease Outcomes Related to Deficient WaSH					
First author, Year	**Country**	**Study summary**	**Infectious agent**	**Process Deficiencies**	**Strategies for prevention or management**
Dijk, 2002	Netherlands	Outbreak analysis among neonates in a teaching hospital with a 12 bed neonatal unit	Enterobacter cloacae	The children are not routinely screened for bacterial colonization, insufficient hygiene measures	Direct measures taken included cohorting of infected children, disinfection of incubators, thermometers and wards, and screening patients. After the introduction of disposable thermometer covers, E. cloacae colonization slowly decreased.
Neylon, 2010	Ireland	Outbreak analysis among neonates in a maternity hospital	Staphylococcus aureus	Lack of routine staff screening	Routine neonatal and staff screening as preventive outbreak measures
Thorburn, 2004	U.K.	Outbreak analysis among children in a pediatric intensive care unit	respiratory syncytial virus (RSV) infection	(1) that a breakdown in barrier precautions resulted in nosocomial RSV cases and reinforcement of basic droplet precautions addressed this breach; (2) persistent shedders of RSV are an important source of nosocomial RSV infection; (3) there is an increased incidence of nosocomial RSV infection in patients with congenital heart disease, chronic lung disease, airways abnormalities and immunosuppression.	This study demonstrated that basic droplet precautions rather than the physical barrier of an isolation cubicle more effectively curtails nosocomial RSV spread

C.M. Herra	Ireland	Outbreak Analysis among 12 patients In ICU	Serratia murcescens	Unable to adequately handle resistant strains	Strict hygiene measures adopted, contaminated macerator and sluice room thoroughly cleaned, patients involved isolated/cohorted together
Ricardo Bou (2004)	Spain	retrospective cohort study among patients with S. epidermidis mediastinitis, endocarditis, or both after valve implantation in a 260-bed community referral center	staphylococcus epidermidis	Insufficient post-operative IPC	Cause of this protracted outbreak was likely multifactorial, reemphasis of already existing policies and guidelines were associated with the resolution of the outbreak
B. Semin-Pelletier (2015)	France	Microbiological assessment of patients affected by an outbreak in a 3000 bed university affiliated tertiary care center	carbapenemase producing Klebsiella pneumonia	Insufficient decontamination of sites in contact with Patient Zero	initial control measures failed to eradicate this outbreak, late implementation of successive cohort units, high numbers of transfers between wards as well as readmissions of cases made control of the scenario more difficult. Hand hygiene observance and safe collection and disposal of urine and feces remain important standard precautions. National and regional policies are necessary to help hospitals confronted with outbreaks like this one
Stefan Hagel (2016)	Germany	Single-center retrospective study among all adult patients (older than 18 years) with laboratory confirmed influenza infections in a 1400-bed tertiary care center	influenza virus	Molecular biological identification of influenza virus does not allow distinction between infectious and non-infectious viruses	WHO hand hygiene guidelines have to be enforced, health care workers are identified as potential sources of transmitters, benefits of vaccination have to be educated among nurses and medical doctors, hygiene management has to be strengthened
C. F Haill (2012)	England	Comparison of two NoV outbreak scenarios in a 1200-bed teaching hospital	human norovirus	cross patient infection	a twofold approach to limit the operational impact of outbreaks. First symptomatic patients are cohorted in single rooms or bays to contain the outbreak without losing the entire ward, second, patients were decanted in single rooms (when those get free) in order to be able to clean the affected areas in shorter time: this lead to a significantly shorter duration of closure

Aida Bianco (2016)	Italy	Outbreak analysis of 8 patients in the ICU of a 165 bed teaching hospital	extensively drug resistant Acinetobacter baumannii	not defined	Integration of epidemiological and microbiological data in combination with the application of infection control measures could be shown to be crucial to bring an outbreak to a rapid halt. Fundamental role of molecular typing to determine strategy could be confirmed as well as the strict adherence to outbreak and infection control measures in place
Yiallouros (2013)	Cyprus	Outbreak analysis of airborne legionella in neonatal ward caused by a cold mist ultrasonic humidifier	Legionella pneumophilla	colonization of cold mist ultrasonic humidifier	an environmental investigation revealed that a cold mist ultrasonic humidifier led to the outbreak with legionella. It was determined that the neonates were infected while in the nursery of a private hospital by contaminated water in a humidifier. These devices must be avoided in nurseries due to the risk of disseminating into the room air.
Mihail R. Halachev (2014)	England	Utilization of whole genome sequencing to determine infection routes of an acinetobacter outbreak in a tertiary health care facility	multi drug resistant Acinetobacter baumannii	limitation on genomic detection methods	The study could show that genomic techniques such as whole genome sequencing have the potential to make an impact on hospital infection prevention and control by delivering a cost-effective tool to identify routes of infection (by pointing out closely related strains) within a clinically relevant timeframe. This might allow infection control teams to track (and eventually prevent) the spread of drug resistant pathogens.
Hanne M. Erikesn (2004)	Spain	description of a gastro-enteritis outbreak among Nordic patients and staff in a specialized health center	norovirus	Environmental hygiene	The outbreak occurred among Nordic patients with psoriasis as well as personnel of the center. Affected fell ill with vomiting and diarrhea (or both) and some had to be hospitalized. Investigation on the source of the outbreak point at food handlers who are reported to fell sick right before the outbreak. Control measures included strict hygiene measures and the banning of buffets.

O'Connor, 2016	Ireland	retrospective microbiological and epidemiological review of three separate, but affiliated healthcare centers impacted by a single pathogen	New Delhi metallo-b-lactamase (NDM)-1 carbapenemase-producing Enterobacteriaceae	Not identified, screening policy identified colonization	modification of antimicrobial stewardship
O'Connor et al., 2017	Ireland	investigation of mother to neonate transmission of disease in the NCU of a hospital	E. coli	failure to screen neonates for exposure upon admittance	now all neonates admitted to the NICU are screened for ESBL-producers and the mothers are screened as well
Marie Laurence Lambert (2011)	Multiple (10)	Cohort study to determine the clinical outcomes of HAI and AMR in patients admitted to European IC units	HAI bloodstream infections and pneumonia	Inadequate IPC	HAI bloodstream infections and pneumonia could be found to greatly increase mortality and length of hospital stay (in ICU) which leads to increased morbidity and mortality as well as costs for the health care system. Additional effects on most common ARS patterns were comparably low.

Appendix 3.3: Impacts on the Natural Environment

Impacts on the Natural Environment					
First author, Year	Country	Study Summary	Exposure of Concern	Sample type	Strategies for prevention or management
Pierrette Landrie Simo Tchuinte (2016)	France and Luxembourg	antibiotic resistance class 3 integrons in gram negative bacteria were isolated from hospital sewage and characterized	potential exposure to ARM	hospital waste water	risk for horizontal gene transfer in the aquatic environment which could amplify the virulence of environmental strains
A.R. Blanch (2002)	Spain, Sweden and England	ARG were analyzed in more than 400 raw and treated urban wastewaters, receiving surface waters and hospital wastewaters	ARG transfer caused by erythromycin and vancomycin resistant enterococci species	hospital waste water, raw water and treated urban waste water	forth tier waste water treatment since conventional waste water treatment seems to be insufficient to remove VRE and ERE from the waste water, better antibiotic stewardship

Gulsum Yilmaz (2016)	Turkey	chemical, toxicological and microbiological assessment of waste water samples	exposure to a variety of potentially hazardous compounds in the waste water under investigation	hospital waste water grab sample	conventional wastewater treatment appears to be insufficient, fourth tier treatment including advanced oxidation and/or adsorption is proposed to reduce the chemical load and toxicological effects of the hospital discharge
Felfoldi, 2009	Hungary	cross-sectional drinking water distribution system of a hospital	Legionella and Pseudomonas aeruginosa	Drinking water distribution system	Insufficient detection limits associated with the conventional use of small sample volumes and the questionable correlation between indicator bacteria and the microbiological quality of water highlight the need for changes in drinking water monitoring.
Roland Leclercq, 2013	France	Culture based study	antibiotic resistance in Enterococcus spp.	Surface waters	wastewater treatment did not result in a specific removal of E. faecium
Jerome Ory (2016)	France	evaluation of hospital effluent WDS biofilms	potential exposure to ARM	hospital waste water	risk for horizontal gene transfer in the aquatic environment which could amplify the virulence of environmental strains
Servais, 2009	France	longitudinal	antimicrobial resistant bacteria	Surface waters	high frequency of multiple antimicrobial resistant bacteria (e.g. E. coli and intestinal enterococci)
Velonakis, 2012	Greece	longitudinal	Legionella	hospital hot and cold water systems and cooling towers	Reemergence of Legionella spp. colonization was evident in more than half of the hospitals where frequent monitoring and appropriate risk assessment plans were absent or lacking Environmental risk assessment together with Legionella isolation should be enforced systematically in hospitals.
Sadowy, 2014	Poland	longitudinal	Drug-resistant Enterococcus faecium	wastewater treatment plant (WWTP) effluent	survival of drug-resistant Enterococcus faecium in WWTP effluent better understand the survival and spread of drug-resistant strains in water ecosystems
Lotte Jakobsen (2008)	Denmark	microbiological assessment of wastewater	potential exposure to ARM	Wastewater samples collected from the outlet of the hospital bed wards and the inlet of the WWTP. Compared to residential area waste water.	a total of 38 gentamicin resistant E. coli has been isolated from patients, 15 from hospital outlets and 21 from residential area wastewater. Possible spread of certain types of resistant bacteria from hospital to the wastewater; better antibiotic stewardship is recommended and fourth tier waste water treatment facilities such as ozone, UV or active carbon are mentioned

Caroline Bréchet, 2014	France	Sampling study	Extended-Spectrum β-Lactamase– Producing Escherichia coli	wastewater treatment plant (WWTP) effluent	The treatment at the waste water treatment plant led to the relative enrichment of ESBLEC
Carla Novais (2004)	Portugal	study to investigate to level of vancomycin resistant enterococci from hospital waste water in Portugal	vancomycin resistant enterococci	26 sewage sample were collected in urban sewers. 12 samples were originated upstream of the hospital and 14 directly at the outlet	Several VRE with different resistances could be identified during the study. The data suggests that both particular clones and mobile elements carrying AR and virulence factors from clinical waste could continuously contaminate the community environment. Reducing the amount of bacteria as well as genetic elements should be priority to avoid the buildup of environmental reservoirs of antibiotic resistance.
Harris et. al, 2013	Ireland	study, investigation	AMR E.coli	water from two wastewater treatment plants- one that receives and treats hospital effluent, and one that does not	E. coli expressing resistance to ampicillin, streptomycin, cefoxitin, and cefotaxime) showed no change in prevalence with the release of hospital effluent---> while some 'hospital specific antimicrobial agents' (ciprofloxacin) showed an increase in antimicrobial resistance with the release of hospital effluent----> overall, the effect of hospital effluent is highly variable and antimicrobial specific; hospital effluents that contain newer antimicrobials should be kept separated to prevent development of further antimicrobial resistance
Mariagrazia Perilli (2013)	Italy	waste water samples were collected from hospital and urban sewage effluents before and after municipal treatment	potential infection with ARM	hospital and urban waste water before and after treatment	eradication of carbapenemase resistant K. pneumoniae should be an important goal in clinical therapy. Therefore it is crucial to identify and eliminate the nosocomial structures and to come up with an effective intervention to limit occurrence in the environment.

Kenny Oberlé (2012)	France	water samples were extracted from river plant continuum downstream of a hospital to evaluate e. coli antibiotic relationship	infection with hospital associated ABR e. coli	surface water influenced with hospital waste water	Multi residue chemical analysis methodology was used to assess if low levels of contamination by 32 antibiotics are related to antibiotic resistance of E. coli. Two of the AB persisted in the environment and did not correspond with the majority of AB resistances in E. coli. Still, it is highly recommended to replace the persistent AB with those degradable to lower the ecotoxicologixal risk.

Appendix 3.4: Prevention and Management of infections in Healthcare Facilities

Prevention and Management of Infections in the Healthcare Setting				
First author, Year	Country	Study Summary	Setting	Outcomes
Gastmeier, 2011	Germany	Longitudinal to analyze two surveillance systems (a hospital based or a unit based) leads to a greater decrease in incidence density of nosocomial MRSA	Hospital/ICU	A unit-based approach of surveillance and feedback seems to be more successful in decreasing nosocomial MRSA rates, compared to a hospital-based approach
W. A. Coulter (2001)	England and Wales	research article to evaluate the knowledge and training of medical personnel (n=700, response rate 53.1% (372)) in England and Wales. Also to determine the frequency and method of autoclave testing in general practice	anonymous postal questionnaire and autoclave performance survey using biological indicators	82% of the practices under investigation operate autoclaves (14% of the practices state that they own but do not use an autoclave). 84% of the practitioners surveyed perceive the behavior of some of their patients to place them at risk of obtaining virus based disease such as AIDS or Hep. Autoclaves are used on average 2.8 times per day and only 3% failed to sterilize the indicator spores. It has to be mentioned that almost half of the recipients of the questionnaire stated that they received special training on how to handle the autoclave. Therefore, the authors ask for policy formulation, implementation and education to improve knowledge and practice of infection control .

C. Schröder (2015)	Germany	research article to evaluate the effectiveness of a large scale HAI surveillance program to reduce the effects of primary bloodstream infections and lower respiratory tract infections	8 year study in 913 ICUs, 142 non-ICU wards and 241 neonatal intense care units to evaluate a German HAI surveillance program	participating in a national surveillance system and using surveillance data for internal QM leads to substantial reduction of HAI and helps identifying potential risk factors which might have been undetected otherwise.
Kaiser, 2014	Netherlands	Prospective study Use health care associated infection surveillance data to support better decision making	Intensive care	reduction in manual surveillance of hospital acquired infections, which reduced workload and costs
M. Eveillard (2001)	France	implementation of an isolation scheme to prevent and control multi resistant bacteria	teaching hospital	The MRB incidence decreased significantly in all types of specialties except for surgical wards. The incidence decreased by 17.9% for MRSA, 54.9% for ESBL and 34.8% for both MRB. Availability and consumption of antiseptic soap (one of the implementations) increased significantly, the results show the efficacy of the program in a large hospital if both availability and compliance of hand hygiene as well as isolation is coordinated and enforced.
Diler Coskun (2007)	Turkey	active prospective and lab based surveillance program to evaluate nosocomial infections after cardiovascular surgery	tertiary health care facility in Istanbul, Turkey	14,502 cases of surgery resulted in 416 patients showing 492 nosocomial infections resulting in increased morbidity and mortality and elongated hospital stay; the study allowed an evaluation of nosocomial infections in the hospital under investigation (including incidence and distribution) following cardiovascular surgery. Risk factors need to be further investigated to allow a sufficient and adequate avoidance of NI and/or their treatment.
Barret, 2014	France	Surveillance for outbreaks	Elderly long term care facilities (LTCF)	Substantial morbidity and mortality, and high antibiotic resistance among staff and residents; Development of infection prevention and control plans at LTCF and to notify any gastroenteritis outbreak to health authorities to ensure that they are rapidly controlled; Understaffing and organizational problems in facilities were primary contributors to hygiene deficiencies
Beckman, 2011	Germany	cross-sectional to evaluate current clinical practices in cardiac surgery concerning the prevention and management of sternal wound infections	cardiac surgery units	adherence to good practice guidelines; improved good hygiene practice in surgical units and correct preoperative antibiotic administration

Smith, 2009	U.K.	Cross-sectional: examine the management policies and procedures associated with infection control and instrument decontamination	Dental practice	Study found that although the majority of surgeries (70%) claimed to have a management policy on infection control, only 50% of these were documented. Recommendations were made for improved training and documentation of infection control practices
Houben, 2013	Netherlands	Longitudinal study evaluating trends in antibiotic resistance among Gram-negative bacteria in ICUs using and not using Selective oropharyngeal decontamination (SOD) and selective decontamination of the digestive tract (SDD)	Hospital 38 Dutch ICUs	Studies evaluating the clinical benefits and ecological safety of these measures in settings with different bacterial ecology are warranted, as well as studies on the impact of SOD and SDD on resistance after their discontinuation.
Cunney et al., 2006	Ireland	nation-wide questionnaire survey assessing the status of nosocomial infection prevention and control with regards to national guidelines	68 acute hospitals in Ireland	First comprehensive surveillance of Irish hospitals regarding nosocomial infection prevention and control, revealing areas in need of improvement and areas of strength
Zahra Sheriteh, 2010	U.K.	In vitro microbiological study investigating the effectiveness of currently recommended decontamination procedures	Dental Practice	The five methods of decontaminating TCDBs investigated in this study were effective in removing viable S. mutans
P. E. Benson, 2007	U.K.	A prospective, cross-sectional, clinical and laboratory investigation measuring the effectiveness of ultrasonic cleaning for decontaminating orthodontic molar bands	Dental Practice	There is a need to investigate effective means of cleaning organic material from orthodontic bands if they are to be sterilized and reused
R. Shah (2009)	England	hospital-based cross-sectional study investigating UK orthodontic departments	Hospital	"UK orthodontic departments have implemented policies and procedures which would ensure a high standard of cross infection control. In particular, this related to the decontamination of surfaces and instruments, the use of personal protection and disposal of clinical waste. Most departments had policies and procedures in place for staff education and training in cross infection control and personal protection."

Appendix 3.5: Environmental Management of the Healthcare Facility

Environmental management of the healthcare facility			
First author, Year	*Country*	*Setting*	*Outcomes*
Elhassan, 2012	U.K.	Health care equipment	Non-disposable tourniquets are contaminated with MRSA. Disposable tourniquets were recommended for MRSA prevention measures.
Bagg, 2006	U.K.	Dental practice	The study determined the cleaning of re-usable dental instruments is undertaken using poorly controlled processes and procedures, which increase the risk of cross infection. The study then recommended that clear and unambiguous advice must be provided to the dental team and implement quality assurance procedures at each stage of the cleaning process.
Holy, 2013	Czech Republic	Hospital	Reported finding *Legionella pneumophilla* and recommended disinfection of flush tanks with chlorine agents
Brady, 2011	U.K.	Inpatients on surgical/urological wards in hospitals	Prevent bacteria transmission between patients in inpatient settings
Klaus Oberdorger (2007)	Germany	Hospital	2012 samples were taken and 747 were positive for L. pneumophilla. 19 different genotypes could be identified; Even though the hospitals were not located at the same location and each had its own warm water supply, identical strains could be identified. Contamination of water supplies seemed to be dominated by the stable genotypes, even after various control measures. Additional genotypes could be isolated sporadically, pathogenic relevance seemed to be questionable, though.
van den Dool, 2016	Netherlands	Nursing home	low hygiene conditions in nursing homes, Model results demonstrate nursing homes are sufficiently connected to the hospital network to drive national epidemics; Nursing homes should be considered in planning for regional and national infection control and surveillance initiatives
Liza F. White (2007)	Scotland	Hospital/ICU	little difference between the methods under investigation, recommendation to "choose to cheapest (method) in a cash-strapping facility". One method (wet scrub) showed long lasting effect and is recommended for outbreak situations and high-risk units
M. Vassey (2010)	England	instruments submitted by 30 dental surgeries in South West England were analyzed for residual protein levels	several shortcomings in cleaning chemistries and operation of the automatic washer disinfector became obvious. Manual washing plus ultrasonic was significantly less effective.

I. P. Lipscomb (2006)	England and Ireland	surgical instrument sets have been acquired from anonymous hospitals in NHS primary care SSDs and analyzed before and after routine sterilization	overall standard for cleaning of surgical instruments has to be raised in order to fulfill the European Standards and to reduce the risk of cross patient contamination and iatrogenic transmission
Smith, 2010	U.K.	Dentistry	improved design and construction of purpose-built areas for dental surgeries
Berthelot, 1998	France	Hospital	80% case-fatality rate led to Ventilation procedures were revised; sterile water was used on respiratory equipment; and regular monitoring
Cummins, 2016	U.K.	Hospital	Main finding was that contact between the infected and susceptible patient is a key driver of the spread of infection. This was evidenced in outbreak control being more difficult to achieve in a hospital with Nightingale-style wards and limited isolation facilities.
Fernanda Perdelli (2008)	Italy	tertiary health care facility	Occupational exposure to glutaraldehyde should be avoided and policies are in place to ensure it. Still, a variety of factors could be identified which could endanger cleaning staff, patients and visitors. Continual assessment is essential if it is to ensure that the high quality of hospital air is maintained. Effective structural and organizational measures can help minimize the risk posed by the disinfectant in the workplace.
Ozdemir, 2010	Turkey	intensive care unit (ICU) and operating rooms (OR)	Monitoring airborne particles can assess air control efficiency in units equipped with high- efficiency particulate air filters by reference to the clean-room classification established by the European Union and in US guidelines
Aygun 2002	Turkey	56 environmental swab samples (e.g. patient beds, ventilators, cables etc.)	several months after an outbreak of a carbapenemase resistant a. baumannii, several environmental samples of the same ICU were identified as reservoirs of the same strains. Obviously, the infection control measures in place were insufficient to prevent this colonization. Improved guidelines, better education and appropriate antibiotic treatment plan should be implemented to avoid repetition of such a scenario.
Dancer, 2008	U.K.	Unspecified wards in a hospital	Methicillin-susceptible/resistant Staphylococcus aureus (MSSA/MRSA) were recovered in both surgical wards. The most contaminated sites were in patients rooms near the bed side.; this study provides evidence supporting the value of cleaning in the control of hospital-acquired MSSA and MRSA
Napoli (2012)	Italy	University Hospital in Italy	risk of creating reservoirs of potentially pathogenic microorganisms in active and passive air cleaning devices

Micael Widerström (2016)	Sweden	hospital environment	risk for horizontal gene transfer in the aquatic environment which could amplify the virulence of environmental strains after HA MRSE have been excreted by colonized individuals, HCW and environments serve as important reservoirs for HA MRSE, effective infection prevention and control measures have to be implemented, as well as better Antibiotic Stewardship and improved infection prevention and control guidelines
Crimi, 2006	Italy	Hematology, the Bone Marrow Transplant Centre, the Emergency Intensive Care Unit, the First Anesthesia and Resuscitation Service (I SAR) which is divided in the east and west side, and the Neurosurgical Intensive Therapy ward	the presence of artificial ventilation systems can lower the bacterial and fungal compared with a ward with natural ventilation; there is a recommendation to raise surveillance during spring and summer seasons

Appendix 3.6: The Role of the Healthcare Worker

Role of the Healthcare Worker			
First author, Year	*Country*	*Setting*	*Outcomes*
Anabela Botelho, 2011	Europe	Private outpatient healthcare,	finds that that compliance with the law is far from ideal, and that provision of education and training is the strongest policy factor influencing the degree of compliance
Angelillo, 2001	Italy	Dental practice	The correct application of disinfection or sterilization methods for instruments was more likely in the older respondents and in those who attended continuing education courses on infection control.; Educational programs are needed for improving knowledge about oral manifestations of AIDS in order to support dentists
Lindberg, 2011	Sweden	Multiple	"Insufficient knowledge of, behavior toward and emotional response to patients with MDRB were found, but the RNs under- stood their own responsibility for adherence to preventative measures for infection control as being great or very great."
Emir YÜZBASIOGLU (2009)	Turkey	Dental Office	Conclusion is that knowledge of Turkish dentists is relatively weak about infection control and prevention procedures. It is indicated that the issue of cross-infection control is not discussed among dentists. Improved dental education programs and short-term courses about cross-infection as well as infection control procedures are suitable and highly recommended

Tamburlini, 2011	Albania, Turkmenistan and Kazakhstan	maternity and neonatal settings in hospitals	develop or revise policies, laws, norms, regulations and clinical guidelines, to strengthen pre- and in-service training, to make an appropriate use of technologies, to establish a referral system, and to introduce maternal and perinatal audits to Improve maternal and neonatal outcomes
Vera Ferreira (2010)	Portugal	tertiary health care facilities in Algarve, Portugal	environmental risks due to hospital waste is concerned highest for the environment and waste workers, followed by patients and visitors. The study could show that proper separation could improve environmental concerns and that this separation is correlated with daily contact with waste. Risk perception of staff is related to lack of knowledge concerning the importance of separation. Risk of infection is significantly higher during patients care than during waste handling and the frequency of such injuries is related to daily tasks. Legislative definitions and education seemed to have positive impact on both risk perception and waste handling.
E. A. Jenner (2010)	England	Hospital	despite several limitations (e.g. self-reporting nature of the survey), the study has achieved its aims (according to the author): using an approach integrating health behavior theories and existing research findings, the study can provide a framework that can be used to build both theoretical developments and practical intervention in a number of hospital settings. Three targets were identified in particular: attitudes of the staff, perceived behavior control and personal responsibility. This might help find angles for successful implementations

Appendix 3.7: Governance

Governance			
First author, Year	**Country**	**Setting**	**Outcome**
Blenkharn, 2006	U.K.	Hospitals	Determined U.K. healthcare waste management practices based on European Hazardous Waste Directive conflicts with CDC's Universal/Standard Precautions; The U.K. guidance made recommendations on ecological and financial criteria
Lynn Parker, 2004	U.K.	General healthcare facility	Adequate guild lines on decontamination practices, although the implementation of the practices are lacking and inconsistent and often do not meet standards
R. Herve, 2012	U.K.	Hospital	Limited action of current decontamination procedures and the lack of applicable quality control methods to assess the cleanliness of channels between patients contribute to increasing the risk of cross-infection of potentially harmful micro-organisms and molecules during endoscopy procedures.
Aura Timen (2010)	Netherlands	General healthcare facility	4 genetic barriers have been identified, to improve adherence to crisis guidelines, those barriers have to be addressed when developing guidelines, irrespective of the infectious agent. Profession specific barriers require profession specific strategies to change attitudes, ensure organizational facilities and provide an adequate setting for crisis management

Yvette H. van Beurden (2016)	Netherlands	Tertiary Care Facility	Total cost is calculated as 1.33 mi. euro with missed revenue due to increased length of stay of the CDI patients and the closure of beds to enable contact isolation of CDI patients. Second highest cost factor was the extra surveillance and activities of the infection control department. High cost of the outbreak should be seen as yet another reason to proactively implement a HAI prevention and control
Jan-Willem H. Dik (2016)	Netherlands	Hospital	seven outbreaks between 2012 - 14 were evaluated and total costs between 10,000 - 350,000 euro were calculated. A variety of microbial agents in the same hospital resulted in a large variation within the average cost due to different strategies.
J. A. Otter (2016)	England	Hospital	total outbreak costs of over 1.1m euro have been calculated over the 10-month period the outbreak persisted. The observational economic analysis was used to provide very detailed information what sums have been spent in which area. Missed revenue comprised the highest cost factor together with reduced capacities to perform elective surgical procedures related to bed closure.
Jan Müller (2015)	Germany and Netherlands	General healthcare facility	Usage of consistent terminology and harmonized diagnostic procedures would greatly improve the possibilities for infection prevention and treatment. The increased number of susceptible (elderly) patients in combination with higher rates of cross border patients further show the necessity for a multi- and interdisciplinary bilateral cooperation to prevent a "post-antibiotic" era.
Timothy Lawes (2015)	Scotland	Hospital	more than 1.2 million hospital admission and 450.000 adults registered in primary health care facilities have been investigated for antibiotic interventions. Policy measures such as a hand hygiene campaign, hospital environment inspections and MRSA admissions screening have been assessed as well. Alongside infection control measures, removal of key antibiotic selection pressures predicted a large and sustained reduction in hospital associated and community associated MRSA. Therefore, antibiotic stewardship is highly recommended
Defez, 2008	France	Hospitals	"Total additional costs of NI (direct medical costs and costs of extra length of stay) in acute care were estimated to be up to 3.2 million (Euro) per year. In conclusion, both prevention of avoidable NI and better estimation of the actual costs of NI should be priorities for all healthcare facilities."
W. Wetzker (2016)	Germany	Hospital	Performance in wards and facilities differed immensely (neonatal ICU and pediatric non-ICU with higher compliance than adult care; nurses with better performance than physicians; rates of hand hygiene performance was significantly higher after patient contact than before)
Heidi S. M. Ammerlaan (2011)	Netherlands	tertiary health care facility	the 2006 guidelines for the eradication of MRSA were evaluated in a two-year study involving 18 Dutch. Following the guideline resulted in 60% successfully decolonized patients after first treatment (increased treatment success compared to the time before introduction of the guideline)

Jean Carlet (2009)	France	Hospital, more than 1,509 tertiary health care facility in France (national level campaign), more than 620,176 surgical procedures between 1999 - 2005 and patients in more than 2,786 healthcare facilities in 2006	This nationwide program has been implemented to strengthen the organized infection control activities on local, regional and national level as well as developing large networks for surveillance of specific infections and antibiotic resistance. Surgical infection rates decreased by 25% over a 6-year period, median proportions of MRSA among S. aureus isolated among patients decreased by 7.8% whereas the same rate increased in other European countries. In conclusion, the French program seems to be effective but continuing efforts are required.

Appendix 4: The scope, responsibilities, and requirements outlined in programs and policies related to WaSH in HCF

Outcome	**Country**					
	Georgia	**Hungary**	**Italy**	**The Republic of Moldova**	**Serbia**	**Tajikistan**
National Standards and Regulations						
Scope	WaSH Infrastructure, medical waste management, water supply, surveillance of nosocomial infections, staff behavior, IPC, cleaning and disinfection, laundering	Sanitary facilities, handwashing/hygiene, Legionella,	Surveillance of nosocomial infections, medical waste management, Legionella, water quality	Handwashing/hygiene, sanitary facilities, water supply, medical waste management, surveillance of nosocomial infections	Water quality, sanitary facilities, epidemiological rules, wastewater, medical waste management,	Water supply and quality, medical waste management
Targeted Programs to improve WaSH						
	Georgia	**Hungary**	**Italy**	**The Republic of Moldova**	**Serbia**	**Tajikistan**
Scope	N/A	WaSH Infrastructure	Surveillance of nosocomial infections, antimicrobial resistance,	Water supply/quality, sanitary facility	IPC, surveillance of nosocomial infections	N/A
Targeted Programs to improve sustainability						
	Georgia	**Hungary**	**Italy**	**The Republic of Moldova**	**Serbia**	**Tajikistan**
Scope	N/A	Energy efficiency, renewable energy, water use efficiency	Conscientious consumption	Medical waste reduction and/or management, wastewater treatment,	Medical waste reduction and/or management	Access to safe water, education

				energy efficiency, water use efficiency		
Division of responsibilities of provision, maintenance, and monitoring of WaSH						
	Georgia	**Hungary**	**Italy**	**The Republic of Moldova**	**Serbia**	**Tajikistan**
Provision and maintenance of WaSH	National law, Responsibility of national agency	National law, Responsibility of national agency	Responsibility of regional and local agencies	Responsibility of organizing body (national hospitals vs other HCF)	Provision is responsibility of local agencies, maintenance is responsibility of national agency	Responsibility of national agency, water supply responsibility of facility in rural areas
Monitoring of WaSH Conditions	Coordinated by national agency	Provision of WaSH the responsibility of facility, oversight by local agency	N/A	Responsibility of national agency	responsibility of national agency	N/A
Overview on the situation of WaSH in HCF						
	Georgia	**Hungary**	**Italy**	**The Republic of Moldova**	**Serbia**	**Tajikistan**
Type of Overview	Ongoing monitoring tool	One-off assessment	One-off assessment	Ongoing monitoring tool	Ongoing monitoring tool; one-off assessment	Ongoing monitoring tool
Scope	Medical waste management, water supply, cleaning and disinfection, laundering, hand hygiene	Medical waste management, water supply, hand hygiene (ongoing monitoring)	IPC, antibiotic resistance	Water supply/quality, medical waste management	Hygiene; wastewater and medical waste management	Water supply/quality, sanitation
WaSH Dimensions Missing	Sanitation, wastewater	Sanitation, wastewater	Water supply, sanitation, hygiene, medical waste management, wastewater	Sanitation, wastewater, hygiene	Water supply/quality, sanitation	Wastewater, hygiene, medical waste management
Requirements for routine surveillance by national authorities of WaSH conditions						
	Georgia	**Hungary**	**Italy**	**The Republic of Moldova**	**Serbia**	**Tajikistan**
Scope	WaSH Infrastructure, medical waste management, water supply, laundering, cleaning and disinfection, hand hygiene, IPC, surveillance of nosocomial infections, staff behavior, antibiotic stewardship	Minimal legal requirements met, Legionella, surveillance of nosocomial infections	N/A	Sanitary facilities, hygiene	WaSH infrastructure, water supply/quality, sanitation, medical waste management, cleaning and disinfection	Sanitary facility, hygiene, medical waste management, water supply
Frequency	N/A	1/year	N/A	1/year	N/A	1/year

Enforcement Mechanism Included	Correction period followed by a third phase planned by state agency, involves the imposition of a penalties or rejection from the universal health care program until corrections made	N/A	N/A	1) Sanitary authorization issued by territorial Centers of Public Health 2) Center applies penalties in the case of non-compliance 3) Accreditation by the National Council of Evaluation and Accreditation	N/A	N/A
Actors	N/A	county public health offices	N/A	N/A	Ministry of Health under the Regulation on the Protection of the Population against Communicable Diseases	Ministry of Health; the district Laboratory of Sanitary and Epidemiological Surveillance

References

Achour, N., & Price, A. D. (2010). Resilience strategies of healthcare facilities: present and future. International Journal of Disaster Resilience in the Built Environment, 1(3), 264-276.

Al-Ahmad, A., Daschner, F. D., & Kümmerer, K. (1999). Biodegradability of cefotiam, ciprofloxacin, meropenem, penicillin G, and sulfamethoxazole and inhibition of waste water bacteria. Archives of environmental contamination and toxicology, 37(2), 158-163.

Allegranzi, B., & Pittet, D. (2009). Role of hand hygiene in healthcare-associated infection prevention. Journal of hospital infection, 73(4), 305-315.

Ammerlaan, Heidi S M, Jan A J W Kluytmans, Hanneke Berkhout, Anton Buiting, Els I G B de Brauwer, Peterhans J. Van den broek, Paula Van gelderen, et al. 2011. "Eradication of Carriage with Methicillin-Resistant Staphylococcus Aureus: Effectiveness of a National Guideline." *Journal of Antimicrobial Chemotherapy* 66 (10): 2409–17. doi:10.1093/jac/dkr243.

Angelillo, I F, G Nardi, C F Rizzo, and N M A Viggiani. 2001. "Dental Hygienists and Infection Control: Knowledge, Attitudes and Behaviour in Italy." *Journal of Hospital Infection* 47 (4). I.F. Angelillo, Medical School, Univ. of Catanzaro Magna Graecia, 88100 Catanzaro, Italy: 314–20. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L32631869.

Aygün, G, O Demirkiran, T Utku, B Mete, S Urkmez, M Yilmaz, H Yaşar, Y Dikmen, and R Oztürk. 2002. "Environmental Contamination during a Carbapenem-Resistant Acinetobacter Baumannii Outbreak in an Intensive Care Unit." *The Journal of Hospital Infection* 52 (4): 259–62. http://www.ncbi.nlm.nih.gov/pubmed/12473469.

Bagg, J, a J Smith, D Hurrell, S McHugh, and G Irvine. 2007. "Pre-Sterilisation Cleaning of Re-Usable Instruments in General Dental Practice." *British Dental Journal* 202 (9): E22; discussion 550-1. doi:10.1038/bdj.2007.124.

Barret, A. S., N. Jourdan-da Silva, K. Ambert-Balay, G. Delmas, A. Bone, J. M. Thiolet, and V. Vaillant. 2015. "Surveillance for Outbreaks of Gastroenteritis in Elderly Long-Term Care Facilities in France, November 2010 to May 2012." *Eurosurveillance* 19 (29). doi:10.2807/1560-7917.ES2014.19.29.20859.

Beckmann, Andreas, Klaus Doebler, Elke Schaefer, Joachim Koetting, Petra Gastmeier, and Karolin Graf. 2011. "Sternal Surgical Site Infection Prevention - Is There Any Room for Improvement?" *EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY* 40 (2): 347–51. doi:10.1016/j.ejcts.2010.12.016.

Benson, P E, and C W I Douglas. 2007. “Decontamination of Orthodontic Bands Following Size Determination and Cleaning.” *Journal of Orthodontics* 34 (1): 18–24. doi:10.1179/146531207225021879.

Berthelot, Philippe, Florence Grattard, Alain Ros, Frédéric Lucht, and Bruno Pozzetto. 1998. “Nosocomial Legionellosis Outbreak over a Three-Year Period: Investigation and Control.” *Clinical Microbiology and Infection* 4 (7): 385–91. doi:http://dx.doi.org/10.1111/j.1469-0691.1998.tb00082.x.

Beurden, Y. H. van, M. K. Bomers, S. D. van der Werff, E. A P M Pompe, S. Spiering, C. M J E Vandenbroucke-Grauls, and C. J J Mulder. 2017. “Cost Analysis of an Outbreak of Clostridium Difficile Infection Ribotype 027 in a Dutch Tertiary Care Centre.” *Journal of Hospital Infection* 95 (4): 421–25. doi:10.1016/j.jhin.2016.12.019.

Bianco, Aida, Angela Quirino, Mariavalentina Giordano, Vito Marano, Claudia Rizzo, Maria Carla Liberto, Alfredo Focà, and Maria Pavia. 2016. “Control of Carbapenem-Resistant Acinetobacter Baumannii Outbreak in an Intensive Care Unit of a Teaching Hospital in Southern Italy.” *BMC Infectious Diseases* 16 (1): 747. doi:10.1186/s12879-016-2036-7.

Birpinar, Mehmet Emin, Mehmet Sinan Bilgili, and Tuğba Erdoğan. 2009. “Medical Waste Management in Turkey: A Case Study of Istanbul.” *Waste Management (New York, N.Y.)* 29 (1): 445–48. doi:10.1016/j.wasman.2008.03.015.

Blanch, A R, J L Caplin, A Iversen, I Kühn, A Manero, H D Taylor, and X Vilanova. 2003. “Comparison of Enterococcal Populations Related to Urban and Hospital Wastewater in Various Climatic and Geographic European Regions.” *Journal of Applied Microbiology* 94 (6). Blanch, A. R.: Department of Microbiology, University of Barcelona, Diagonal 645, 08028 - Barcelona, Catalonia, Spain.: Blackwell Science: 994–1002. https://auth.lib.unc.edu/ezproxy_auth.php?url=http://search.ebscohost.com/login.aspx?direct=true&db=lhh&AN=20033091044&site=ehost-live&scope=site.

Blenkharn, J I. 2006. “Lowering Standards of Clinical Waste Management: Do the Hazardous Waste Regulations Conflict with the CDC’s Universal/standard Precautions?” *Journal of Hospital Infection* 62 (4). Blenkharn, J. I.: 18 South Road, London W5 4RY, UK.: Elsevier: 467–72. https://auth.lib.unc.edu/ezproxy_auth.php?url=http://search.ebscohost.com/login.aspx?direct=true&db=lhh&AN=20063079900&site=ehost-live&scope=site.

Boillot, C., Bazin, C., Tissot-Guerraz, F., Droguet, J., Perraud, M., Cetre, J. C., ... & Perrodin, Y. (2008). Daily physicochemical, microbiological and ecotoxicological fluctuations of a hospital effluent according to technical and care activities. Science of the total environment, 403(1-3), 113-129.

Borer, A., Gilad, J., Smolyakov, R., Eskira, S., Peled, N., Porat, N., ... & Schlaeffer, F. (2005). Cell phones and Acinetobacter transmission. Emerging infectious diseases, 11(7), 1160.

Botelho, Anabela. 2012. "The Impact of Education and Training on Compliance Behavior and Waste Generation in European Private Healthcare Facilities." *Journal of Environmental Management* 98 (1): 5–10. doi:10.1016/j.jenvman.2011.12.003.

Bou, Ricardo, Miguel Peris, Javier Perpinan, Pilar Ramos, and Angel Aguilar. 2004. "A Protracted Outbreak of Staphylococcus Epidermidis Infections among Patients Undergoing Valve Replacement." *Infection Control and Hospital Epidemiology* 25 (6): 498–503. doi:10.1086/502429.

Brady, R. R., A. C. Hunt, A. Visvanathan, M. A. Rodrigues, C. Graham, C. Rae, P. Kalima, H. M. Paterson, and A. P. Gibb. 2011. "Mobile Phone Technology and Hospitalized Patients: A Cross-Sectional Surveillance Study of Bacterial Colonization, and Patient Opinions and Behaviours." *Clinical Microbiology and Infection* 17 (6): 830–35. doi:10.1111/j.1469-0691.2011.03493.x.

Bréchet, Caroline, Julie Plantin, Marlène Sauget, Michelle Thouverez, Daniel Talon, Pascal Cholley, Christophe Guyeux, Didier Hocquet, and Xavier Bertrand. 2014. "Wastewater Treatment Plants Release Large Amounts of Extended-Spectrum β-Lactamase-Producing Escherichia Coli into the Environment." *Clinical Infectious Diseases* 58 (12): 1658–65. doi:10.1093/cid/ciu190.

Carlet, J, P Astagneau, C Brun-Buisson, B Coignard, V Salomon, B Tran, J C Desenclos, et al. 2009. "French National Program for Prevention of Healthcare-Associated Infections and Antimicrobial Resistance, 1992-2008: Positive Trends, but Perseverance Needed." *Infect.Control Hosp.Epidemiol.* 30 (1559–6834 (Electronic)): 737–45. doi:10.1086/598682.

Coskun, Diler, and Jale Aytac. 2007. "Evaluation of Nosocomial Infections Following Cardiovascular Surgery." *Anadolu Kardiyoloji Dergisi : AKD = the Anatolian Journal of Cardiology* 7 (2): 164–68.

Coulter, W A, C A Chew-Graham, S W Cheung, and F J T Burke. 2001. "Autoclave Performance and Operator Knowledge of Autoclave Use in Primary Care: A Survey of UK Practices." *JOURNAL OF HOSPITAL INFECTION* 48 (3): 180–85. doi:10.1053/jhin.2001.0959.

Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org

Crimi, Paolo, F. Argellati, G. Macrina, C. Tinteri, L. Copello, D. Rebora, L. Romania, and R. Rizzetto. 2006. "Microbiological Surveillance of Hospital Ventilation Systems in Departments at High Risk of Nosocomial Infections." *Journal of Preventive Medicine and Hygiene* 47 (3): 105–9.

Cummins, Martina, and Derren Ready. 2016. “Role of the Hospital Environment in Norovirus Containment.” *Journal of Infectious Diseases* 213: S12–14. doi:10.1093/infdis/jiv529.

Cunney, R, H Humphreys, and N Murphy. 2006. “Survey of Acute Hospital Infection Control Resources and Services in the Republic of Ireland.” *Journal of Hospital Infection* 64 (1). Elsevier: 63–68.

Dancer, Stephanie J, Liza White, and Chris Robertson. 2008. “Monitoring Environmental Cleanliness on Two Surgical Wards.” *International Journal of Environmental Health Research* 18 (5): 357–64. doi:10.1080/09603120802102465.

Defez, C., P. Fabbro-Peray, M. Cazaban, T. Boudemaghe, A. Sotto, and J. P. Daurès. 2008. “Additional Direct Medical Costs of Nosocomial Infections: An Estimation from a Cohort of Patients in a French University Hospital.” *Journal of Hospital Infection* 68 (2): 130–36. doi:10.1016/j.jhin.2007.11.005.

Dijk, Y v, E M Bik, S Hochstenbach-Vernooij, G J v d Vlist, P H M Savelkoul, J A Kaan, and R J A Diepersloot. 2002. “Management of an Outbreak of Enterobacter Cloacae in a Neonatal Unit Using Simple Preventive Measures.” *The Journal of Hospital Infection* 51 (1): 21–26. doi:10.1053/jhin.2002.1186.

Dik, Jan Willem H., Ariane G. Dinkelacker, Pepijn Vemer, Jerome R. Lo-Ten-Foe, Mariëtte Lokate, Bhanu Sinha, Alex W. Friedrich, and Maarten J. Postma. 2016. “Cost-Analysis of Seven Nosocomial Outbreaks in an Academic Hospital.” *PLoS ONE* 11 (2). doi:10.1371/journal.pone.0149226.

Elhassan, Hassan A, and Teresa Dixon. 2012. “MRSA Contaminated Venepuncture Tourniquets in Clinical Practice.” *Postgraduate Medical Journal* 88 (1038): 194–97. doi:10.1136/postgradmedj-2011-130411.

Erasmus, V., Daha, T. J., Brug, H., Richardus, J. H., Behrendt, M. D., Vos, M. C., & van Beeck, E. F. (2010). Systematic review of studies on compliance with hand hygiene guidelines in hospital care. Infection Control & Hospital Epidemiology, 31(3), 283-294.

Eveillard, M., F. Eb, B. Tramier, J. L. Schmit, F. X. Lescure, M. Biendo, B. Canarelli, et al. 2001. “Evaluation of the Contribution of Isolation Precautions in Prevention and Control of Multi-Resistant Bacteria in a Teaching Hospital.” *Journal of Hospital Infection* 47 (2): 116–24. doi:10.1053/jhin.2000.0877.

Felföldi, T., Z. Heéger, M. Vargha, and K. Márialigeti. 2010. “Detection of Potentially Pathogenic Bacteria in the Drinking Water Distribution System of a Hospital in Hungary.” *Clinical Microbiology and Infection* 16 (1): 89–92. doi:10.1111/j.1469-0691.2009.02795.x.

Ferreira, Vera, and Margarida Ribau Teixeira. 2010. “Healthcare Waste Management Practices and Risk Perceptions: Findings from Hospitals in the Algarve Region, Portugal.” *Waste Management* 30 (12): 2657–63. doi:10.1016/j.wasman.2010.07.012.

Frumkin, H., Hess, J., Luber, G., Malilay, J., & McGeehin, M. (2008). Climate change: the public health response. American journal of public health, 98(3), 435-445.

Gastmeier, Petra, Frank Schwab, Iris Chaberny, and Christine Geffers. 2012. “Individual Units rather than Entire Hospital as the Basis for Improvement: The Example of Two Methicillin Resistant Staphylococcus Aureus Cohort Studies.” *Antimicrobial Resistance and Infection Control* 1 (1): 8. doi:10.1186/2047-2994-1-8.

Goldemberg, J. (1998). Leapfrog energy technologies. Energy Policy, 26(10), 729-741.

Goren, Sami, Goksel Demir, Cevat Yaman, and Abdulkadir Yildiz. 2011. “Medical Waste Management by Geographical Region in Turkey.” *JOURNAL OF RESIDUALS SCIENCE & TECHNOLOGY* 8 (3): 109–15.

Hagel, Stefan, Katrin Ludewig, Anne Moeser, Michael Baier, Bettina L????ffler, Benjamin Schleenvoigt, Christina Forstner, and Mathias W. Pletz. 2016. “Characteristics and Management of Patients with Influenza in a German Hospital during the 2014/2015 Influenza Season.” *Infection* 44 (5): 667–72. doi:10.1007/s15010-016-0920-0.

Haill, C. F., P. Newell, C. Ford, M. Whitley, J. Cox, M. Wallis, R. Best, and P. J. Jenks. 2012. “Compartmentalization of Wards to Cohort Symptomatic Patients at the Beginning and End of Norovirus Outbreaks.” *Journal of Hospital Infection* 82 (1): 30–35. doi:10.1016/j.jhin.2012.05.015.

Halachev, Mihail R, Jacqueline Z-m Chan, Chrystala I Constantinidou, Nicola Cumley, Craig Bradley, Matthew Smith-Banks, Beryl Oppenheim, and Mark J Pallen. 2014. “Genomic Epidemiology of a Protracted Hospital Outbreak Caused by Multidrug-Resistant Acinetobacter Baumannii in Birmingham, England.” *Genome Medicine* 6 (11): 70. doi:10.1186/s13073-014-0070-x.

Harris, S., C. Morris, D. Morris, M. Cormican, E. Cummins, M. Kosek, C. Bern, et al. 2013. “The Effect of Hospital Effluent on Antimicrobial Resistant E. Coli within a Municipal Wastewater System.” *Environmental Science: Processes & Impacts* 15 (3): 617. doi:10.1039/c2em30934c.

Herra, C. M., S. J. Knowles, M. E. Kaufmann, E. Mulvihill, B. McGrath, and C. T. Keane. 1998. "An Outbreak of an Unusual Strain of Serratia Marcescens in Two Dublin Hospitals." *Journal of Hospital Infection* 39 (2): 135–41. doi:10.1016/S0195-6701(98)90327-9.

Hervé, R., and C. W. Keevil. 2013. "Current Limitations about the Cleaning of Luminal Endoscopes." *Journal of Hospital Infection* 83 (1): 22–29. doi:10.1016/j.jhin.2012.08.008.

Holy, O, I Matouskova, and E Juraskova. 2014. "Risk of Hospital-Acquired Legionellosis from Microbial Contamination of Potable Water at a Bone Marrow Transplant Unit in a Czech University Hospital." *Journal of Water Chemistry and Technology* 36 (5). Holy, O.: Department of Preventive Medicine, Faculty of Medicine and Dentistry, Palacky University Olomouc, Olomouc, Czech Republic.: Allerton Press, Inc.: 247–51. https://auth.lib.unc.edu/ezproxy_auth.php?url=http://search.ebscohost.com/login.aspx?direct=true&db=lhh&AN=20153204568&site=ehost-live&scope=site.

Houben, A. J M, E. A N Oostdijk, P. H J van der Voort, J. C M Monen, M. J M Bonten, A. K. van der Bij, F. Vlaspolder, et al. 2014. "Selective Decontamination of the Oropharynx and the Digestive Tract, and Antimicrobial Resistance: A 4 Year Ecological Study in 38 Intensive Care Units in the Netherlands." *Journal of Antimicrobial Chemotherapy* 69 (3): 797–804. doi:10.1093/jac/dkt416.

Inglis, T J, L J Sproat, P M Hawkey, and P Knappett. 1992. "Infection Control in Intensive Care Units: U.K. National Survey." *British Journal of Anaesthesia* 68 (2): 216–20.

Jakobsen, Lotte, Dorthe Sandvang, Lars H. Hansen, Line Bagger-Skjøt, Henrik Westh, Claus Jørgensen, Dennis S. Hansen, et al. 2008. "Characterisation, Dissemination and Persistence of Gentamicin Resistant Escherichia Coli from a Danish University Hospital to the Waste Water Environment." *Environment International* 34 (1): 108–15. doi:10.1016/j.envint.2007.07.011.

Jenner, E. a., P. W. B. Watson, L. Miller, F. Jones, and G. M. Scott. 2010. "Explaining Hand Hygiene Practice: An Extended Application of the Theory of Planned Behaviour." *Psychology, Health & Medicine* 7 (3): 311–26. doi:10.1080/13548500220139412.

Jeske, H. C., Tiefenthaler, W., Hohlrieder, M., Hinterberger, G., & Benzer, A. (2007). Bacterial contamination of anaesthetists' hands by personal mobile phone and fixed phone use in the operating theatre. Anaesthesia, 62(9), 904-906.

Kaiser, Anna Maria, Evelien de Jong, Sabine Fm Evelein-Brugman, Jan M Peppink, Christina Mje Vandenbroucke-Grauls, and Armand Rj Girbes. 2014. "Development of Trigger-Based Semi-Automated Surveillance of Ventilator-Associated Pneumonia and Central Line-Associated

Bloodstream Infections in a Dutch Intensive Care." *Annals of Intensive Care* 4 (1): 40. doi:10.1186/s13613-014-0040-x.

Karabay, O., Koçoglu, E., & Tahtaci, M. (2007). The role of mobile phones in the spread of bacteria associated with nosocomial infections. J Infect Dev Ctries, 1(1), 72-3.

Lawes, T., Lopez-Lozano, J. M., Nebot, C. A., Macartney, G., Subbarao-Sharma, R., Dare, C. R., ... & Gould, I. M. (2015). Effects of national antibiotic stewardship and infection control strategies on hospital-associated and community-associated meticillin-resistant Staphylococcus aureus infections across a region of Scotland: a non-linear time-series study. *The Lancet Infectious Diseases*, *15*(12), 1438-1449.

Leclercq, Roland, Kenny Oberlé, Sébastien Galopin, Vincent Cattoir, Héléne Budzinski, and Fabienne Petit. 2013. "Changes in Enterococcal Populations and Related Antibiotic Resistance along a Medical Center-Wastewater Treatment Plant-River Continuum." *Applied and Environmental Microbiology* 79 (7): 2428–34. doi:10.1128/AEM.03586-12.

Lindberg, Maria, Bernice Skytt, Marieann Högman, and Marianne Carlsson. 2012. "The Multidrug-Resistant Bacteria Attitude Questionnaire: Validity and Understanding of Responsibility for Infection Control in Swedish Registered District, Haematology and Infection Nurses." *Journal of Clinical Nursing* 21 (3–4): 424–36. doi:10.1111/j.1365-2702.2011.03914.x.

Lipscomb, I. P., A. K. Sihota, and C. W. Keevil. 2006. "Comparative Study of Surgical Instruments from Sterile-Service Departments for Presence of Residual Gram-Negative Endotoxin and Proteinaceous Deposits." *Journal of Clinical Microbiology* 44 (10): 3728–33. doi:10.1128/JCM.01280-06.

Muller, Jan, Andreas Voss, Robin Koeck, Bhanu Sinha, John W Rossen, Martin Kaase, Martin Mielke, et al. 2015. "Cross-Border Comparison of the Dutch and German Guidelines on Multidrug-Resistant Gram-Negative Microorganisms." *ANTIMICROBIAL RESISTANCE AND INFECTION CONTROL* 4 (February). doi:10.1186/s13756-015-0047-6.

Napoli, Christian, Vincenzo Marcotrigiano, and Maria Montagna. 2012. "Air Sampling Procedures to Evaluate Microbial Contamination: A Comparison between Active and Passive Methods in Operating Theatres." *BMC Public Health* 12 (1): 594. doi:10.1186/1471-2458-12-594.

Neylon, Orla, Nuala H. O'Connell, Barbara Slevin, James Powell, Regina Monahan, Liz Boyle, Dominic Whyte, et al. 2010. "Neonatal Staphylococcal Scalded Skin Syndrome: Clinical and Outbreak Containment Review." *European Journal of Pediatrics* 169 (12): 1503–9. doi:10.1007/s00431-010-1252-1.

Novais, Carla, Teresa M. Coque, Helena Ferreira, João Carlos Sousa, and Luisa Peixe. 2005. "Environmental Contamination with Vancomycin-Resistant Enterococci from Hospital Sewage in Portugal." *Applied and Environmental Microbiology* 71 (6): 3364–68. doi:10.1128/AEM.71.6.3364-3368.2005.

O'Connor, C., M. Cormican, T. W. Boo, E. McGrath, B. Slevin, A. O'Gorman, M. Commane, et al. 2016. "An Irish Outbreak of New Delhi Metallo-??-Lactamase (NDM)-1 Carbapenemase-Producing Enterobacteriaceae: Increasing but Unrecognized Prevalence." *Journal of Hospital Infection* 94 (4): 351–57. doi:10.1016/j.jhin.2016.08.005.

O'Connor, Ciara, Roy K. Philip, John Kelleher, James Powell, Alan O'Gorman, Barbara Slevin, Neil Woodford, et al. 2017. "The First Occurrence of a CTX-M ESBL-Producing Escherichia Coli Outbreak Mediated by Mother to Neonate Transmission in an Irish Neonatal Intensive Care Unit." *BMC Infectious Diseases* 17 (1): 16. doi:10.1186/s12879-016-2142-6.

Oberdorfer, Klaus, Grita Müssigbrodt, and Constanze Wendt. 2008. "Genetic Diversity of Legionella Pneumophila in Hospital Water Systems." *International Journal of Hygiene and Environmental Health* 211 (1–2): 172–78. doi:10.1016/j.ijheh.2007.04.003.

Oberlé, Kenny, Marion Justine Capdeville, Thierry Berthe, Hélène Budzinski, and Fabienne Petit. 2012. "Evidence for a Complex Relationship between Antibiotics and Antibiotic-Resistant Escherichia Coli: From Medical Center Patients to a Receiving Environment." *Environmental Science and Technology* 46 (3): 1859–68. doi:10.1021/es203399h.

Ory, Jérôme, Geneviève Bricheux, Anne Togola, Jean Louis Bonnet, Florence Donnadieu-Bernard, Laurence Nakusi, Christiane Forestier, and Ousmane Traore. 2016. "Ciprofloxacin Residue and Antibiotic-Resistant Biofilm Bacteria in Hospital Effluent." *Environmental Pollution* 214: 635–45. doi:10.1016/j.envpol.2016.04.033.

Otter, J. A., P. Burgess, F. Davies, S. Mookerjee, J. Singleton, M. Gilchrist, D. Parsons, E. T. Brannigan, J. Robotham, and A. H. Holmes. 2017. "Counting the Cost of an Outbreak of Carbapenemase-Producing Enterobacteriaceae: An Economic Evaluation from a Hospital Perspective." *Clinical Microbiology and Infection* 23 (3): 188–96. doi:10.1016/j.cmi.2016.10.005.

Parker, L J. 2004. "Decontamination of Medical Devices: Legislation and Compliance to Practice." *British Journal of Nursing* 13 (17): 1028–32. https://login.ezproxy1.acu.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=2005011752&site=ehost-live.

Perdelli, Fernanda, Gianluca Ottria, Maria Luisa Cristina, Roberto Lombardi, Marina Sartini, Anna Maria Spagnolo, Maurizio Dallera, and Paolo Orlando. 2008. "Evaluation of Environmental

Contamination by Glutaraldehyde in an Outpatient Facility for Digestive Endoscopy in an Italian Hospital." *International Journal of Environmental Health Research* 18 (1): 73–78. doi:10.1080/09603120701633354.

Perilli, Mariagrazia, Carlo Bottoni, Eugenio Pontieri, Bernardetta Segatore, Giuseppe Celenza, Domenico Setacci, Pierangelo Bellio, Roberto Strom, and Gianfranco Amicosante. 2013. "Emergence of blaKPC-3-Tn4401a in Klebsiella Pneumoniae ST512 in the Municipal Wastewater Treatment Plant and in the University Hospital of a Town in Central Italy." *Journal of Global Antimicrobial Resistance* 1 (4): 217–20. doi:10.1016/j.jgar.2013.07.002.

Peters, Claudia, Anja Schablon, Kirsten Bollongino, Monika Maaß, Dietmar Kaß, Madeleine Dulon, Roland Diel, and Albert Nienhaus. 2014. "Multiresistant Pathogens in Geriatric Nursing - Infection Control in Residential Facilities for Geriatric Nursing in Germany." *GMS Hygiene and Infection Control* 9 (3): Doc22. doi:10.3205/dgkh000242.

Pittet, D., Allegranzi, B., Sax, H. et al. Evidence-based model for hand transmission during patient care and the role of improved practices. Lancet Infect Dis. 2006; 6: 641–652

Rehfuess, E. A., Bruce, N., & Bartram, J. K. (2009). More health for your buck: health sector functions to secure environmental health. Bulletin of the World Health Organization, 87, 880-882.

Sadat-Ali, M., Al-Omran, A. K., Azam, Q., Bukari, H., Al-Zahrani, A. J., Al-Turki, R. A., & Al-Omran, A. S. (2010). Bacterial flora on cell phones of health care providers in a teaching institution. American journal of infection control, 38(5), 404-405.

Sadowy, E, and A Luczkiewicz. 2014. "Drug-Resistant and Hospital-Associated Enterococcus Faecium from Wastewater, Riverine Estuary and Anthropogenically Impacted Marine Catchment Basin." *BMC Microbiol* 14: 66. doi:10.1186/1471-2180-14-66.

Safety, W. P., & World Health Organization. (2009). WHO guidelines on hand hygiene in health care.

Schröder, C, F Schwab, M Behnke, A-C Breier, F Maechler, B Piening, M Dettenkofer, C Geffers, and P Gastmeier. 2015. "Epidemiology of Healthcare Associated Infections in Germany: Nearly 20 Years of Surveillance." *International Journal of Medical Microbiology* 305 (7). Elsevier: 799–806.

Semin-Pelletier, B., L. Cazet, C. Bourigault, M. E. Juvin, D. Boutoille, F. Raffi, M. Hourmant, et al. 2015. "Challenges of Controlling a Large Outbreak of OXA-48 Carbapenemase-Producing Klebsiella Pneumoniae in a French University Hospital." *Journal of Hospital Infection*. doi:10.1016/j.jhin.2014.11.018.

Servais, P, and J Passerat. 2009. “Antimicrobial Resistance of Fecal Bacteria in Waters of the Seine River Watershed (France).” *Science of the Total Environment* 408 (2). Servais, P.: Ecologie des Systèmes Aquatiques, Université Libre de Bruxelles, Campus de la Plaine, C.P. 221, Boulevard du Triomphe, B-1050 Bruxelles, Belgium.: Elsevier: 365–72. https://auth.lib.unc.edu/ezproxy_auth.php?url=http://search.ebscohost.com/login.aspx?direct=true&db=lhh&AN=20093356786&site=ehost-live&scope=site.

Shah, R, J M Collins, T M Hodge, and E R Laing. 2009. “A National Study of Cross Infection Control: ‘Are We Clean Enough?’.” *British Dental Journal* 207 (6): 267–74. doi:10.1038/sj.bdj.2009.824.

Sheriteh, Zahra, Tasnim Hassan, Martyn Sherriff, Martin Cobourne, and Peter Riley. 2010. “Decontamination of Viable Streptococcus Mutans from Orthodontic Tungsten Carbide Debonding Burs. An in Vitro Microbiological Study.” *Journal of Orthodontics* 37 (3): 181–87. doi:10.1179/14653121043083.

Simo Tchuinte, Pierrette Landrie, Thibault Stalder, Silvia Venditti, Antoinette Ngandjio, Christophe Dagot, Marie C??cile Ploy, and Olivier Barraud. 2016. “Characterisation of Class 3 Integrons with Oxacillinase Gene Cassettes in Hospital Sewage and Sludge Samples from France and Luxembourg.” *International Journal of Antimicrobial Agents* 48 (4): 431–34. doi:10.1016/j.ijantimicag.2016.06.018.

Smith, A., S. Creanor, D. Hurrell, J. Bagg, and M. McCowan. 2009. “Management of Infection Control in Dental Practice.” *Journal of Hospital Infection* 71 (4): 353–58. doi:10.1016/j.jhin.2008.11.026.

Smith, A. J., D. E A Lockhart, E. McDonald, S. Creanor, D. Hurrell, and J. Bagg. 2010. “Design of Dental Surgeries in Relation to Instrument Decontamination.” *Journal of Hospital Infection* 76 (4): 340–44. doi:10.1016/j.jhin.2010.06.002.

Smith, G W G, a J Smith, S Creanor, D Hurrell, J Bagg, and D F Lappin. 2009. “Survey of the Decontamination and Maintenance of Dental Handpieces in General Dental Practice.” *British Dental Journal* 207 (4): E7; discussion 160-1. doi:10.1038/sj.bdj.2009.761.

Soysal, A, H Simsek, D Soysal, and F Alyu. 2010. “Management of Health-Care Waste in Izmir, Turkey.” *Annali dell’Istituto Superiore Di Sanità* 46 (3): 299–302. https://auth.lib.unc.edu/ezproxy_auth.php?url=http://search.ebscohost.com/login.aspx?direct=true&db=lhh&AN=20113001348&site=ehost-live&scope=site%5Cnhttp://www.iss.it/anna/%5Cnemail:ahmet.soysal@deu.edu.tr.

Szabó, Rita, Júlia Morvai, Fernando Bellissimo-Rodrigues, and Didier Pittet. 2015. “Use of Hand

Hygiene Agents as a Surrogate Marker of Compliance in Hungarian Long-Term Care Facilities: First Nationwide Survey." *Antimicrobial Resistance and Infection Control* 4 (1). BioMed Central: 32.

Tamburlini, Giorgio, Gelmius Siupsinskas, Alberta Bacci, Maternal, Neonatal Care Quality Assessment Working Group, and others. 2011. "Quality of Maternal and Neonatal Care in Albania, Turkmenistan and Kazakhstan: A Systematic, Standard-Based, Participatory Assessment." *PLoS One* 6 (12). Public Library of Science: e28763.

Thorburn, K, S Kerr, N Taylor, and H K F van Saene. 2004. "RSV Outbreak in a Paediatric Intensive Care Unit." *The Journal of Hospital Infection* 57 (3): 194–201. doi:10.1016/j.jhin.2004.03.013.

Timen, Aura, Marlies E J L Hulscher, Laura Rust, Jim E van Steenbergen, Reinier P Akkermans, Richard P T M Grol, and Jos W M van der Meer. 2010. "Barriers to Implementing Infection Prevention and Control Guidelines during Crises: Experiences of Health Care Professionals." *AMERICAN JOURNAL OF INFECTION CONTROL* 38 (9): 726–33. doi:10.1016/j.ajic.2010.03.006.

Varela, A. R., Ferro, G., Vredenburg, J., Yanık, M., Vieira, L., Rizzo, L., ... & Manaia, C. M. (2013). Vancomycin resistant enterococci: from the hospital effluent to the urban wastewater treatment plant. Science of the Total Environment, 450, 155-161.

Vassey, M, C Budge, T Poolman, P Jones, D Perrett, N Nayuni, P Bennett, et al. 2011. "A Quantitative Assessment of Residual Protein Levels on Dental Instruments Reprocessed by Manual, Ultrasonic and Automated Cleaning Methods." *British Dental Journal* 210 (9): E14. doi:10.1038/sj.bdj.2011.341.

Verlicchi, P., Al Aukidy, M., Galletti, A., Petrovic, M., & Barceló, D. (2012). Hospital effluent: investigation of the concentrations and distribution of pharmaceuticals and environmental risk assessment. Science of the total environment, 430, 109-118.

Wetzker, W, K Bunte-Schönberger, J Walter, G Pilarski, P Gastmeier, and Ch Reichardt. 2016. "Compliance with Hand Hygiene: Reference Data from the National Hand Hygiene Campaign in Germany." *Journal of Hospital Infection* 92 (4). Elsevier: 328–31.

White, Liza F, Stephanie J Dancer, and Chris Robertson. 2007. "A Microbiological Evaluation of Hospital Cleaning Methods." *International Journal of Environmental Health Research* 17 (4): 285–95. doi:10.1080/09603120701372433.

Widerström, Micael, Johan Wiström, Helén Edebro, Elisabeth Marklund, Mattias Backman, Per

Lindqvist, and Tor Monsen. 2016. “Colonization of Patients, Healthcare Workers, and the Environment with Healthcare-Associated Staphylococcus Epidermidis Genotypes in an Intensive Care Unit: A Prospective Observational Cohort Study.” *BMC Infectious Diseases* 16 (1): 743. doi:10.1186/s12879-016-2094-x.

World Health Organization, & Unicef. (2015). Water, sanitation and hygiene in health care facilities: status in low and middle income countries and way forward.

Yiallouros, Panayiotis K., Thalia Papadouri, Christina Karaoli, Elena Papamichael, Maria Zeniou, Despo Pieridou-Bagatzouni, Georgios T. Papageorgiou, Nicolas Pissarides, Timothy G. Harrison, and Andreas Hadjidemetriou. 2013. “First Outbreak of Nosocomial Legionella Infection in Term Neonates Caused by a Cold Mist Ultrasonic Humidifier.” *Clinical Infectious Diseases* 57 (1): 48–56. doi:10.1093/cid/cit176.

Yilmaz, Gulsum, Yasemin Kaya, Ilda Vergili, Z. Beril Gönder, Gül Özhan, Berna Ozbek Celik, Serdar M. Altinkum, Yasar Bagdatli, Andrea Boergers, and Jochen Tuerk. 2017. “Characterization and Toxicity of Hospital Wastewaters in Turkey.” *Environmental Monitoring and Assessment* 189 (2). doi:10.1007/s10661-016-5732-2.

Yüzbasioglu, Emir, Duygu Saraç, Sevgi Canbaz, Y Sinasi Saraç, and Seda Cengiz. 2009. “A Survey of Cross-Infection Control Procedures: Knowledge and Attitudes of Turkish Dentists.” *Journal of Applied Oral Science : Revista FOB* 17 (6): 565–69. doi:10.1590/S1678-77572009000600005.