CLASSIFICATION OF WATER-RELATED DISEASE

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Contents

Summary

Water related disease encompasses illness resulting from both direct and indirect exposure to water, whether by consumption or by skin exposure during bathing or recreational water use. It includes disease due to waterborne or water-associated pathogens and toxic substances. A broader definition includes illness related to water shortage or water contamination during adverse climate events, such as floods and droughts, diseases related to vectors with part of their life cycle in water habitats; and disease related to inhalation of contaminated water aerosols. Water-related disease may be classified in terms of the agents responsible and the types of water exposure, but for surveillance purposes, the classification system must also include the probability of association with water, since multifactorial aetiology is involved in most, if not all, of the water-related diseases. In public health terms, the classification system should also include factors related to intervention, such as the type of water treatment or sanitation measures required to remove the disease-causing factors. Host factors are relevant to water related disease transmission, since many of the agents have more impact on individuals who are malnourished or already suffering from other disease, including diseases associated with immune deficiency. The inherent relationship between water and food also complicates water related disease classification: in many surveillance systems, statistics on water related diseases are subsumed within data on gastroenteritis

or on food poisoning.

1. Introduction

(i)The classification of water-related disease poses particular problems. Agents, diseases and types of exposures are well documented, but the relationship between them is subject to degrees of certainty, timing of exposure and the nature of the exposure. Water in one form or another is a universal exposure for human beings: water is a fundamental requirement for nutrition and overall health, with a corresponding wide range of diseases that can be classified as having a water component. All the agents involved have other means of transmission and the evidence that confirms a water association can be elusive, often depending on whether a large outbreak or documented incident of contamination has been identified. While it has been estimated that the worldwide burden of water-related disease includes millions of cases of illness and deaths, surveillance systems for detecting and confirming water related disease vary considerably between countries. In some countries, only severe and wide-scale outbreaks are recorded; in most, minor episodes of water-related disease are either not investigated or not recorded on national databases.

(ii)Historically, water related disease has been a major health problem for both developed and developing countries. Its priority as a surveillance issue has fallen partly as a result of improved water and sanitation in industrialized and northern countries of the world, associated with lower morbidity and mortality from diseases such as cholera and typhoid fever. Food related disease surveillance has overtaken it in importance and in some countries water-related disease is classified under food poisoning or gastrointestinal infection, further diminishing its importance in surveillance statistics. The emphasis on the infections affecting the gastrointestinal system is appropriate in terms of numbers of cases, since gastrointestinal infection is the commonest water-related illness, worldwide: but a gastrointestinal-based classification ignores respiratory infections linked to contaminated water, such as legionellosis, and also skin or systemic disorders. Non-infectious water-borne disease is increasingly recognized as a public health concern, requiring different types and complexity of surveillance from the traditional systems based on microbiological agents.

(iii)While surveillance of illness attributable to treated water is a particular concern in developed or industrialized countries, only a minority of the world's population receives continuous piped supplies. According to figures from the WHO and UNICEF in 2000, 2.4 billion people do not have acceptable means of sanitation and 1.1 billion are estimated to lack an improved water supply. For the 'water poor' populations of the world, the risks associated with untreated water or poor sanitation include both individual risk of illness and public health issues of monitoring, surveillance and prevention. Increased population mobility and travel to different countries has to some extent globalized the risk of water-related disease, and the corresponding requirement for national surveillance systems to include the wide range of potential illnesses. Water-related disease surveillance is likely to rise in priority with the impact of climate change, including the effects of global warming on water habitats and adverse weather events threatening the security of water supplies. Other threats to safe water include the effect of the world economy on the funds available for public health measures and the

possibility of deliberate release of pathogens or toxic agents into water intended for human consumption.

(iv) This chapter includes both a basic and an extended system for classifying water-related disease, as well as discussing how attribution of cause, in terms of levels of likelihood, can be incorporated into the classification.

2. Definitions and Systems for Classifying Water Related Disease

2.1. Essential Components for the Classification

There are three essential components for the classification: the pathogens and other agents involved in water-related disease; the type of water exposure; and the level of probability of a water cause. Host factors, such as nutritional status, are important in terms of the priority and detail required for surveillance systems in countries with high levels of malnutrition, immune deficiency, or significant mortality from water borne pathogens **(**see Figure 1**)**

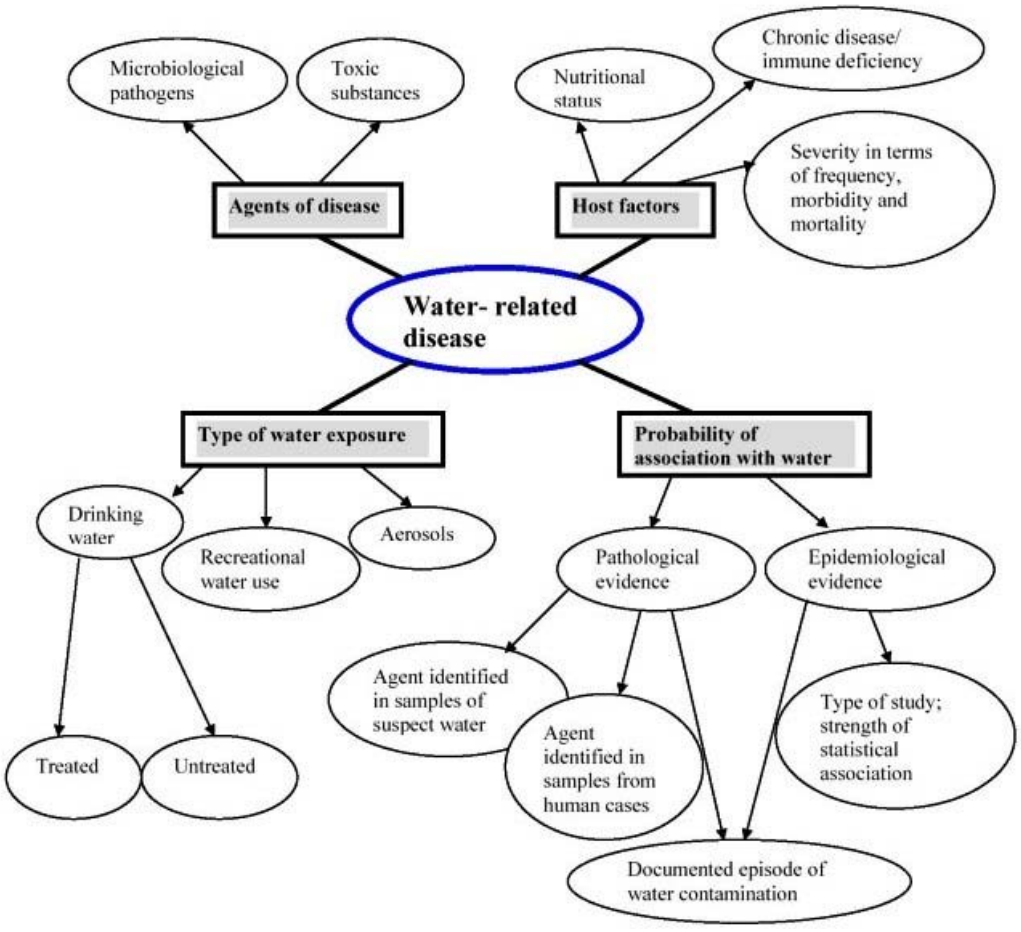

Figure 1. Relationships involved in the classification of water-related disease

2.2. Definition of Water-related Disease

Of the various terms for disease linked to water, water related disease is the most comprehensive. Water-related disease is defined as any significant or widespread adverse effects on human health, such as death, disability, illness or disorders, caused directly or indirectly by the condition, or changes in the quantity or quality of any waters. The causes of water related disease include micro-organisms, parasites, toxins and chemical contamination of water. Other terms include 'waterborne disease', which implies direct spread and is used mainly to refer to disease caused by microbiological pathogens or chemical contaminants in water. 'Water associated disease' covers the wide range of diseases in which water plays a part, such as legionnaires' disease, as well as diseases related to lack of water for washing and hygiene. The advantage of the term water related disease is that it includes both water borne and water associated ill health, although diseases with an indirect association and another major mode of spread are usually excluded from specific surveillance systems. An example of an indirectly related disease is trachoma: the predominant mode of spread is via poor hygiene and flies thriving in conditions of poor sanitation: clean water for hygiene is an important element in prevention, but the disease is not otherwise water-related. Such diseases used to be known as 'water-washed', referring to the role of clean water in removing the agents, but the term is no longer widely used: McJunkin suggested the alternative of 'water-hygiene diseases'.

2.3. Categories of Water-related Disease

Seven categories of water-related disease can thus be identified (Table 1) waterborne microbiological disease; waterborne chemical disease; water hygiene disease; water contact disease; water vector habitat disease; excretal disposal disease and water aerosol disease. In addition to the subcategories in Table 1, other subcategories could be included such as those related to duration of exposure (acute/ prolonged).

2.4. Type of water exposure

The commonest distinction regarding water exposure is between drinking water and recreational water. For some surveillance systems, disease is also classified according to whether the water supply involved is a public water system, usually regulated by national legislature and local by-laws, or other types of supply, such as private wells or untreated water sources. A more detailed classification requires specification of the type of water source, such as groundwater or surface water. For water-contact diseases, the classification sub-categories include fresh water and marine waters.

Category	Description of category	Type of water exposure	Subcategories	Example(s)
Waterborne microbiological disease	Diseases related to consumption of pathogens consumed in water; most due to human or animal faecal contamination of water	Drinking water	(i) Treated or untreated (raw) water (ii) Public (municipal) supplies or private supplies	Cholera, Typhoid fever, viral gastroenteritis e.g. due to Norovirus
Waterborne chemical disease	Disease related to ingestion of toxic substances in water	Drinking water	(i) Treated or untreated (raw) water (ii) Public (municipal) supplies or private supplies	Arsenicosis
Water hygiene diseases	Diseases whose incidence, prevalence or severity can be reduced by using safe (clean) water to improve personal and domestic hygiene	Any water used for washing/ personal hygiene	(i) Disease related to variations in water quality (ii) Disease related to water shortage	Scabies, shigellosis; trachoma
Water contact diseases	Caused by skin contact with pathogen-infested water or with chemical-contaminated water	Recreational water	(i) fresh water sources (ii) marine waters	Schistosomiasis (bilharzia); cyanobacteria
Water vector habitat diseases	Diseases where vector lives all or part of its life in or adjacent to a water habitat	Untreated freshwater sources	(i) rivers, streams (ii) small collections of stagnant water e.g. water butts	Malaria (mosquitoes); filiariasis (mosquitoes); onchocerciasis (aquatic flies); schistosomiasis (snails); trypanosomiasis (tsetse flies)
Excreta disposal diseases	Diseases related to unsanitary disposal of human waste (faeces and urine)	Drinking water and untreated water sources	(i) diseases related to human/animal waste in drinking water (ii) diseases related to direct/ indirect contact with faeces/ urine	Ascariasis; faecal-oral infections e.g. shigellosis; schistosomiais; trachoma
Water aerosol diseases	Diseases related to respiratory transmission, where a water aerosol containing suspended pathogens enters airway	Drinking or raw water sources	(i) water used in industrial/ residential buildings (ii) raw water sources	Legionellosis (legionnaires' disease; humidifier fever); Norwalk-like viral gastroenteritis

Table 1. Classification of water related disease

2.5. Cause and evidence: important issues in classifying water-related disease

For surveillance purposes, the definition of water related disease must include probability of a water cause as well as the agent responsible. Attributing cause to water is not straightforward, because of the factors and levels of probability to be considered. Most of the diseases related to water can also be transmitted in other ways and the evidence of water contamination is not always available by the time an outbreak of disease is identifiedWhile epidemiological evidence, such as an analytical study showing a strong statistical association with water, is an important element in attributing cause, epidemiological data, without strong microbiological or chemical evidence, may not meet the requirements for legal evidence and may therefore be disputed by water providers. There are practical, political as well as epidemiological considerations involved in attributing cases of disease or an outbreak to water. These include the cost of arranging alternative water supplies at short notice and the damage to public confidence in water supplies when a water outbreak is suspected or announced. Hence surveillance systems usually include a system for classifying probability on the basis of the available evidence. For example, in the UK, outbreaks are classified as definite, probable or possible, depending on the quality of microbiological and epidemiological evidence (Table 2). A broadly similar system is used in the USA.

1. UK Criteria		
(a) the pathogen found in human case samples was also found in water samples;		
(b) documented water quality failure or treatment failure;		
(c) significant result from analytical epidemiological study (case control or cohort);		
(d) suggestive evidence of association from a descriptive epidemiological study, for the		
Strength of Association		
Strong	**(a)+(c), (a)+(d) or (b)+(c)**	
Probable	**(b)+(d), (c) only for (a)**	
Possible	**(b) + (d)**	
2. USA (MMWR 1996)		
Class	**Epidemiological data**	**Water quality data**
I Adequate	Adequate data provided in outbreak report about exposed vs unexposed persons; Relative risk or odds ration ≥2 or p-value ≤0.05	Historical information or laboratory data e.g. history of malfunction of chlorine treatment; broken water main; no detectable free-chlorine residual; presence of coliforms in water
II Adequate	As above	Inadequate information
III Provided, but limited	Data provided but not meeting Class I criteria; no data provided to	As in class I.

	substantiate claim of no common exposures except water	
IV Provided, but limited	As above	Inadequate information

Table 2. Criteria for estimating strength of association between human illness and water

2.6. Burden of Proof in the Case of Water-related Disease

The need for evidence applies to all disease causation, but in the case of water-related disease the burden of proof has two important effects:

(i) Water related disease is under-estimated in most surveillance systems, since often only outbreaks with strong evidence are included, despite strong circumstantial evidence (such as descriptive epidemiological studies) for other incidents. The problem of attributing cause is even greater for small clusters and travel-related cases of disease, where the evidence may be impossible to collect. Under-estimation is related to the causative agent, the severity and duration of illness and the size of the outbreak: Under-estimation of the burden of water-related disease has a secondary effect on the priority given to surveillance systems and to preventive measures.

(ii) Attribution of cause to water is often delayed, while evidence is collected or until further cases occur. This can result in a much higher level of disease due to persistent or recurrent contamination. The mercury poisoning in Minamata, Japan, is a classic example of delayed attribution of a water-related cause. Delay in identifying a water cause is particularly likely to occur where the associated disease has a long incubation, for example in waterborne typhoid fever, or only occurs after prolonged accumulation in the body, as in water related arsenicosis. For some pathogens, the water exposure may be so far in the past that the link is missed for years, for example the possible water association only recently recognized for the emerging pathogen *Helicobacter pylori.*

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