

# Economic Assessment of the Waterborne Outbreak of *Cryptosporidium hominis* in Galway, 2007

Authors: Dearbháile Morris, Aksana Chyzheuskaya, Diarmuid O'Donovan,  
Srinivas Raghavendra, Martina Prendergast and Martin Cormican



## ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

### The work of the EPA can be divided into three main areas:

**Regulation:** *We implement effective regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.*

**Knowledge:** *We provide high quality, targeted and timely environmental data, information and assessment to inform decision making at all levels.*

**Advocacy:** *We work with others to advocate for a clean, productive and well protected environment and for sustainable environmental behaviour.*

## Our Responsibilities

### Licensing

We regulate the following activities so that they do not endanger human health or harm the environment:

- waste facilities (e.g. landfills, incinerators, waste transfer stations);
- large scale industrial activities (e.g. pharmaceutical, cement manufacturing, power plants);
- intensive agriculture (e.g. pigs, poultry);
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- sources of ionising radiation (e.g. x-ray and radiotherapy equipment, industrial sources);
- large petrol storage facilities;
- waste water discharges;
- dumping at sea activities.

### National Environmental Enforcement

- Conducting an annual programme of audits and inspections of EPA licensed facilities.
- Overseeing local authorities' environmental protection responsibilities.
- Supervising the supply of drinking water by public water suppliers.
- Working with local authorities and other agencies to tackle environmental crime by co-ordinating a national enforcement network, targeting offenders and overseeing remediation.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Prosecuting those who flout environmental law and damage the environment.

### Water Management

- Monitoring and reporting on the quality of rivers, lakes, transitional and coastal waters of Ireland and groundwaters; measuring water levels and river flows.
- National coordination and oversight of the Water Framework Directive.
- Monitoring and reporting on Bathing Water Quality.

### Monitoring, Analysing and Reporting on the Environment

- Monitoring air quality and implementing the EU Clean Air for Europe (CAFÉ) Directive.
- Independent reporting to inform decision making by national and local government (e.g. *periodic reporting on the State of Ireland's Environment and Indicator Reports*).

### Regulating Ireland's Greenhouse Gas Emissions

- Preparing Ireland's greenhouse gas inventories and projections.
- Implementing the Emissions Trading Directive, for over 100 of the largest producers of carbon dioxide in Ireland.

### Environmental Research and Development

- Funding environmental research to identify pressures, inform policy and provide solutions in the areas of climate, water and sustainability.

### Strategic Environmental Assessment

- Assessing the impact of proposed plans and programmes on the Irish environment (e.g. *major development plans*).

### Radiological Protection

- Monitoring radiation levels, assessing exposure of people in Ireland to ionising radiation.
- Assisting in developing national plans for emergencies arising from nuclear accidents.
- Monitoring developments abroad relating to nuclear installations and radiological safety.
- Providing, or overseeing the provision of, specialist radiation protection services.

### Guidance, Accessible Information and Education

- Providing advice and guidance to industry and the public on environmental and radiological protection topics.
- Providing timely and easily accessible environmental information to encourage public participation in environmental decision-making (e.g. *My Local Environment, Radon Maps*).
- Advising Government on matters relating to radiological safety and emergency response.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

### Awareness Raising and Behavioural Change

- Generating greater environmental awareness and influencing positive behavioural change by supporting businesses, communities and householders to become more resource efficient.
- Promoting radon testing in homes and workplaces and encouraging remediation where necessary.

### Management and structure of the EPA

The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

- Office of Environmental Sustainability
- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiological Protection
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

**EPA Research Programme 2014–2020**

**Economic Assessment of the Waterborne  
Outbreak of *Cryptosporidium hominis* in Galway,  
2007**

**(2013-W-DS-11)**

**EPA Research Report**

Prepared for the Environmental Protection Agency

by

National University of Ireland Galway

**Authors:**

**Dearbháile Morris, Aksana Chyzheuskaya, Diarmuid O'Donovan, Srinivas Raghavendra,  
Martina Prendergast and Martin Cormican**

**ENVIRONMENTAL PROTECTION AGENCY**

An Ghníomhaireacht um Chaomhnú Comhshaoil  
PO Box 3000, Johnstown Castle, Co. Wexford, Ireland

Telephone: +353 53 916 0600 Fax: +353 53 916 0699

Email: [info@epa.ie](mailto:info@epa.ie) Website: [www.epa.ie](http://www.epa.ie)

## **ACKNOWLEDGEMENTS**

This report is published as part of the EPA Research Programme 2014–2020. The programme is financed by the Irish Government and is administered by the Environmental Protection Agency, which has the statutory function of co-ordinating and promoting environmental research.

We thank all relevant representatives of Galway County Council, Galway City Council, the Health Service Executive (HSE), the EPA and others for provision of data. We thank Dr Ronán Hennessey for generation of relevant maps. We would also like to thank residents of Galway City and Galway County for responding to the survey and the Health Research Board (HRB) for funding the summer student scholarship under which it was conducted.

We also wish to thank the project advisory committee, comprising Dr John Curtis (ESRI), Mr Ray Brennan (Galway City Council), Dr Darragh Page (EPA), Dr Gerry Galvin (Irish Water) and Dr Dorothy Stewart (EPA) for their input. The authors are grateful to the EPA for generous financial support.

## **DISCLAIMER**

Although every effort has been made to ensure the accuracy of the material contained in this publication, complete accuracy cannot be guaranteed. The Environmental Protection Agency, the authors and the Steering Committee members do not accept any responsibility whatsoever for loss or damage occasioned, or claimed to have been occasioned, in part or in full, as a consequence of any person acting, or refraining from acting, as a result of a matter contained in this publication. All or part of this publication may be reproduced without further permission, provided the source is acknowledged.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment and may inform policy decisions. Participation in this project does not imply unanimous agreement with all findings among participants.

**EPA RESEARCH PROGRAMME 2014–2020**  
Published by the Environmental Protection Agency, Ireland

ISBN: 978-1-84095-647-4

June 2016

Price: Free

Online version

## Project Partners

**Dearbháile Morris**

(Principal Investigator)  
Antimicrobial Resistance and Microbial  
Ecology Group  
Discipline of Bacteriology  
School of Medicine  
and Centre of Health From Environment  
Ryan Institute  
National University of Ireland  
Galway  
Ireland  
Tel: +353 91 544652  
Email: dearbhaile.morris@nuigalway.ie

**Aksana Chyzheuskaya**

(Researcher)  
Centre for Health from Environment  
Ryan Institute  
National University of Ireland  
Galway  
Ireland  
Email: aksanac.research@gmail.com

**Diarmuid O'Donovan**

(Co-investigator)  
Department of Public Health  
HSE West  
Merlin Park  
Galway  
Ireland  
Email: diarmuid.odonovan@hse.ie

**Srinivas Raghavendra**

(Co-investigator)  
Cairnes School of Business and Economics  
Whitaker Institute  
National University of Ireland  
Galway  
Ireland  
Email: s.raghav@nuigalway.ie

**Martina Prendergast**

(Co-investigator)  
Centre for Health from Environment  
Ryan Institute  
National University of Ireland  
Galway  
Ireland  
Email: martina.prendergast@nuigalway.ie

**Martin Cormican**

(Co-investigator)  
Centre for Health from Environment  
Ryan Institute  
National University of Ireland  
Galway  
Ireland  
Email: martin.cormican@nuigalway.ie



# Contents

<b>Acknowledgements</b>	<b>ii</b>
<b>Disclaimer</b>	<b>ii</b>
<b>Project Partners</b>	<b>iii</b>
<b>List of Figures and Tables</b>	<b>vi</b>
<b>Executive Summary</b>	<b>vii</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Project Aims and Objectives	2
<b>2 Estimation of Direct and Indirect Costs Associated with the Outbreak</b>	<b>4</b>
2.1 Data Sources and Assumptions	4
2.1.1 Reported cases	6
2.1.2 Unreported cases	6
2.1.3 Households	7
2.1.4 Public sector costs	8
2.1.5 Private sector costs	8
2.2 Results	9
<b>3 Assessment of Cost Benefits Arising from Remedial Actions Taken</b>	<b>11</b>
3.1 Cost–Benefit Analysis	11
3.2 What-If Analysis	11
<b>4 Assessment of the Immediate and Long-Term Costs Associated with Loss of Public Trust in Public Services</b>	<b>12</b>
<b>5 Development of a Template for Real-Time Data Collection in Future Incidents</b>	<b>13</b>
<b>6 Discussion and Conclusions</b>	<b>15</b>
<b>7 Recommendations</b>	<b>16</b>
<b>References</b>	<b>17</b>
<b>Abbreviations</b>	<b>19</b>
<b>Appendix 1 Survey Questionnaire</b>	<b>20</b>

# List of Figures and Tables

## Figures

Figure 2.1.	Structure of the costs associated with the outbreak	4
Figure 2.2.	Area affected by the boil water notice	7
Figure 2.3.	Cost composition	10

## Tables

Table 2.1.	Costs included by category, data sources and assumptions applied	5
Table 2.2.	Estimated costs per category	9
Table 4.1.	Level of public trust in drinking water (percentage of residents)	12
Table 5.1.	Data required and sources for estimation of costs in future similar incidences	13



# Executive Summary

Water is a limited and precious resource and is being consumed worldwide at unsustainable levels. According to the United Nations World Water Development Report, 47% of the world's population will be living in areas of high water stress by 2030 (UN, 2012). "Hidden water" is water used to produce consumable items that do not obviously contain water (Emmott, 2013). For example, it is estimated that it takes 72,000 L of water to produce a microchip to power a laptop computer (UN, 2012). Water is one of the most critical environmental resources that people depend on. It is therefore essential to place an economic value on this precious resource. Good access to water supports health in many ways, including drinking, food production, hygiene and health care. Although Ireland has abundant water resources, problems with the quality of water cause illnesses in Ireland, as elsewhere in the world. Problems with water quality may be caused by contamination with chemicals or microorganisms. Compromised water quality can have adverse effects on industry, particularly the tourism and agricultural sectors, as well as having significant impacts on public health.

*Cryptosporidium* is a protozoan parasite that lives in the intestinal tract of infected humans and animals. It is shed in faeces, thereby contaminating waters and soils, and may be present in inadequately treated drinking water. Infection can be asymptomatic in some cases, but more frequently results in watery diarrhoea, stomach cramps, bloating, vomiting and fever. Although usually a self-limiting illness in otherwise healthy people, it may be associated with chronic gastrointestinal sequelae in some people and may be fatal for those with impaired immune function. In Ireland, cases of cryptosporidiosis are usually associated with *Cryptosporidium parvum* and are predominantly rural in occurrence. Endemic disease generally occurs in spring (peaking in April). *Cryptosporidium parvum* is primarily a parasite of ruminant animals with incidental human infection associated with farming activities or interactions with animals. *Cryptosporidium hominis* is primarily a parasite of primates, including humans, and is less common in Ireland. Epidemiological data reveal that exposure to drinking water from private supplies represents a high risk for cryptosporidiosis.

In March 2007, the largest outbreak of cryptosporidiosis since surveillance began in Ireland was identified, and was associated with contamination of the water supply serving Galway City and surrounding areas. The outbreak lasted for 5 months, by which time there were 242 confirmed cases of cryptosporidiosis, although it is likely that the actual number affected was far higher. A boil water notice was put in place for the duration of the outbreak and affected approximately 120,000 people living in the area, all of whom required an alternative water supply. A key challenge in managing the risk of waterborne infection associated with *Cryptosporidium* spp. is that the parasite is not inactivated by chlorination. Chlorination is the mainstay of water treatment and the only treatment applied in many rural areas in Ireland (Callaghan *et al.*, 2009). A number of technologies are available to remove or inactivate *Cryptosporidium* spp. during water treatment. These include filtration and ultra-violet (UV) light treatment systems. *Cryptosporidium* spp. have become recognised as an important cause of waterborne infection, so existing water treatment systems will require additional investment to enhance treatment systems to manage this risk.

The outbreak ended in August 2007 following major investments by local authorities in water treatment infrastructure and major disruption to residents and local businesses.

The goal of this research was to place a monetary value on the costs and inconvenience imposed by the 2007 Galway outbreak on the public, local businesses, the healthcare system, local authorities, national agencies, tourism and other water-dependent sectors. The research also examined the relationship between the investment needed to mitigate risk of contamination with *Cryptosporidium* and the benefits that would arise from such an investment. Water quality incidents such as the 2007 outbreak may have negative impacts on the public's confidence in the water supply, and may also negatively affect confidence in other public bodies. Although challenging, this research also explored these effects on confidence by the distribution of a survey among residents of Galway City and County.

This study represents the first of its kind in Ireland and posed some challenges. The estimation of costs posed a particular challenge, particularly for the private sector where the study was limited by data availability.

Key findings from this project include:

1. The overall cost of the waterborne outbreak of cryptosporidiosis that occurred in Galway in 2007 was estimated to amount to €19 million or €120,000 per day of the outbreak.
2. The estimated total cost to households in the affected area was approximately €3.9 million. This translates into an average cost of almost €88 per household (or €0.55 per household per day of the outbreak) in the boil notice zone over the 23 weeks (158 days) while the boil water notice was in effect.
3. The estimated cost to lodging and care businesses amounted to almost €8 million or €50,000 per day of the outbreak.
4. Almost €6 million of the total cost of the outbreak was the cost of mitigation actions by the local authorities. This included €388,000 for the installation of a UV treatment facility that effectively inactivates *Cryptosporidium* oocytes in water, thus preventing waterborne transmission.
5. When the capital investment necessary to accommodate the installation of a UV treatment system was taken into account, the total cost was €1,674,000. If we consider that this investment made prior to the outbreak would have prevented the outbreak, the potential saving per euro invested amounts to €11.

# 1 Introduction

Water is a limited and precious resource and is being consumed worldwide at unsustainable levels. According to the United Nations (UN) World Water Development Report, 47% of the world's population will be living in areas of high water stress by 2030 (UN, 2012). "Hidden water" is water used to produce consumable items that do not obviously contain water (Emmott, 2013). For example, it is estimated that it takes 72,000L of water to produce a microchip to power a laptop computer (Emmott, 2013). It is therefore essential to place an economic value on this precious resource. The UN Statistical Commission has developed a framework for monitoring the impact of social and economic development on the environment and, specifically, water – the System of Environmental Economic Accounts for Water (SEEA-Water; UN, 2011). It is estimated that over 50 countries are compiling or are planning to compile water accounts. In 2004, the Department of the Environment, Heritage and Local Government (DEHLG) commissioned an economic analysis of water use in Ireland. The report estimated the annual value of water in the domestic, agricultural and industrial sectors at €201,565,415, €122,991,821, and €75,374,122 respectively (DEHLG, 2004). Compromised water quality can have adverse effects on industry, particularly the tourism and agricultural sectors, as well as having significant impacts on public health. Within the European Union (EU), water quality is generally good, although pathogenic microorganisms remain a hazard in drinking and recreational waters. Of particular concern in Ireland is the level of non-compliance for microbiological parameters found in some drinking water supplies and bathing waters (EPA, 2015a,b). Provision of potable water "fit for human consumption" requires compliance with strict standards set for 48 microbiological, chemical and indicator parameters by the European Union (Drinking Water) Regulations, 2014. Most recent data for the year 2014 indicate that the drinking water quality in Ireland's public water supplies continues to improve (EPA, 2015a). These improvements have been attributed to investment in the physical infrastructure of water treatment plants, examples of which include the provision of chlorine monitors and alarms at all public water supplies and the installation of appropriate *Cryptosporidium*

barriers. Significant improvements have also been made in the provision of up-to-date information to users of public water supplies through the development of dedicated websites that are updated on a regular basis. Despite the documented improvements in water quality in Ireland in recent years, a number of incidents have occurred in which the quality of water available to the community has been compromised because of contamination. The Environmental Protection Agency (EPA) maintains a Remedial Action List of public water supplies to ensure compliance with drinking water standards (EPA, 2016). Most recent data for the first quarter of 2016 indicate that eight water supplies serving approximately 39,740 people were on a boil water notice or other water restriction. Furthermore, these data also reveal that 20 water supplies serving approximately 85,948 people did not have a *Cryptosporidium* barrier in place. The continuing risk to public health from *Cryptosporidium* in drinking water is clear from the 2015 outbreak in Westport, County Mayo.

*Cryptosporidium* is a protozoan parasite that lives in the intestinal tract of infected humans and animals. It is shed in faeces, thereby contaminating waters and soils. It may be present in inadequately treated drinking water. Infection can be asymptomatic in some cases, but more frequently results in watery diarrhoea, stomach cramps, bloating, vomiting and fever (Vijgen, 2007; Mead *et al.*, 1999; Dietz *et al.*, 2000). Although usually a self-limiting illness in otherwise healthy people, it may be associated with chronic gastrointestinal sequelae in some people and may be fatal for those with impaired immune function (Garvey, 2007). In Ireland there is a strong urban–rural divide in relation to notified cases of cryptosporidiosis with a crude incidence rate (CIR) of 1.4 cases per 100,000 in the Health Services Executive (HSE) east region as compared with CIRs of 15.5, 15.5 and 15.2 cases per 100,000 in the HSE north-west, HSE south and HSE midlands regions, respectively (HPSC, 2015a). The highest incidence rates are consistently reported for children under 5 years of age, and contact with farm animals is recognised as a significant risk factor (HPSC, 2015a). In Ireland, cases of cryptosporidiosis are usually associated with *Cryptosporidium*

*parvum* and are predominantly rural in occurrence. This species is primarily a parasite of ruminant animals, with incidental human infection associated with farming activities or interactions with animals (Garvey, 2007; Callaghan *et al.*, 2009). *Cryptosporidium hominis* is primarily a parasite of primates, including humans, and is less common in Ireland. Endemic disease generally occurs in spring (peaking around April), coinciding with the calving season (Garvey, 2007; HPSC, 2015a). Significantly, the data also reveal that exposure to drinking water from private supplies represents a higher risk for cryptosporidiosis (HPSC, 2015a).

Internationally, a number of large waterborne outbreaks of cryptosporidiosis have been reported (Corso *et al.*, 2003; Bridge *et al.*, 2010; HPSC, 2015b). In 1993, contamination of the municipal water supply affected an estimated 403,000 people in Milwaukee, WI, USA (Corso *et al.*, 2003). In March 2001 in North Battleford, SK, Canada, an estimated 7,000 people became unwell as a result of contaminated water (Jameson, 2008). A key challenge in managing the risk of waterborne infection associated with *Cryptosporidium* spp. is that it is not inactivated by chlorination. Chlorination has been the mainstay of water treatment for many years and remains the only method of treatment applied in many rural areas in Ireland (Callaghan *et al.*, 2009). A number of technologies are available to remove or inactivate *Cryptosporidium* spp. during water treatment. These include filtration and ultraviolet (UV) light treatment systems. As *Cryptosporidium* spp. have become recognised as an important cause of waterborne infection, existing water treatment systems have required additional investment to manage this risk. Protection of source waters from contamination with *Cryptosporidium* spp. and other pathogens is also an important process in managing risk.

In March 2007, the largest outbreak of cryptosporidiosis since surveillance began in Ireland was identified, and was associated with contamination of the water supply serving Galway City and surrounding areas. The outbreak lasted for 5 months, by which time there were 242 confirmed cases of cryptosporidiosis, although it is likely that the actual number affected was far higher. A boil water notice was put in place for the duration of the outbreak and affected approximately 120,000 people living in the area, all of whom required an alternative water supply. The outbreak ended in August 2007, following major investments by local authorities in water

treatment infrastructure and major disruption to residents and local businesses.

In addition to direct impacts on human health, water quality incidents such as the outbreak of cryptosporidiosis in Galway in 2007 lead to economic losses (Corso *et al.*, 2003; Ailes *et al.*, 2013) and may undermine public confidence in the safety of water supplies (Ailes *et al.*, 2013). Many international studies have estimated the economic costs of infection related to microbial contamination of drinking water supplies (Corso *et al.*, 2003; Hutton *et al.*, 2007; Halonen *et al.*, 2012; Safe Drinking Water Foundation, 2015). However, there is no standard method for performing such analyses. For example, Halonen *et al.* (2012) calculated the cost of the lost workdays by the employees in the public sector residing in clean and contaminated areas in Finland (Halonen *et al.*, 2012). In the study by Corso *et al.* (2003), a wide range of costs were included in the calculations, including medical costs and the loss of productivity related to the *Cryptosporidium* outbreak in Milwaukee, Wisconsin in 1993 (Corso *et al.*, 2003). A similar approach was used in a Canadian study by the Safe Drinking Water Foundation (2015), which conducted a full cost–benefit analysis of the outbreak associated with microbial contamination of the water supply in Walkerton, ON (Safe Drinking Water Foundation, 2015). Irrespective of the approach used by the researchers, there is agreement in existing international literature that the cost of outbreaks is very significant and the benefits of the preventative measures need to be examined (Hutton *et al.*, 2007; Halonen *et al.*, 2012; Safe Drinking Water Foundation, 2015).

## **1.1 Project Aims and Objectives**

The overall aim of this project was to assess the economic impact of the waterborne outbreak of cryptosporidiosis that occurred in Galway in 2007.

### ***Specific objectives included:***

- to review studies that have placed an economic value on major water quality incidents;
- to place a monetary value on the costs and inconvenience imposed on the public, business and production sectors, local authorities and government agencies;
- to assess the costs and benefits arising from remedial actions taken;

- to investigate means of assessing the immediate and long-term costs associated with loss of trust by communities in the public water supply and more general loss of trust in public services;
- to identify key knowledge gaps that limit evaluation of the economic impact of the outbreak with a view to developing a template for real-time data collection in future incidents.

## 2 Estimation of Direct and Indirect Costs Associated with the Outbreak

The costs associated with the waterborne outbreak of cryptosporidiosis that occurred in Galway in 2007 have a multi-level structure and include costs incurred by those individuals directly affected; households and local businesses affected by water restrictions; and governmental organisations (local authorities, HSE, EPA and other public service agencies). The structure of the costs included is depicted in Figure 2.1. In line with previous research and traditional health economic frameworks, both direct and indirect costs were included in calculations (Ailes *et al.*, 2013). Direct costs include medical and healthcare costs, the cost of providing an alternative water supply and response costs. Indirect costs include loss of income, loss of business and productivity loss, among others (Ailes *et al.*, 2013). The costs included are consistent with those included in previous economic assessments of waterborne outbreaks of infectious diseases (Corso *et al.*, 2003; Safefood, 2003; Ailes *et al.*, 2013).

### 2.1 Data Sources and Assumptions

The data used in this analysis came from different sources, as outlined in Table 2.1. Where the data were unavailable or did not exist, assumptions were made and these are also outlined in Table 2.1. Shortly after the outbreak, the HSE western area commissioned Ipsos MORI to carry out a post-outbreak survey to gain insights into the effect of the outbreak on residents of the area affected by the boil water notice, and on those visiting the area for work or recreational activities (commuters and tourists). Although the findings of this survey remain unpublished, the results of the survey were available to this study and data generated were used in this economic assessment. The data, its sources, and the assumptions (if any) that were made in estimating the costs are listed in Table 2.1. The Stata statistical software package (StataCorp, 2011) was used to complete the analysis.

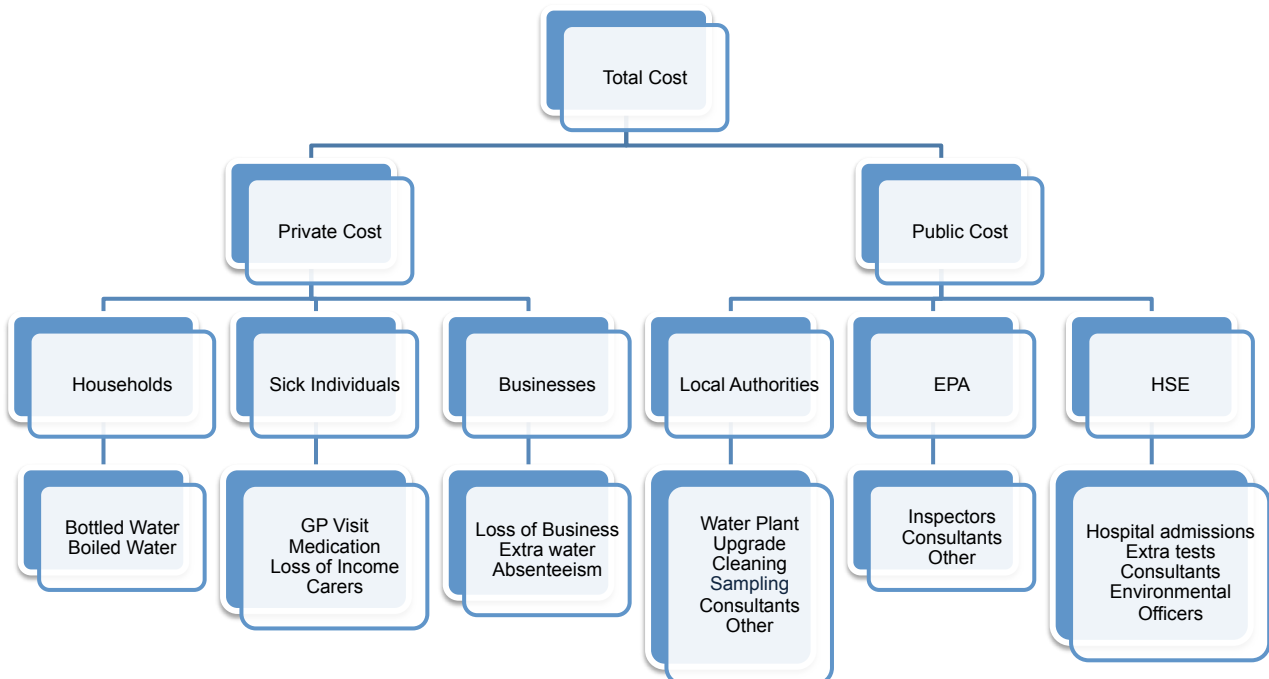


Figure 2.1. Structure of the costs associated with the outbreak.

**Table 2.1. Costs included by category, data sources and assumptions applied**

Costs	Data and assumptions	Source
<i>Costs to symptomatic (reported and non-reported) individuals</i>		
Number of notified cases	242	Public health data for period of outbreak, 2007
Number of non-reported cases	497 cases, 70.8% are not reported	Public health data for period of outbreak, 2007; Safefood (2003)
GP visits	€50 per visit, one GP visit per confirmed case; all reported cases consulted GP; GMS cost is €50.46, assume to be €50	HSE primary care reimbursement service data for 2008
Self-medication	Antidiarrhoeal medication: €9.26; oral rehydration solution (1 packet): €6.99. 30% self-medication (reported); 17.6% self-medication (non-reported)	Pharmacy prices (Corso <i>et al.</i> , 2003)
Loss of income	€122.85 per day; 5 days of work missed; 10 days of work missed for hospitalised patients	CSO data for 2007; public health data for period of outbreak, 2007
Loss of income for carers	€122.85 per day; children under 15 and those over 65: a carer took 5 days off work; 10 days off work for hospitalised patients	CSO data for 2007 (Garvey, 2007), public health data for period of outbreak, 2007
Cost of missing college/school	€69.20 per student per day; under 21 is either in school or college (reported). 19% took time off school/college (non-reported); 5 days missed (10 for hospitalised)	CSO data for 2007; Safefood, (2003); public health data for period of outbreak, 2007
<i>Costs to households</i>		
Number of households	45,160	O'Donoghue (2012)
Cost of bottled water	48% reported buying bottled water; 80% increased bottled water consumption from 3.2L to 16.1L; 20% from 3.2L to 20L	Public health data for period of outbreak, 2007
Cost of boiling water	Cost of bottled water: €0.50 per litre Usage of boiled water (per HH): drinking ≥ 12% (2.1L per adult, 1L per child); cooking ≥ 30% (2L per HH); dishwashing ≥ 43% (5–10L per HH); hygiene ≥ 14% (250ml per person per day)	Estimated bottled water retail price Ailes <i>et al.</i> (2013)
<i>Public sector costs</i>		
EPA	€20,000	EPA data
Emergency Department cost	€100; 1.3% of reported cases went through A&E, €100 A&E admission charge	HSE data (Fitzgerald <i>et al.</i> , 2004)
5810 extra lab tests for <i>Cryptosporidium</i> detection	€46.06	HSE data (number of laboratory tests) and commercial service provider (cost)
3000 extra faecal lab culture tests	€59.58	
Hospital admissions	€753 per person per day; 35% admitted to the hospital; 10 days stay	HSE data, public health data for period of outbreak, 2007
Galway City Council	€3,388,840	Galway City Council data
Galway County Council	€2,272,837	Galway County Council data
<i>Response team</i>		
Opportunity cost of labour	€356 per staff member per meeting; 16 people, 28 meetings	Institute of Public Administration report
<i>Private sector costs</i>		
Cost to businesses: productivity loss	€134 per person per day; 5 days on average (10 days for hospitalised) affected and carers	Health & Safety Times (2011)

Table 2.1. Continued

Costs	Data and assumptions	Source
<i>Hospitality industry (hotels, B&amp;Bs, hostels)</i>		
Extra water	4.2L per room per day	
Cancellations	13% cancellation rate	Ipsos MORI survey
<i>Care industry (nursing homes and crèches)</i>		
Bottled water	2.1L per person per day	The Sphere Project (2011)
Boiled water	1.5L per person per day	

HH, household; B&B, bed and breakfast

### 2.1.1 Reported cases

The assumptions about the costs to reported cases are presented in Table 2.1. It was assumed that all confirmed cases visited a general practitioner (GP) at least once at an estimated cost of €50. The same cost was assigned irrespective of private or public patients [or General Medical Services (GMS) patients] as the GMS GP claim for out-of-house services is €50.64 (HSE, 2008). It was assumed that 30% self-medicated (Corso *et al.*, 2003) by taking an antidiarrhoeal agent (e.g. loperamide) and an oral rehydration solution. It was assumed that each patient purchased one packet of antidiarrhoeal medication and one packet of oral rehydration solution. The reported cases missed on average 5 days of work, and those who were hospitalised (35% of reported cases) missed an average of 10 days, based on findings of the Ipsos MORI survey. Due to uncertainty about employment status and sector of the individuals under consideration, it was assumed that everybody aged 22–65 was in employment at the average industrial wage for the region and was not getting paid for days of work missed through illness. It was assumed that dependants [symptomatic children (under the age of 15) and the elderly (65 years old and older)] would require a full-time carer for the duration of their illness – 5 days for non-hospitalised cases and 10 days for hospitalised cases. The loss of income (for both reported and non-reported cases) was estimated at an average industrial wage rate in 2007 of €122.85 per day, based on census data. Moreover, those who were under the age of 21 (reported and non-reported cases) were assumed to either attend college/school or to be unemployed. In line with previous research by Safefood (2003), the opportunity cost of the time they were ill was assigned at a minimum wage rate in 2007 of approximately €69.20 per day for an 8-hour working day based on census data.

### 2.1.2 Unreported cases

A variety of studies indicate that there is variation with regard to the number of unreported cases of gastroenteritis that occur in outbreak settings (Safefood, 2003; Corso *et al.*, 2003; Fitzgerald *et al.*, 2004; Ailes *et al.*, 2013). Fitzgerald *et al.* (2004) reported that 71% of those whose health was affected did not report as cases (Fitzgerald *et al.*, 2004), while Corso *et al.* (2003) estimated that during the outbreak of cryptosporidiosis in Milwaukee in 1993, 25% of the population in the area were affected and 88% of these did not report (Corso *et al.*, 2003). If an estimate of 25% of the population affected was applied in this study, the number of non-reported cases would have been estimated at 25,291. For the purposes of this economic assessment we adopted the more conservative approach and assumed that 71% of those with symptoms did not report as cases. In addition, it was assumed that non-reported cases would fall into the less vulnerable population aged 5–64 (approximately 101,000 or 84% of total population in the area as estimated using the Simulation Model of the Irish Local Economy (SMILE) (O'Donoghue, 2012). Therefore, based on the number of reported cases, it was estimated that 497 people who were unwell did not present for healthcare treatment or their cases were not notified. The costs estimated here are based on the most conservative figure, but we acknowledge that there is substantial uncertainty regarding the number of people infected and the actual number may be significantly higher. It was assumed that all confirmed cases visited a GP at least once at an estimated cost of €50. The same cost was assigned irrespective of private or public patients (or GMS patients) as the GMS GP claim for out-of-house services is €50.64, based on HSE primary care reimbursement service data for 2008. It was assumed that 30% of reported cases and 17.6% of non-reported cases self-medicated (Corso *et al.*, 2003) with an antidiarrhoeal agent and an oral rehydration



solution. It was assumed that each patient purchased one packet of antidiarrhoeal medication and one packet of oral rehydration solution (Table 2.1).

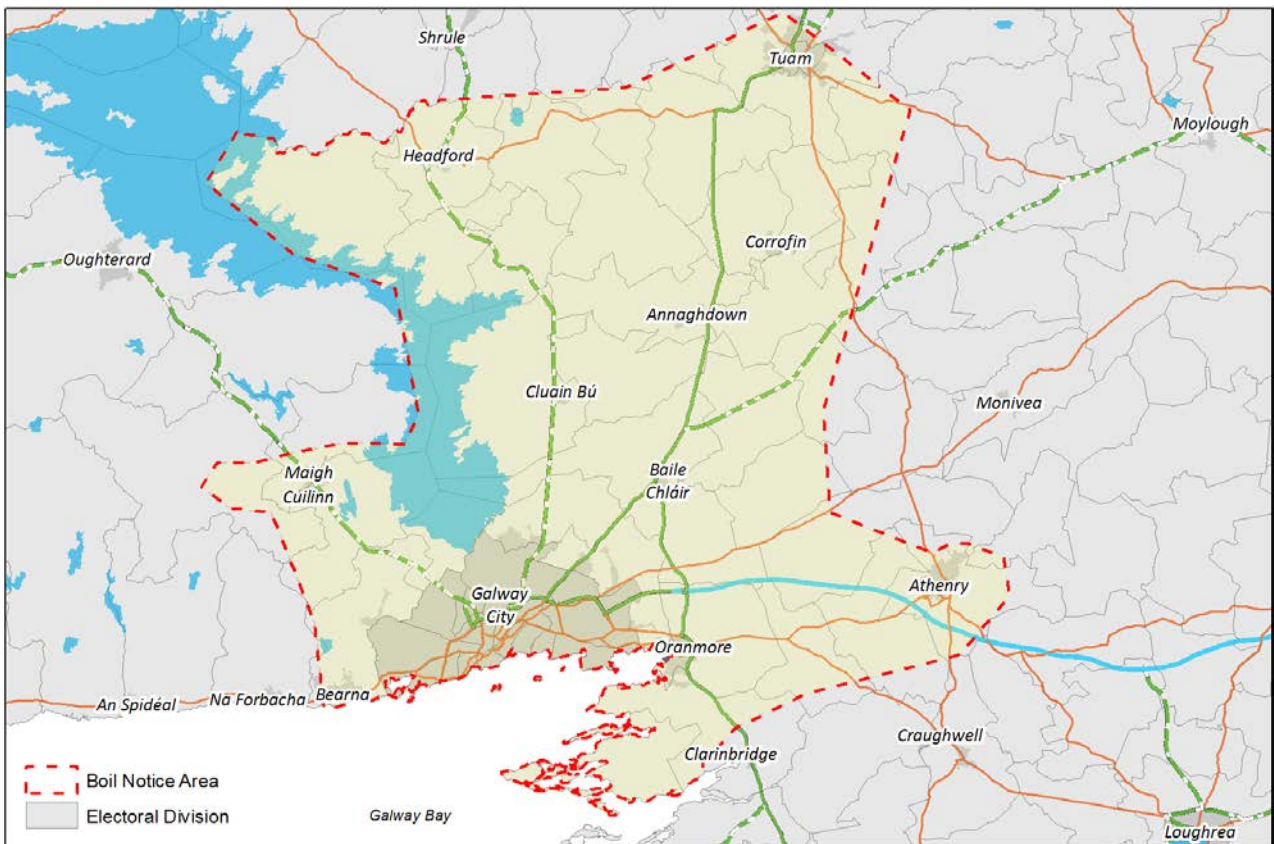
It was estimated that 17.4% of non-reported cases missed on average 5 days of work (Ipsos MORI survey), and those who were hospitalised (35% of reported cases) were absent from work for an average of 10 days. Due to uncertainty about employment status and sector of the individuals under consideration, it was assumed that all individuals aged 22–65 were in employment, receiving an average industrial wage and were not paid for days of work missed due to illness. It was assumed that dependants [symptomatic children (under the age of 15) and the elderly (65 years old and older)] would require a full-time carer for the duration of their illness – 5 days for non-hospitalised cases and 10 days for hospitalised cases.

### 2.1.3 Households

In order to estimate the household costs, SMILE data (O'Donoghue, 2012) were used, as absolute data were

not available. The SMILE model is a synthetic dataset that is spatially representative of households and farms at an electoral district (ED) level. SMILE data were used to determine the number of households located within the boil water notice area and their socio-economic characteristics. In the context of the present analysis, SMILE data for the year 2008 were used to identify households located in the boil water notice zone (Figure 2.2) and to estimate the numbers of people within various age groups that reside in this area.

The costs incurred by all the households in the boil water notice zone included the cost of bottled water bought and the cost of boiling water (Table 2.1). Based on the Ipsos MORI survey results, it was assumed that 48% of households bought extra bottled water, 80% of these increased bottled water consumption from 3.2L per week to 16.1L per week, with the remaining 20% increasing consumption of bottled water to 20L per week. Based on the average price of 1L of bottled water, it was assumed that €0.50 was paid per litre of bottled water purchased. It was also assumed that, for their household needs, the households boiled water



Data: EEA Corine CLC 2012; OpenStreetMap contributors. Includes Ordnance Survey Ireland Generalised ED and Settlement data. All rights reserved. Licence number NUIG230815. © Ordnance Survey Ireland 2015.

Figure 2.2. Area affected by the boil water notice.

during the boil water notice period. Based on previous research by Ailes *et al.* (2013) it was assumed that 12% of households boiled water for drinking, 30% boiled water for cooking, 43% boiled water for dishwashing and 14% boiled water for personal hygiene purposes (Ailes *et al.*, 2013). The further assumptions about the number of litres boiled for each of these purposes are reported in Table 2.1. It takes approximately 133W to boil 1 L of water (Energy Association, 2013) and the cost per litre was estimated at €0.01 based on Electricity Supply Board tariffs reported in 2007 (ESB, 2007).

#### **2.1.4 Public sector costs**

The cost to the public sector that resulted from the outbreak of cryptosporidiosis in 2007 consists of the healthcare cost, cost to local authorities and the cost of the response team. The healthcare cost includes the cost of accident and emergency (A&E) attendances, which is assumed to apply to 1.3% of reported cases (Fitzgerald *et al.*, 2004) at €100 per visit, which is the sum normally charged to private patients in Ireland based on current rates. The cost of a hospital stay is taken at a rate of €753 per day reported by the HSE, with 35% of patients reportedly hospitalised (Garvey and McKeown, 2007) for 10 days on average during this outbreak, based on the Ipsos MORI survey data.

Costs incurred by Galway City Council and Galway County Council included costs of chemical treatment, consultants' fees, advertising, mechanical plant maintenance, metering, payroll, water sampling, waterworks refurbishment, water routine operations, sludge management, loss of revenue due to concessions given to businesses and households, and other costs. These amounted to €3,388,840 and €2,272,837, respectively. A response team was formed to manage the outbreak, which consisted of 16 representatives of HSE West, Galway City Council, Galway County Council, EPA and others. The time spent by these highly skilled specialists was considered an opportunity cost – time diverted from other activities. There were 28 meetings held during the course of the outbreak, representing an estimated opportunity cost that was assigned as €356 per person per meeting. The opportunity cost was assigned based on the HSE senior management pay scale that ranges from €110,000 to €150,000 per annum with an average €130,000 assigned pro-rata per meeting (HSE, 2013). Although the actual pay of the response team members is not available for confidentiality reasons, nor were the

response team members paid overtime, it was decided to assign an opportunity cost to the time taken away from their day-to-day duties to deal with the outbreak.

#### **2.1.5 Private sector costs**

The costs to the private business sector in the area proved to be more challenging to estimate because of a lack of available data. In particular, it proved difficult to obtain reliable data on costs incurred by restaurants and to make assumptions on the costs that resulted from the outbreak. Thus, it was decided to exclude these costs from calculations. The remaining business costs (hotels and the care sector, e.g. crèches and nursing homes), sources and assumptions are outlined in Table 2.1.

Absenteeism is costly for private businesses and was estimated to be on average €134 per person per day (Health & Safety Times, 2011). The cost of absenteeism for both reported and non-reported cases, and for carers was included in the cost of the outbreak with 5 days for non-hospitalised cases (for both symptomatic cases and their carers) and 10 days for hospitalised cases (for both symptomatic cases and their carers).

One of the private sectors affected by the outbreak was the hospitality sector, i.e. hotels, guest houses, bed and breakfasts (B&Bs) and hostels. These businesses were affected in a number of ways: they had to provide water for their guests for drinking, as well as experiencing higher than average numbers of cancellations. The assumption was made that hotels, B&Bs and hostels provided 4.2L of bottled water per room per day (based on the daily water intake requirement of 2.1 L per adult with an assumption of two adults sharing a room). The list of the registered lodging businesses for the area affected, including the number of rooms per business, was obtained from the Fáilte Ireland website ([www.failteireland.ie](http://www.failteireland.ie)) and the current listings were used to estimate numbers for 2007. The cancellations due to the outbreak were assumed to be 13% based on the survey conducted by Ipsos MORI. The price per room was estimated from the average of prices reported on the Trivago.ie website (Trivago.ie, 2015) at €66 per hotel room, €65 per B&B room and €17 per hostel room, with an occupancy level of 57% for the relevant period of 2007 taken from the Fáilte Ireland report on tourism data (Fáilte Ireland, 2010).

The care industry was also affected: in particular, nursing homes and crèches had to provide alternative

drinking water to persons in their care. The number of nursing homes in the affected area was obtained from HSE (HSE, 2015). Eighteen of these nursing homes were located in the area affected by the boil water notice. These 18 nursing homes were contacted and the number of residents determined. It was assumed that nursing home residents were provided with 2.1 L of drinking water per day and 1.5 L per resident per day was boiled for other purposes.

Details of crèches and childminders registered in the area were obtained from the Child and Family Agency, Tusla, and 129 crèches were found to be located within the boil water notice zone. A random selection of 20 crèches was surveyed to ascertain the number of children they cater for, and an average of this number was used for calculations. It was assumed that during an outbreak, crèches provided 1 L of bottled water per child per day, and 1.5 L per child was boiled for other purposes. The assumption was based on the average weight of a child and the recommended 30 mL of water per kilogram of body weight per day, as cited by EPA and HSE (2011).

## 2.2 Results

The overall cost of the waterborne outbreak of cryptosporidiosis that occurred in Galway in 2007 was estimated to amount to €19 million or €120,000 per day of the outbreak. The costs are broken down by category in Table 2.2. The estimated cost to households in the affected area is approximately €3.6 million. This translates into an average cost of almost €95 per household (or €0.55 per household per day of the outbreak) in the boil water notice zone over the 23 weeks (158 days) during which the boil water notice was in effect. This is consistent with the recent study by Ailes *et al.* (2013), which estimated that households spent on average \$87 during an outbreak of waterborne salmonellosis in Alamosa, CO, USA in 2008. The loss of income to the households with symptomatic individuals is estimated at €287,000. This cost includes the wages of those unwell as well as the wages of the carers of patients who reported their sickness.

The costs to non-reported cases amounted to €74,000. The total wage loss and expense of water to households during the outbreak were estimated to have been €4,310,000. Assuming that average household income in the boil water zone was €27,251 per annum (as estimated using SMILE data) or €11,796 in 158 days, the

**Table 2.2. Estimated costs per category**

Cost category	Estimated costs (€)
<b>Public authorities</b>	
Galway City Council	3,388,840
Galway County Council	2,472,837
EPA	20,000
Response team	159,488
A&E visit	315
Hospital	637,791
Total public authorities' costs	6,679,271
<b>Households</b>	
Bottled water	3,552,299
Boiled water	401,011
Total household costs	3,953,310
<b>Costs to non-reported cases</b>	
Self-medication	1418
Wages	52,973
Carers' income loss	17,689
School days lost	1922
Total non-reported costs	74,002
<b>Costs to confirmed cases</b>	
Self-medication	1180
Wages	36,339
Carers' income loss	161,544
GP	12,100
School days lost	89,074
Total confirmed case costs	300,236
<b>Costs to businesses</b>	
Lodging industry cancellations	5,374,115
Lodging industry bottled water	1,734,285
Crèche and nursing homes	525,929
Carers' productivity loss (reported)	176,206
Symptomatic (non-reported) productivity loss	57,781
Carers' productivity loss (non-reported)	19,294
Symptomatic (reported) productivity loss	36,554
Business costs	7,924,164
Total estimated cost	18,930,983

loss has translated into 0.8% of household income in the affected area.

It was estimated that the cost to lodging and care businesses amounted to almost €8 million or €50,000 lost per day of the outbreak. It was estimated that almost €5.4 million was lost due to cancellations, with a further

€1.7 million required to provide an alternative supply of water to customers. Care businesses were estimated to have provided safe water to people in their care with a total cost of €526,000.

Almost €6 million of the total cost of an outbreak was the cost of the mitigation of an outbreak by the local authorities. This cost includes €388,000, which represented the cost of installation of a UV treatment system that effectively inactivates *Cryptosporidium* oocytes in water, thus preventing waterborne transmission. The percentage breakdown of costs is depicted in Figure 2.3.

In terms of comparing the total cost of the outbreak with the cost of a UV treatment system, the analysis shows the potential savings of €48 per unit of investment. However, when the capital investment necessary to accommodate installation of the UV treatment system (€1,674,000) is taken into account, the potential saving per euro invested amounts to €11.

In addition to the cost of installation of the UV treatment systems, the research group was advised that there were additional costs amounting to €5,126,000 related to decommissioning of the Old Terryland water

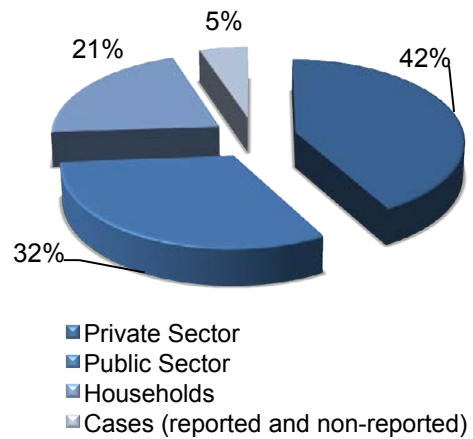


Figure 2.3. Cost composition.

treatment plant and other works. This research team did not consider that this additional cost was strictly related to the prevention of cryptosporidiosis infection and therefore did not include this as a cost necessary to prevent the outbreak. However, an argument may be made to include this cost. If this cost is included, then the cost of those measures, which, if taken, would have prevented the outbreak, is €6,800,000, and the cost of the outbreak is €24,056,000, giving a saving per €1 invested of €4.

### 3 Assessment of Cost Benefits Arising from Remedial Actions Taken

A number of scenarios were considered in an attempt to assess the cost benefits of remedial actions taken.

#### 3.1 Cost–Benefit Analysis

Completion of a full cost–benefit analysis in line with the approach adopted previously by the World Health Organization (WHO) was originally considered. This approach would have involved (1) using data on notifications of human cryptosporidiosis and gastrointestinal illness, and assessing the economic benefits to the healthcare system due to decreases in illness as a result of remedial actions taken, (2) estimating the cost saving in both the operational and the capital cost categories using an appropriate market interest rate and depreciation rate, respectively, and (3) using the net present value method to estimate the stream of benefits [as the deviation of the average income (cash flows) or output in the last few years without the incident to the average income (cash flows) or output during the episode] to local business, tourism and the production sectors.

Unfortunately, this approach was not feasible. An accurate estimation of the probability of a similar outbreak occurring and the reduction in the number of people affected as a result of preventative measures taken is required. Moreover, the decreased number of cases of illness as a result of remedial actions needs to be known. This information was not possible to determine with accuracy for the following reasons: (1) since cryptosporidiosis became a notifiable disease in 2004, only one large waterborne outbreak of infection associated with *Cryptosporidium hominis* has been recorded, therefore it was not possible to determine the probability of a similar outbreak happening again; (2) a review of international literature did not assist with determining a probability of a repeat occurrence with accuracy; and (3) data on the number of cases of cryptosporidiosis before and after an outbreak were reviewed (HPSC, 2015a) and no change in the baseline number of cases of cryptosporidiosis in the region under investigation was apparent after remedial actions were completed. There was no expectation that the improved water

treatment for the city supply would impact on the annual seasonal occurrence of infection with *Cryptosporidium parvum*, as this is spread through animal contact and through water supplies that service small groups or single households.

#### 3.2 What-If Analysis

In order to provide a useful insight to stakeholders of the relationship between investment needed and the benefits that would arise from such an investment, we calculated a ratio ( $R$ ) of the cost of upgrading a water treatment system necessary ( $I$ ) to eliminate *Cryptosporidium* from the water supply and the cost ( $C$ ) that could have been avoided if the 2007 outbreak had been prevented (Equation 3.1).

$$R = C/I \quad (\text{Equation 3.1})$$

Such an analysis allows the evaluation in monetary terms of a possible saving per euro of expenditure necessary to inform public investment decisions.

In terms of comparing the total cost of the outbreak and the cost of installation of a UV treatment system, the analysis shows a potential saving of €48 per unit of investment. However, when all the capital investment necessary to accommodate the UV treatment system installation (€1,674,000) is taken into account, the potential saving per euro invested amounts to €11.

In addition to the cost of installation of the UV treatment systems, the research group was advised that there were additional costs amounting to €5,126,000 related to decommissioning of the Old Terryland water treatment plant and other works. This research team did not consider that this additional cost was strictly related to the prevention of cryptosporidiosis infection and therefore did not include this as a cost necessary to prevent the outbreak. However, an argument may be made to include this cost. If this cost is included, then the cost of those measures, which, if taken, would have prevented the outbreak, is €6,800,000, and the cost of the outbreak is €24,056,000, giving a saving per €1 invested of €4.

## 4 Assessment of the Immediate and Long-Term Costs Associated with Loss of Public Trust in Public Services

A survey of the public's (residents of Galway City and County) knowledge concerning their drinking water was carried out in summer 2014 through a Health Research Board (HRB) summer student scholarship.

The aim of this survey was to gain an insight into what people know about where their drinking water comes from and their awareness of its quality. The survey was administered face-to-face, house-to-house and online between 26 June and 23 July 2014. This survey included questions relating to costs associated with bottled water use, the public's memories of the outbreak of cryptosporidiosis that occurred in Galway in 2007, and what effect, if any, it had on them (Appendix 1).

In total, 487 responses were received in the 4-week period of the survey. Analysis revealed that 387 respondents (79.5%) drink tap water, while 93 (19%) do not, with the predominant reason for not drinking water from the tap being concern about water safety.

One hundred and ninety-six (40%) respondents buy bottled water for drinking purposes at home and 100 (21%) filter tap water at home using a jug filter prior to drinking. Of those who purchase bottled water, 39 (20%) buy up to 2L per week, a further 24 (12%) buy up to 20L per week and 12 (6%) respondents indicated that they buy more than 20L of bottled water per week.

The primary reasons for buying bottled water were taste (96 respondents) followed by water safety (89 respondents), convenience (67), catering (6), and other reasons (21).

The respondents were asked to state on a scale of 1 to 5 (1 – lowest, 5 – highest) how much trust they had in their drinking water, with the majority of respondents indicating a moderate level of trust (Table 4.1).

**Table 4.1. Level of public trust in drinking water (percentage of residents)**

Level of trust				
1	2	3	4	5
8.21	12.7	29.6	29.2	17.4

Knowledge of water supply type was relatively low, with 264 (54%) of the respondents indicating that they knew what kind of water supply they were served by. In addition, only one-third (158 respondents) were aware of whether or not their water supply was routinely monitored for microbial contamination.

When asked about what, if any, problems respondents encountered with their drinking water supply in the previous 10 years, the primary issue was bad taste [137 respondents (28.1%)] followed by low pressure [132 respondents (27.1%)], presence of sediment [87 respondents (17.9%)], discoloration [79 respondents (16.2%)] and bad smell [66 respondents (13.5%)]. Overall, 39 respondents (8%) brought these issues to the attention of their water supplier, and the majority of these [29 respondents (74%)] indicated that they had received a satisfactory reply.

In total, 240 respondents (49%) indicated that their drinking water supply had been the subject of a boil water notice/restriction in the previous 10 years. The majority of those affected [229 respondents (95%)] reported that they understood the reason for the boil water notice/restriction and 144 (60%) felt that they were updated adequately during the restriction period. Just under 46% of these people (110 respondents) indicated that being subject to a boil water notice/restriction had no impact on their use of drinking water.

Overall, 414 respondents (85%) remembered the waterborne outbreak of cryptosporidiosis that occurred in Galway in 2007. In total, 212 (43%) of these were affected by the boil water notice during this outbreak; 24 (5%) respondents reported being ill during the outbreak and nine of these reported also having a family member that became ill; and 15 (3%) respondents reported a loss of income during the outbreak. In total, 128 respondents (or 60% of those affected by the outbreak) indicated they had changed the way they use their drinking water as a result.

These findings suggest that incidences such as the waterborne outbreak of cryptosporidiosis that occurred in Galway in 2007 undermine the public's trust in their drinking water supply.

## 5 Development of a Template for Real-Time Data Collection in Future Incidents

As outlined in Chapter 2, it was not possible to include all costs to the private sector in the calculations, and a number of assumptions had to be made to estimate the remaining costs because of limited data availability. Owing to the extent of the lack of data relating to certain aspects of the local economy, our estimation was not devoid of statistical uncertainty. For instance, it is very likely that the businesses in the area had sustained financial losses during the outbreak that are not systematically recorded. Therefore, owing to the extent of the unavailability of such data, our estimations reflect an underestimation of the possible impact of the outbreak of waterborne cryptosporidiosis under investigation.

In Table 5.1, we present the type of data that would be useful for future analyses. If capacities are created to collect real-time data, it would be immensely helpful to monitor the outbreak and positively intervene through relatively faster policy solutions. Moreover, collecting data outlined in Table 5.1 would help to estimate the costs with greater certainty, would provide better information to stakeholders and policymakers, and would certainly help the relevant governing authorities to make informed decisions about public investment in safe water provision in Ireland.

**Table 5.1. Data required and sources for estimation of costs in future similar incidences**

Cost category	Data required	Source
Cases (reported and non-reported)	Number of reported cases	HSE, survey, business, Central Statistics Office (CSO)
	Number of people who self-medicated	
	Number of people who sought healthcare, source and number of visits	
	Number of people who needed a carer and duration of care in days	
	Duration of illness in days	
	Number of reoccurrences of illness	
	Number of A&E visits	
	Number hospitalised	
	Length of hospital stay, tests completed	
	Cost of A&E visit	
	Cost of hospital stay	
	Cost of lab tests	
	Loss of income due to illness	
	Loss of income of carers	
	Number of people in full-time education	
	Number of people employed/unemployed	
	Households	
Number in affected households		
Number of extra litres of water bought/week		
Number of litres of water boiled/day for drinking, cooking, washing, hygiene		
Number of household members who experienced symptoms		
How many household members visited the GP		
Cost of bottled water		
Loss of household income due to an outbreak		
Cost of boiling water		

Cost category	Data required	Source
Businesses	Number of businesses in the boil water notice zone (hotels, restaurants, food processors, nursing homes, crèches, etc.) Arrangements put in place due to an outbreak Customers/revenue loss Absenteeism Other costs related to outbreak	Representative associations, HSE, local authorities, Irish Water
Public Sector	Chemical treatment Consultant fees Advertising Mechanical plant maintenance Metering Payroll Water sampling Waterworks refurbishment Water routine operations Sludge management Loss of revenue due to concessions given to businesses, households Other costs Response team costs Cost of EPA monitoring Lab overtime cost	Irish Water, local authorities, HSE, EPA



## 6 Discussion and Conclusions

The waterborne outbreak of cryptosporidiosis that occurred in Galway in 2007 resulted in 242 notified cases of illness, with a conservative estimate of 497 additional cases that were not reported. The outbreak also generated considerable costs to residents, visitors, public bodies and local businesses. This study highlights the economic importance of a safe drinking water supply by reporting both public expenditure on mitigating the results of the outbreak and private costs to households and businesses in the area. The outbreak is believed to have occurred because the lake that serves as the source of drinking water for the city became contaminated with *Cryptosporidium hominis*, and the treatment process in place at that time was not sufficient to eliminate or inactivate the parasite before this water was distributed in the municipal supply.

Considering the fact that an investment of €1,674,235 (updating waterworks and installing a UV water treatment system) could have prevented viable parasites from entering the water supply, we calculated that a cost of €11 would have been avoided for each euro invested in implementing this additional treatment step. Thus, the results indicate that there are economic benefits of investing in safe drinking water supplies and water treatment enhancement. This is consistent with the findings of Hutton *et al.* (2007), who reported between US\$5 and US\$46 return per dollar invested in water and sanitation improvements, with all water improvement interventions examined in their study being cost-beneficial (Hutton *et al.*, 2007).

We recognise a significant limitation in our approach to assessing relative costs. There is no basis upon which to estimate the frequency of occurrence with which a source water contamination event will be likely to result in a comparable outbreak. If such a contamination event occurs frequently (for example annually), the cost of implementation greatly outweighs the associated costs of infection. If such an event occurs every 100 years, then the situation may be reversed. In the context of a municipal supply based on a large surface water body where source protection is challenging, we believe that it is reasonable to suppose that contamination is likely to occur relatively frequently. Methods to define more precisely the annual probability of a major contamination event for a particular water supply would be of value.

The costs assessed for this evaluation related to the period of an outbreak. However, there is reason to believe that some economic impacts continued for years afterwards, related to the undermining of public trust in the water supply, and affected the Galway area and local businesses as a result of fewer visitors. As many as 13% of survey respondents to the Ipsos MORI survey indicated that they were less likely to return to the Galway area due to the outbreak. Thus, the economic impact may be far larger.

In addition, cryptosporidiosis can be potentially fatal, with a fatality rate cited in international literature ranging between 0.05% (Mead *et al.*, 1999) and 0.6% (Dietz *et al.*, 2000). Fortunately, there were no fatalities associated with the 2007 outbreak in Galway; however, if there had been, the costs are likely to have been much higher. Thus, preventative measures can prove to be economically beneficial.

Limited data is one of the obstacles that resulted in the number of assumptions made in this study. Thus, the results reported here should be interpreted with care and careful examination of the assumptions is advised before drawing conclusions. The lack of data related to businesses in the area and the impact the outbreak had on their operation prevented us from accounting for these impacts in our calculations. Also the lack of regional input–output data is a major drawback in terms of estimating the intersectoral feedback arising from the forward and backward linkages between and within the business and household sectors. This highlights the need for real-time data collection, and the lack of various other data, including the sectoral feedback data, only indicates that the costs may have been much higher than reported here. Moreover, there is an uncertainty about the number of people who were unwell as a result of the outbreak but did not seek help.

Notwithstanding the limitations of the analysis discussed here, this study provides a useful insight into the possible magnitude of the costs that can result as a result of compromised drinking water quality and indicates that preventative measures are economically beneficial. However, further analysis is needed to determine the magnitude of these benefits.

## 7 Recommendations

- The economic benefits of investment in safe drinking water supplies and water treatment enhancement, as well as the benefits to public health, should be considered by decision-makers.
- Methods to define more precisely the annual probability of a major contamination event for a particular water supply should be developed.
- Appropriate data should be collected in real time during incidences and outbreaks such as the waterborne outbreak of cryptosporidiosis in Galway in 2007.
- Investment should be made in the development of data collection software/applications that could capture all costs in real time.
- Methods should be investigated to better define the number of people who are unwell as a result of an outbreak such as this but do not seek help.

# References

- Ailes, E., Budge, P., Shankar, M. *et al.*, 2013. Economic and health impacts associated with a *Salmonella* Typhimurium drinking water outbreak – Alamosa, CO, 2008. *PLoS One* 8: e57439.
- Bridge, J.W., Oliver, D.M., Chadwick, D. *et al.*, 2010. Engaging with the water sector for public health benefits: waterborne pathogens and diseases in developed countries. *Bulletin of the World Health Organisation* 88: 873–875.
- Callaghan, M., Cormican, M., Prendergast, M. *et al.*, 2009. Temporal and spatial distribution of human cryptosporidiosis in the west of Ireland 2004–2007. *International Journal of Health Geographics* 8: 64.
- Corso, P.S., Kramer, M.H., Blair, K.A. *et al.*, 2003. Cost of illness in the 1993 waterborne *Cryptosporidium* outbreak, Milwaukee, Wisconsin. *Emerging Infectious Diseases* 9: 426–431.
- DEHLG (Department of the Environment, Health and Local Government), 2004. *Economic Analysis of Water Use in Ireland*. Available online: [www.wfdireland.ie/docs/35\\_Economics/Economic%20Analysis%20of%20Water%20use.pdf](http://www.wfdireland.ie/docs/35_Economics/Economic%20Analysis%20of%20Water%20use.pdf)
- Dietz, V., Vugia, D., Nelson, R. *et al.*, 2000. Active, multisite, laboratory-based surveillance for *Cryptosporidium parvum*. *American Journal of Tropical Medicine and Hygiene* 62: 368–372.
- Emmott, S., 2013. *Ten Billion*. Penguin Group, London.
- Energy Association, 2013. *Cost - Boiling a Kettle*. Available online: [www.energy-association.com/public/faq-boiling-a-kettle/](http://www.energy-association.com/public/faq-boiling-a-kettle/)
- EPA (Environmental Protection Agency), 2015a. *Drinking Water Report 2014*. Available online: [www.epa.ie/pubs/reports/water/drinking/dwreport2014.html](http://www.epa.ie/pubs/reports/water/drinking/dwreport2014.html)
- EPA (Environmental Protection Agency), 2015b. *The Quality of Bathing Water in Ireland 2014*. Available online: [www.epa.ie/pubs/reports/water/bathing/thequalityofbathingwaterinireland2014.html#.VaTixkDfV8E](http://www.epa.ie/pubs/reports/water/bathing/thequalityofbathingwaterinireland2014.html#.VaTixkDfV8E)
- EPA (Environmental Protection Agency), 2016. *EPA Drinking Water Remedial Action List for Q1 of 2016*. Available online: [http://www.epa.ie/pubs/reports/water/drinking/Q1\\_2016\\_RALforweb.pdf](http://www.epa.ie/pubs/reports/water/drinking/Q1_2016_RALforweb.pdf)
- EPA and HSE (Environmental Protection Agency and Health and Safety Executive), 2011. *Joint Position Statement. Trihalomethanes in Drinking Water*. Available online: [www.hse.ie/eng/services/Publications/Environmentalhealth/Joint%20Position%20Statement%20Trihalomethanes%20in%20Drinking%20Water.pdf](http://www.hse.ie/eng/services/Publications/Environmentalhealth/Joint%20Position%20Statement%20Trihalomethanes%20in%20Drinking%20Water.pdf)
- ESB (Electricity Supply Board), 2007. *ESB Customer Supply Tariff Methodology Statement. Tariff Period November 2007 to September 2008*. Available online: [www.cer.ie/docs/000067/cer07108.pdf](http://www.cer.ie/docs/000067/cer07108.pdf)
- European Union (Drinking Water) Regulations, 2014. Statutory Instrument 122 of 2014. Government Publications, The Stationery Office, Dublin.
- Fáilte Ireland, 2010. *Tourism Facts, 2010*. Available online: [www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/3\\_Research\\_Insights/3\\_General\\_SurveysReports/Tourism-Facts-2010-FINAL-v2.pdf?ext=.pdf](http://www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/3_Research_Insights/3_General_SurveysReports/Tourism-Facts-2010-FINAL-v2.pdf?ext=.pdf)
- Fitzgerald, M., Scallan, E., Collins, C. *et al.*, 2004. Results of the first population based telephone survey of acute gastroenteritis in Northern Ireland and the Republic of Ireland. *Eurosurveillance*: 8.
- Garvey, P. and McKeown, P., 2007. *Epidemiology of Cryptosporidiosis in Ireland, 2007*. Health Protection Surveillance Centre, Dublin, Health Service Executive. Available online: [www.hpsc.ie/A-Z/Gastroenteric/Cryptosporidiosis/Publications/EpidemiologyofCryptosporidiosisinIrelandAnnualReports/File,3475,en.pdf](http://www.hpsc.ie/A-Z/Gastroenteric/Cryptosporidiosis/Publications/EpidemiologyofCryptosporidiosisinIrelandAnnualReports/File,3475,en.pdf)
- Halonen, J.I., Kivimaki, M., Oksanen, T. *et al.*, 2012. Waterborne outbreak of gastroenteritis: effects on sick leaves and cost of lost workdays. *PLoS One* 7: e33307.
- Health & Safety Times, 2011. *Absenteeism is Proving a Costly Business*. Ocean Publishing. Available online: [www.oceanpublishing.ie/health\\_safety/images/featuredarticles/workplace%20absenteeism.pdf](http://www.oceanpublishing.ie/health_safety/images/featuredarticles/workplace%20absenteeism.pdf)
- HPSC (Health Protection Surveillance Centre), 2015a. *Annual Epidemiological Reports on Cryptosporidiosis in Ireland*. Available online: [www.hpsc.ie/A-Z/Gastroenteric/Cryptosporidiosis/Publications/EpidemiologyofCryptosporidiosisinIrelandAnnualReports/](http://www.hpsc.ie/A-Z/Gastroenteric/Cryptosporidiosis/Publications/EpidemiologyofCryptosporidiosisinIrelandAnnualReports/)

- HPSC (Health Protection Surveillance Centre), 2015b. *HPSC Annual Epidemiological Report 2014*. Available online: [www.hpsc.ie/A-Z/Gastroenteric/Cryptosporidiosis/Publications/EpidemiologyofCryptosporidiosisinIrelandAnnualReports/File,15317,en.pdf](http://www.hpsc.ie/A-Z/Gastroenteric/Cryptosporidiosis/Publications/EpidemiologyofCryptosporidiosisinIrelandAnnualReports/File,15317,en.pdf)
- HSE (Health and Safety Executive), 2008. *Schedule of Fees and Allowances Payable to Doctors Participating in the General Medical Services Schemes and Other Community Schemes*. HSE Finance Shared Services Primary Care Reimbursement Service, Dublin.
- HSE (Health and Safety Executive), 2013. *Consolidated Salary Scales in Accordance with Clause 2.32 of the Haddington Road Agreement*. HSE.
- HSE (Health and Safety Executive), 2015. *Cost of Care in Approved Facilities*. Available online: [www.hse.ie/eng/services/list/4/olderpeople/nhss/costs.html](http://www.hse.ie/eng/services/list/4/olderpeople/nhss/costs.html)
- Hutton, G., Haller, L. and Bartram, J., 2007. Global cost–benefit analysis of water supply and sanitation interventions. *Journal of Water and Health* 5: 481–502.
- Jameson, P.B., Hung, Y-T, Kuo, C.H. *et al.*, 2008. *Cryptosporidium* outbreak (water treatment failure): North Battleford, Saskatchewan, Spring, 2001. *Journal of Performance of Constructed Facilities* 22: 342–347.
- Mead, P.S., Slutsker, L., Dietz, V. *et al.*, 1999. Food-related illness and death in the United States. *Emerging Infectious Diseases* 5: 607–625.
- O'Donoghue, C., Ballas, D., Clarke, G. *et al.*, 2012. *Spatial Microsimulation for Rural Policy Analysis*. Springer, Berlin and Heidelberg.
- Safe Drinking Water Foundation, 2015. *Cost–Benefit Analysis: Treat the Illness or Treat the Water?* Available online: [www.safewater.org/PDFS/resourcesknowthefacts/CostBenefit\\_Analysis\\_Treat.pdf](http://www.safewater.org/PDFS/resourcesknowthefacts/CostBenefit_Analysis_Treat.pdf)
- Safefood, 2003. *Acute Gastroenteritis in Ireland: A Telephone Survey*. Available online: [www.safefood.eu/SafeFood/media/SafeFoodLibrary/Documents/Publications/Research%20Reports/Acute\\_Gastroenteritis.pdf](http://www.safefood.eu/SafeFood/media/SafeFoodLibrary/Documents/Publications/Research%20Reports/Acute_Gastroenteritis.pdf)
- Statacorp, 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP.
- The Sphere Project, 2011. *Humanitarian Charter and Minimum Standards in Humanitarian Response*. Available online: [www.sphereproject.org/resources/?search=1&keywords=&language=English&category=22&subcat-22=23&subcat-29=0&subcat-31=0&subcat-35=0&subcat-49=0](http://www.sphereproject.org/resources/?search=1&keywords=&language=English&category=22&subcat-22=23&subcat-29=0&subcat-31=0&subcat-35=0&subcat-49=0)
- Trivago.ie, 2015. *County Galway*. Available online: [www.trivago.ie/galway-42401/hotel](http://www.trivago.ie/galway-42401/hotel)
- UN, 2011. *Monitoring Framework for Water*. UN World Water Assessment Programme (UN WWAP) and UN Statistics Division (UNSD). Available online: [unstats.un.org/unsd/envaccounting/WWAP\\_UNSD\\_WaterMF.pdf](http://unstats.un.org/unsd/envaccounting/WWAP_UNSD_WaterMF.pdf)
- UN, 2012. *Managing Water under Uncertainty and Risk*. UN World Water Development Report 4. Available online: [www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/wwdr4-2012](http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/wwdr4-2012)
- Vijgen, S.M.C., Mangen, M.J.M., Ortbeek, L.M. *et al.*, 2007. *Disease Burden and Related Costs of Cryptosporidiosis and Giardiasis in the Netherlands*. RIVM Report 330081001. Available online: [https://www.researchgate.net/publication/27453554\\_Disease\\_burden\\_and\\_related\\_costs\\_of\\_cryptosporidiosis\\_and\\_giardiasis\\_in\\_the\\_Netherlands](https://www.researchgate.net/publication/27453554_Disease_burden_and_related_costs_of_cryptosporidiosis_and_giardiasis_in_the_Netherlands)

# Abbreviations

<b>CIR</b>	Crude incidence rate
<b>CSO</b>	Central Statistics Office
<b>DEHLG</b>	Department of the Environment, Heritage and Local Government
<b>EPA</b>	Environmental Protection Agency
<b>GMS</b>	General Medical Services
<b>HSE</b>	Health Services Executive
<b>SMILE</b>	Simulation Model of the Irish Local Economy
<b>UN</b>	United Nations

# Appendix 1 Survey Questionnaire

# Do You Live in Galway City or Galway County and Drink Water?

If yes, we would appreciate it if you could take 10 minutes to complete the following 4-page survey. This research is being carried out by the Discipline of Bacteriology, School of Medicine, NUI Galway, to get a better understanding of what people know about where drinking water comes from and their awareness of its quality. This project is funded by the Health Research Board. Results of this survey will help inform the general public, providers of water and governing bodies on how to improve communication with the general public on water related issues. If you would like further information, please find website and contact details at the end of the survey.

Please tick  appropriate response:

Q1. Do you live in?

Galway City	
Galway County – Town	
Galway County – Countryside	
Other	

*If other, please do not complete the rest of this survey, as we are only looking for survey respondents from Galway City and Galway County, but thank you for your time.*

Q2. Do you drink water from the tap at home?

Yes	
No	

*If No: Why not? (Please choose all options that apply)*

Taste	
Smell	
Colour	
Previous problem with water quality	
Worry about water safety	
Other (please specify) :	

Q3. Do you use a jug filter for drinking purposes at home?

Yes	
No	

Q4. Do you buy bottled water for drinking purposes at home?

Yes	
No	

If No: Proceed to Q5.

*If Yes: Please estimate how much your household buys and what it costs to the nearest € each week?*

Volume (in litres)	Cost

*If Yes: Why do you buy bottled water?*

Worry about water safety	
Catering (e.g. guest use)	
Taste (e.g. sparkling water)	
Convenience (e.g. lunchbox)	
Other (please specify) :	

**Q5. If you were worried about your drinking water where would you go to find out more information? Please tick all options that apply**

EPA	
Local Authority	
Group Water Scheme	
Local T.D.	
Local newspaper	
Local radio	
Internet	
Facebook	
Twitter	
Don't know	
Other (please specify) :	

**Q8. Do you know what type of drinking water supply you use at your home?**

Yes	
No	

**If Yes: Please specify**

Connection to a public main	
Connection to a Group Water Scheme with a Local Authority source of supply	
Connection to a Group Water Scheme with a private source of supply (e.g. lake, borehole, etc.)	
Connection to other private source (e.g. well, lake, rain water tank, etc.)	
No piped water supply	

**Q6. On a scale of 1-5 how much do you trust your drinking water? (1 being not trusting it at all and 5 being trusting it completely)**

1	2	3	4	5

**Q7. Do you know if your drinking water supply is tested routinely?**

Yes	
No	
Don't know	

**Q10. In the last year have you had any of the following problems with your water supply? (Please choose all options that apply)**

	Yes	No
Discoloration		
Bad smell		
Bad taste		
Presence of sediment in your water		
Low pressure		

**If No to all: Proceed to Q11.**

**If Yes: Have any of the above problems happened more than once?**

	Yes	No
Discoloration		
Bad smell		
Bad taste		
Presence of sediment in your water		
Low pressure		

**If Yes: Have you brought these problems to the attention of your water supplier?**

Yes	
No	

**If Yes: Were you satisfied with the response you received?**

Yes	
No	

**Q9. Do you know if any treatment is applied to your water supply to prevent contamination with bacteria and other organisms?**

	Yes	No	Don't know
Chlorine			
UV			
Filter			



**Q11. In the last 10 years has your drinking water supply been subject to a boil water notice/restriction?**

Yes	
No	
Don't know	

**If No: Proceed to Q12.**

**If Yes:** How did you find out about the boil water notice/restriction?

T.V.	
National radio	
National newspaper	
Local radio	
Local newspaper	
Internet	
Twitter	
Facebook	
Leaflet drop	
Other (please specify) :	

**If Yes:** Did you understand the reason for the boil water notice/restriction?

Yes	
No	
Don't know	

**If Yes:** Did you feel you were updated enough during the boil water notice period/restriction?

Yes	
No	
Don't know	

**If Yes:** What difference did this make to your use of drinking water at home after the boil water notice/restriction ended?

Changed to only drinking bottled water	
Use jug filter for drinking water	
Now, I always boil tap water to drink it	
No impact	
Other (please specify) :	

**Q12. Do you remember the 2007 outbreak of cryptosporidiosis in Galway City and surrounding areas?**

Yes	
No	

**If Yes:** Please specify how this outbreak affected you: (tick all the options that apply to you)

Boil water notice was put in place in the area in which you live	
Became ill with cryptosporidiosis	
You were absent from work/school	

Family member ill and absent from school/work	
Business owner affected by boil water notice	
Place of work affected by boil water notice	
Not affected	

**Q13. Did you suffer a loss of earnings due to the 2007 outbreak of cryptosporidiosis?**

Yes	
No	
If Yes please estimate your loss of earnings:	

**Q14. Has the way you use drinking water changed since the cryptosporidium outbreak in 2007?**

Yes	
No	

**If Yes:** Please indicate in what way

Changed to only drinking bottled water	
Use jug filter for drinking water	
I always boil tap water to drink it	
No impact	
Other (please specify) :	

**Q15. Sex:**

Male	
Female	

**Q16. Age:**

18–24	25–34	35–44	45–54	55–64	65+

**Q17. What is the highest level of education you have completed to date?**

No formal education	
Primary education	
Second level education	
Third level education – Non-degree	
Third level education – Primary degree	
Third level education – Postgraduate qualification	

**Q18. What is your nationality?**

Irish	
Other	
If other, please specify:	

**Q19. What is your main language?**

English	
Irish	
Other	

**Q20. How would you describe your present principal status?**

Employed	
Unemployed	
Student/pupil	
Looking after home/family	
Retired from employment	
Unable to work due to permanent sickness or disability	

**If employed: Do you work for a public service organisation?**

Yes	
No	

**Q21. Does your household own or rent the house you live in?**

Owens	
Rents	
Local Authority housing	
Other	
If other, please specify:	

**Q22. How many people live in your household including yourself?**

--

**Thank you for taking the time to complete this survey.**

For further information please contact:

Dr Dearbháile Morris,  
Discipline of Bacteriology,  
Antimicrobial Resistance and  
Microbial Ecology Group  
School of Medicine,  
National University of Ireland Galway

✉: [dearbhaile.morris@nuigalway.ie](mailto:dearbhaile.morris@nuigalway.ie)

☎ : 091-544652

[http://www.nuigalway.ie/bac/water\\_survey.html](http://www.nuigalway.ie/bac/water_survey.html)



**Note:** The EPA recently launched a public awareness campaign on private wells. Please feel free to take the attached leaflet. For more details see following website:

<http://www.epa.ie/water/dw/hhinfo/protpriv/well/>

## AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL

Tá an Gníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaoil a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaoil a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

## Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

**Rialú:** Déanaimid córais éifeachtacha rialaithe agus comhlionta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcleoíonn leis na córais sin.

**Eolas:** Soláthraimid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírthe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.

**Tacaíocht:** Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaoil atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaoil inbhuanaithe.

## Ár bhFreagrachtaí

### Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaoil:

- saoráidí dramhaíola (*m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola*);
- gníomhaíochtaí tionsclaíocha ar scála mór (*m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta*);
- an diantalmhaíocht (*m.sh. muca, éanlaith*);
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géimhódhnaithe (*OGM*);
- foinsí radaíochta ianúcháin (*m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha*);
- áiseanna móra stórála peitрил;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

### Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdarás áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhírú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídiú an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaoil.

### Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uisce idirchríosacha agus cósta na hÉireann, agus screamhuisce; leibhéal uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

## Monatóireacht, Anailís agus Tuairisciú ar an gComhshaoil

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil (*m.sh. tuairisciú tréimhsúil ar staid Chomhshaoil na hÉireann agus Tuarascálacha ar Tháscairí*).

## Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gás ceaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

## Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainaithe, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

## Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaoil in Éirinn (*m.sh. mórfheananna forbartha*).

## Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéal radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

## Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaoil ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaoil (*m.sh. Timpeall an Tí, léarscáileanna radóin*).
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhail ghuaiseach a chosc agus a bhainistiú.

## Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

## Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- An Oifig um Cosaint Raideolaíoch
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair inní agus le comhairle a chur ar an mBord.

## Economic Assessment of the Waterborne Outbreak of *Cryptosporidium hominis* in Galway, 2007



Authors: Dearbháile Morris, Aksana Chyzheuskaya, Diarmuid O'Donovan, Srinivas Raghavendra, Martina Prendergast and Martin Cormican

Water is a limited and precious resource and is being consumed worldwide at unsustainable levels. It is therefore essential to place an economic value on this precious resource. In March 2007, the largest outbreak of cryptosporidiosis since surveillance began in Ireland occurred, and was associated with contamination of the water supply serving Galway City and surrounding areas.

In this report, a twelve month study was undertaken to 1) place a monetary value on the costs and inconveniences imposed on the public, business and production sectors, local authorities and government agencies, 2) assess the cost benefits arising from remedial actions taken, 3) investigate means of assessing the immediate and long-term costs associated with loss of trust by communities in the public water supply and more general loss of trust in public services 4) identify key knowledge gaps that limit evaluation of the economic impact of the outbreak with a view to development of a template for real-time data collection in future incidents.

### Identifying Pressures

This report highlights the significant economic pressures across a range of sectors arising from microbial contamination of a drinking water supply resulting in a major outbreak. The report reveals that compromises in water quality undermine the public's trust in their drinking water supply. This research also identifies significant knowledge gaps particularly in the private sector that limit such economic evaluations.

### Informing Policy

The research informs policies on investment in water infrastructure intended to protect public health. The research builds capacity in the area of Environment and Health. The research is relevant in the context of the EU Water Framework Directive, the European Commission's 'A Blueprint to Safeguard Europe's Water Resources' and to the 7th EU Environment Action Programme which aims "to safeguard the Union's citizens from environment-related pressures and risks to health and wellbeing". The research also informs the following national regulations and EU directives: the EU Water Framework Directive, the Urban Wastewater Directive (1991), the Bathing Water Directive (2008), and the Drinking Water Directive (2014).

### Developing Solutions

The overall cost of the outbreak was estimated to amount to €19 million or €120,000 per day of the outbreak. This strongly supports the value of a sustainable economic model to ensure that water infrastructure upgrades anticipate and prevent outbreaks. The research identifies that availability of appropriate data is a limiting factor in completion of such economic assessments and has developed a template for data collection. This study provides valuable evidence that investment in safe drinking water supplies and water treatment enhancement benefits both public health and the wider economy.