

# **What is the burden of disease associated with recreational water?**

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## **1. Introduction**

In developed countries such as Canada and the United States, acute gastrointestinal illness (AGI) associated with water recreation remains a public health issue. The Public Health Agency of Canada (PHAC) estimates that Canadians experience 20.5 million cases of acute gastrointestinal illnesses (AGI) annually (Thomas et al. 2013), of which, 23.8% are attributable to water recreation (Butler, Pintar & Thomas, 2016).

Recreators involved in both primary and secondary contact activities in natural waterways such as swimming and fishing have a higher risk for the development of AGI (Pruss, 1998; King et al. 2014; Russo et al. 2018). Quantifying the exact burden of waterborne diseases at the national level is unfeasible and requires the construction of estimates based on available epidemiological data (Pruss-Ustin, 2003; Rice et al. 2006). The quantity and quality of data that published burden estimates rely on, however, may vary and may not necessarily represent all subgroups of a population. The US CDC for example, consolidates reported cases of illness associated with waterborne disease outbreaks in the United States from only 32 states and Puerto Rico (Hvalsa et al. 2015). Methods used to measure waterborne disease burden have also changed over time with the advent of novel methods such as qPCR (Fewtrell & Kay, 2015), as have the methods used to estimate disease burden. Disability-adjusted life years (DALY) have become the World Health Organization's (WHO) preferred metric for tracking disease burden within the last two decades (World Health Organization, 2003). Older estimates conducted by the WHO are primarily based on quality-adjusted life years (QALY), a measure of health outcomes, instead (Sassi, 2006).

Prior reviews examining epidemiological data on natural water recreation in lakes, rivers, and coasts have primarily focused on summarizing the risk of different recreational exposures and activities as opposed to disease burden itself (Pruss, 1998; King et al. 2014; Leonard et al. 2018). The present review will examine epidemiological studies and burden of disease estimates of AGI and AGI symptoms attributable to natural water recreation in high-income countries and evaluate methods most applicable to developing a similar estimate in Canada.

## **2. Objectives**

The objective of this review is to compile existing burden estimates of AGI associated with natural water recreation, identify knowledge gaps in water recreation epidemiology, and evaluate methods applicable to developing a novel estimate in Canada.

## **3. Methods**

### *3.1 Protocol*

The review will be conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines outlined by Page et al. 2021. The protocol for this review will be published in the University of Guelph atrium.

### 3.2 Search Strategy

The search methodology for this review was developed with the guidance of *A systematic review of waterborne disease burden methodologies from developed countries* by Murphy et al. (2014) and the *Cochrane Handbook for Systematic Reviews of Interventions version 6.2* by Lasserson et al. 2021.

The following databases will be searched:

- PubMed
- Web of Science SCI-EXPANDED
- ProQuest Medline

Database filters will be applied whenever possible to ensure that all results are written in English. Search results will be consolidated within Zotero, where an initial screening will be conducted to ensure the removal of all non-English articles. Initial screening will be conducted by one researcher, HN.

After initial screening, articles will be additionally screened twice by their titles and then abstracts to ensure that they meet the following criteria:

- a) Focuses on natural waterway(s) used for recreation, namely lakes, rivers, and coasts.
- b) Measures or estimates enteric disease burden using epidemiological or statistical methods for a population of water recreators.
- c) Defines burden as symptoms or cases of illness across a defined exposed population, DALYs, QALYs, and/or economic cost.
- d) Represents the Canadian context based on climate and economic development (countries with arid/tropical climates or are considered developing will be excluded)

Articles that meet the criteria will then be screened a third time in their entirety to be included for data extraction. Title, abstract, and full screening will be conducted by two researchers, HN, and IL, with a third researcher, either JH, or HM, acting as a tiebreaker for records chosen for exclusion by only one screener. The reference sections of all relevant articles selected for data extraction will also be hand-searched to identify additional records for the review.

### 3.3 Search Terms

The following terms described on Table 1 will be used to conduct a Boolean search. OR functions will be used to interchange terms within categories (columns), and AND functions will be used to include terms across each category (rows). Enteric pathogens included in the search were derived from the third edition of Health Canada's *Guidelines for Canadian Recreational Water Quality* and Murphy et al. 2014.

**Table 1:** Search terms to be inputted into databases. OR functions will be used to substitute terms within columns while AND functions will be used to include terms from each row.

<b>Enteric Pathogen</b>	<b>Recreational Source</b>	<b>Estimation</b>	<b>Burden</b>
Adenovirus	"Recreational water+"	Estima*	Burden
Astrovirus	Coast+	Model+	"Disability adjusted life years"
Enterovirus	"Coastal water+"	Attribution+	"Quality adjusted life years"
Echovirus	Swimming	"Structured judgement+"	Cost+
Norovirus	Beach+	"Expert elicitation+"	Incidence
Rotavirus	Lake+		Prevalence
Campylobacter	River+		Risk
Shigella	Stream+		
"Escherichia coli"	Pond+		
"E. coli"	Surfing		
Salmonella	Sailing		
Enterococci	Yachting		
Coliform+	Waterskiing		
"Fecal indicator bacteria"	Kayaking		
Cryptosporidium	Rowing		
Giardia	Canoeing		
	Fishing		
	Rafting		
	Diving		

### 3.4 Data Extraction

Articles selected for data extraction will be randomly assigned to two of three researchers, HN, IL, or JH, with the remaining author remaining as a tiebreaker for the articles they were not assigned. Each article will then be examined for the following:

1. The chosen burden of disease indicator.
2. The measured/estimated burden for enteric waterborne disease.
3. Methods and assumptions used to justify the author(s)' results.
4. Potential areas for further study identified by the author(s).

Burden estimates presented as percentage values will be converted to risk per 100 individuals. Additional information will also be collected about the waterways examined in each record. Aspects of interest include the location of the waterway, its salinity, and size. Results from data extraction will be collected on a Microsoft Excel spreadsheet.

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