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Policy, practice and decision making for zoonotic disease management: Water and *Cryptosporidium*

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ABSTRACT

Decision making for zoonotic disease management should be based on many forms of appropriate data and sources of evidence. However, the criteria and timing for policy response and the resulting management decisions are often altered when a disease outbreak occurs and captures full media attention. In the case of waterborne disease, such as the robust protozoa, *Cryptosporidium* spp, exposure can cause significant human health risks and preventing exposure by maintaining high standards of biological and chemical water quality remains a priority for water companies in the UK. Little has been documented on how knowledge and information is translated between the many stakeholders involved in the management of *Cryptosporidium*, which is surprising given the different drivers that have shaped management decisions. Such information, coupled with the uncertainties that surround these data is essential for improving future management strategies that minimise disease outbreaks. Here, we examine the interplay between scientific information, the media, and emergent government and company policies to examine these issues using qualitative and quantitative data relating to *Cryptosporidium* management decisions by a water company in the North West of England. Our results show that political and media influences are powerful drivers of management decisions if fuelled by high profile outbreaks. Furthermore, the strength of the scientific evidence is often constrained by uncertainties in the data, and in the way knowledge is translated between policy levels during established risk management procedures. In particular, under or over-estimating risk during risk assessment procedures together with uncertainty regarding risk factors within the wider environment, was found to restrict the knowledge-base for decision-making in *Cryptosporidium* management. Our findings highlight some key current and future challenges facing the management of such diseases that are widely applicable to other risk management situations.

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1. Introduction

Institutional responses to zoonotic disease include those arising through government or industry. The extent to which institutional responses are proactive or reactive can be a function of multiple factors. These relate often to foresight, preparedness and the ability to influence policy and standard practices, and should be based on many forms of data and sources of evidence. In all such cases, the conditions of response are often altered when a disease outbreak suddenly erupts, and captures full media attention (Jalba et al., 2010; Tabbaa, 2010). These have become the typical conditions of risk management for zoonotic diseases, more so, for example, for swine-flu and human pandemic concerns, than for a more endemic zoonotic condition such as cryptosporidiosis. However, even in less acutely media-publicised risk situations, the social and organisational conditions of knowledge-production and translation are salient to effective policy practice. But 'policy' is a frequently oversimplified process and is rarely about a single decision-maker or set of decision-makers. Instead, it is usually a complex web of actors and networks, each with their own different

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constraints, immediate priorities, responsibilities, methods and sources of information. Therefore, the way in which knowledge is translated and used across these scientific, governmental and operational policy levels can have an impact on the resulting management decisions aimed at containing emerging diseases. Crucially, identifying where uncertainties lie and what form they take, is essential when understanding the current and future challenges for risk management (Fish et al., 2011).

Environmental contamination with zoonotic microorganisms can have significant health and environmental implications at the local, regional and national levels. Microbial contamination of drinking water supplies can pose a significant human health risk because of the potential for rapid widespread exposure of large numbers of people to harmful pathogens. The resulting human health and economic implications can be long-lasting and far wider-reaching than the original source of contamination (Corso et al., 2003). Microbial contaminants can enter the source waters that supply drinking water prior to treatment through connectivity to surface and ground waters from animal or human sources (Bridge et al., 2010).

The robust waterborne protozoa, *Cryptosporidium* spp, is responsible for between 3000 and 6000 cases of the illness cryptosporidiosis in the UK per year (Nichols et al., 2006). Symptoms of the illness range from mild diarrhoea through to chronic and life-threatening conditions in those with weakened immune systems. The *Cryptosporidium* species, *C. parvum* and *C. hominis*, have been found to account for more than 90% of infections in human cases world-wide (Chalmers and Giles, 2010). For the purposes of this paper, we use the term '*Cryptosporidium*' to represent all infective species where they are not defined in the literature. As cryptosporidiosis is transmitted by the ingestion of *Cryptosporidium* oocysts that have been excreted in the faeces of infected animals or humans, the disease can be contracted via drinking water from public water supplies that have been contaminated by sewage effluent or livestock waste, even via runoff from land used for grazing infected animals (Davies and Chalmers, 2009; Oliver et al., 2005). However, humans can also contract the disease via private water supplies (Hunter et al., 2011), recreational waters including swimming pools and beaches (Schets et al., 2011; Schoen and Ashbolt, 2010), contaminated food (Macarisin et al., 2010), direct contact with infected animals (Gormley et al., 2011) and direct human to human contact, particularly within infected households (Siwila et al., 2011) with many infections being associated with foreign travel.

In the UK, water companies are legally required to provide drinking water that is 'wholesome' in order to protect public health and prevent widespread transmission of waterborne disease (Hrudey et al., 2006). However, *Cryptosporidium* oocysts are extremely resistant to chlorine disinfectants that are commonly used in most water treatment plants prior to distribution. As a consequence, the management of *Cryptosporidium* by water companies in the UK has undergone substantial change over the last two decades, with changes to monitoring and treatment approaches, which have resulted in a recognised reduction in outbreaks of the disease (Lake et al., 2007; Sopwith et al., 2005). However, there are still many challenges facing the management of the disease, not just in the UK but across the globe. Outbreaks of cryptosporidiosis occur worldwide but the disease is under-reported in many developing countries, with the majority of reported cases occurring in North America and the UK (Karanis et al., 2007; Putignani and Menichella, in press) due to the well established surveillance and reporting systems. With outbreaks still occurring in these countries and other parts of Europe, *Cryptosporidium* remains a priority in terms of risk management for water companies.

While much has been published on waterborne outbreaks, the focus has rarely been on how knowledge and information is translated between stakeholders in the management of *Cryptosporidium*. This is surprising given that we can learn so much from previous events for improving current risk management strategies. In general, little attention has been given to how scientific and other salient risk-management knowledge is restricted in transmission or scope, or indeed validity, by social and institutional factors. Recognising and understanding these factors is an essential precondition for overcoming them. In particular, it would be useful to examine how knowledge is translated across different levels of policy, given the different drivers that have shaped management decisions and the knowledge informing them. Which management drivers have been important? Do they occur at different spatial or temporal scales? Given these drivers, are there uncertainties surrounding this information that make it less reliable as a basis for forming management decisions? Here, we use an example of the interplay between scientific information, the media, and emergent government and company policies during the course of on-going outbreaks to examine these issues. We use a combination of qualitative and quantitative data relating to *Cryptosporidium* management decisions by a water company in the North West of England under a number of national, regional and local management conditions. From this case-study we aim to derive insights that can be useful in assisting more effective risk management in a broader range of cases.

2. Materials and methods

2.1. Study area and background

In the North West of England, water and sewerage services are provided by a single water company, hereafter referred to as 'the Water Company'. Their operations cover a total land area of 14,415 km^2, supplying water to 7 million people in the North West, including 3.2 - million households and 400,000 businesses. It was first recognised that *Cryptosporidium* could be transmitted through drinking water in 1984 (Dantonio et al., 1985). At this time, many of the region's water supplies did not receive sufficient treatment for removing *Cryptosporidium* from potable water. As a consequence, outbreaks of cryptosporidiosis were a particular problem during the 1990s. Between the period of 1991 and 1999, 22 outbreaks of cryptosporidiosis in England and Wales associated with potable water were recorded and five of these were attributed to Thirlmere reservoir, Cumbria: the supply was known to be prone to contamination by *Cryptosporidium* (Hughes et al., 2004; Hunter et al., 2001) and provided the region with 50 million gallons of water per day. Over the last decade, the Water Company has upgraded water treatment processes through significant investment in its water treatment works (WTWs) and catchment management projects, which have seen an improvement in water quality and a reduction in outbreaks of cryptosporidiosis (Lake et al., 2007).

2.2. Data sources

Our research is supported by a number of qualitative and quantitative data sources. The primary qualitative data was obtained through semi-structured interviews with 11 key individuals selected for their key roles within the Water Company (existing and former employees) related to previous and current *Cryptosporidium* management strategies at a region-wide scale and key strategic stakeholders from the Drinking Water Inspectorate (DWI) and the Health Protection Agency (HPA). The interviews consisted of open-ended questions around key themes, including: policy background and data collection procedures, risk assessment drivers and procedures, drivers and practices for upgrading water treatment procedures and how the company has worked with legislation, regulators and landowners. The interviews were recorded with permission of the interviewees and transcribed verbatim. Interviews typically lasted between 60 and 120 min and, in most cases, were conducted at the participant's place of work.

These data were supplemented with quantitative *Cryptosporidium* monitoring data obtained via permission of the Water Company, as

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