Effective public health practice: Insights from Cardrona 2012

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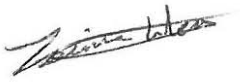

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EXECUTIVE SUMMARY

The report examines effective public health practice for managing environmental microbial risks at a local or regional level.Specifically, this report documents a case study on the inter-agency dynamics involved in managing a norovirus (NoV) outbreak in the Cardrona village in late August and early September, 2012.

The purpose of this report is twofold:

- to consider how the framework proposed in our earlier reports[1] illuminates or explicates important aspects of the Cardrona 2012 case.
- to use the incident management of the Cardrona 2012 outbreak as both an illustration of and lens to test the conclusions drawn in our earlier reports examining other incidents and outbreaks

The Cardrona 2012 outbreak (OB-12-103287-IN) was first notified to Public Health South (PHS), the PHU for Southern DHB, on Monday 27 August, 2012. Four separate groups reported illness with acute gastroenteritis, all of whom had eaten or consumed water at the Cardrona Hotel in the previous 48 hours. Sporadic cases of gastroenteritis had been reported the week earlier.

After epidemiological, environmental and microbiological investigation the PHS team concluded:

> 'Given the positive [NoV] GI detected in faecal samples and in the Cardrona Hotel drinking water supply; positive [NoV] GI and GII in one of the faecal samples, and from the Benbrae drinking water supply and Cardrona River; reports of many cases of illness compatible with a Norovirus gastroenteritis, visual contamination of the water system and inadequate chlorination, we conclude that this was most likely a mixed waterborne and person-to-person outbreak of Norovirus gastroenteritis' (Jack 2012).

The Cardrona valley has a small permanent resident population (about 60 people), but hosts large numbers of visitors. It has several accommodation facilities (including Benbrae Resort), the Cardrona ski resort, and is the gateway to Snow Farm NZ, a conference and recreation area offering cross country skiing.

The response to the 2012 outbreak was framed, in part, by the memory and experience of an earlier outbreak in the same area. It was also framed differently by different stakeholders, depending on their particular interest in the incident. As such the 2012 outbreak poses the theoretical question of how the mix of roles and expertise that was engaged in understanding and managing the outbreak and the surrounding issues could have been expanded, and what effect that might have had. Finally, the outbreak provides some insight into the importance of existing relationships between key agencies at a time of incident management.

This report offers a socio-technical review of the 2012 outbreak and its historical and geographical context. We suggest a number of complexities that could inform any proposal to improve public health practice. We use a framework of three inter-related elements that

[1] Nicholas and Weaver, 2014; 2015a&b.

influence effective inter-agency response to public health events to discuss findings from our review of Cardrona 2012. The three elements of the framework are:

- the mix of roles and expertise
- the quality of relationships between key actors
- how the situation is framed, both initially and over time.

1. INTRODUCTION

This report documents a case study on the inter-agency dynamics involved in managing a norovirus (NoV) outbreak in the Cardrona village in late August and early September, 2012. The outbreak itself has been documented in a report by the Southern District Health Board (Jack 2012) and a paper in the New Zealand Medical Journal (Jack et al. 2013).

The purpose of this report is twofold:

- to use the incident management of the Cardrona 2012 outbreak as both an illustration of and lens to test the conclusions drawn in our earlier reports (Nicholas and Weaver 2014; 2015a; 2015b) examining other incidents and outbreaks
- to consider how the framework proposed in our earlier reports may illuminate or explicate important aspects of the Cardrona 2012 case.

This report is not a critique of how the Cardrona 2012 outbreak was managed, nor is it an investigation or review of what may have caused that outbreak. Instead, the report draws insights from the particular case in order to inform effective public health practice for managing environmental microbial risks at a local or regional level. This is the fourth in a series of such reports (Nicholas and Weaver 2014; 2015a; 2015b). Together, these reports document a wider research programme on inter-agency collaboration in public health. The 'project brief' for the research programme is summarised in Appendix B. Further research in this programme is likely.

The wider research programme seeks to complement environmental *risk assessment* (e.g. microbiological hazard identification, dose-response characterisation, consideration of vulnerable populations, exposure pathways, risk characterisation and risk management). It examines issues of *risk management* in terms of how critical decision-makers function and interact. The focus of the research is on what could be seen as a 'preventive framework' (Jalba et al 2010; Jalba et al 2014), or an additional barrier to disease outbreak occurrence,[2] that is, effective multi-agency planning and collaboration. In particular, the programme considers interactions between public health practitioners, local government officials, science advisors, the proprietors and managers of affected facilities and the link between local and national agencies.

The research comprises exploratory qualitative case studies (Stake 2005) and compares findings with selected literature. Earlier reports in the series have examined three cases of inter-agency management of environmental microbial risks to public health. Case studies have been compared with findings in the literature to develop principles to guide future practice by public health and local government officials. Provisional conclusions were then field tested, refined and used to develop practical guidelines and an incident management tool to support public health personnel manage public health incidents (Nicholas and Weaver 2015b).

The current report adds insights from a fourth case study and provides an opportunity for some summary conclusions from the series of projects. A final stage in the project will be to

[2] The term 'barrier' here is used in the sense of that it is used in protecting drinking. Barriers are the protective measures that prevent or reduce contamination. The usual measures are source protection, treatment, securing the distribution system, monitoring programmes, and responses to adverse conditions. [O'Connor. 2002. *Part Two: Report of the Walkerton Commission of Inquiry* Ontario: Ontario Ministry of the Attorney General]

prepare practice guidelines for New Zealand public health units (PHUs)[3] on inter-agency and multi-stakeholder collaboration in incident management.

[3] Appendix A provides a brief introduction to the structures of public health in New Zealand.

2. CARDRONA 2012: THE OUTBREAK

The Cardrona 2012 outbreak (OB-12-103287-IN) was first notified to Public Health South (PHS), the PHU for Southern DHB, on Monday 27 August, 2012. Four separate groups reported illness with acute gastroenteritis, all of whom had eaten or consumed water at the Cardrona Hotel in the previous 48 hours. Sporadic cases of gastroenteritis had been reported the week earlier.

The PHS established a coordinating group from its staff to investigate and manage the outbreak. The group was led by the medical officer of health working in the Queenstown area. The group included staff in Dunedin and Invercargill, and met by teleconference. Initial investigation focused on foodborne, waterborne and/or person-to-person pathways. 'As the investigation continued, wider environmental contamination was considered' (Jack 2012). Samples were taken from outbreak cases, food, drinking water supplies and the environment to be tested for bacteria and viruses (especially norovirus (NoV)). Drinking water, sewage and wastewater facilities were also investigated for faecal indicator bacteria (*E. coli*) and the drinking water was also tested for NoV.

After epidemiological, environmental and microbiological investigation the PHS team concluded:

> 'Given the positive [NoV] GI detected in faecal samples and in the Cardrona Hotel drinking water supply; positive [NoV] GI and GII in one of the faecal samples, and from the Benbrae drinking water supply and Cardrona River; reports of many cases of illness compatible with a Norovirus gastroenteritis, visual contamination of the water system and inadequate chlorination, we conclude that this was most likely a mixed waterborne and person-to-person outbreak of Norovirus gastroenteritis' (Jack 2012).

The background to the 2012 outbreak is a complex situation including a private drinking water supply, on-site wastewater treatment systems, local tourist business owners, historic resource and building consents, apparent historic failures of process, and relationships between local residents, local and regional councils, the medical officer of health, the Ministry of Health and scientists.

There has been a history of local gastroenteritis reports and outbreaks in this small community. A well-documented outbreak occurred in July 2006 at Cardrona ski field (Hewitt et al 2007), but we were told by local residents of gastroenteritis symptoms in the community on at least two other occasions before the 2012 outbreak.

The 2006 outbreak provided an immediate reference point and backdrop to the 2012 incident. In 2006 there was an investigation of an outbreak of acute gastroenteritis among staff and visitors at the nearby ski field.

> 'Early environmental investigations did not support a common source of infection, but identification of *E. coli* contamination of the water supply and the subsequent identification of NoV in the feces [sic] of individuals with gastroenteritis suggested that the water supply had been contaminated by human sewage. The finding of gastroenteritis cases due to rotavirus and *Cryptosporidium* infection also supported sewage contamination' (Hewitt et al 2007).

The 2006 outbreak served to identify potential problems with regulation at that time of privately owned community drinking water supplies, and led to 'wider recognition of the vulnerability of water supplies at all ski resorts and alpine venues' (Hewitt et al 2007). In addition, that outbreak profiled to public health professionals the use in investigating a waterborne NoV outbreak of a new scientific method: the rapid detection and genogrouping

of NoV from faecal and water samples by real-time reverse-transcription polymerase chain reaction technology (RT-PCR).

While public health personnel quickly recognised that the 2012 outbreak was associated with Cardrona village rather than the ski field, the earlier incident continued to inform the investigation.

The Cardrona valley has a very small permanent resident population (about 60 people), but hosts large numbers of visitors. It has several accommodation facilities (including Benbrae Resort), the Cardrona ski resort, and is the gateway to Snow Farm NZ, a conference and recreation area offering cross country skiing. Visitors to the ski resort alone are said to have risen from 500 to 5000 per year in recent years. The large influx of people puts a lot of stress on the community's infrastructure, particularly drinking water and wastewater.

The investigation of the 2012 outbreak led to improvements being made to treatment of the water supplied by Cardrona Water Supply Limited. This included the installation of ultra violet (UV) treatment using a unit supplied by the responsible local authority, Queenstown Lakes District Council (QLDC).

3. METHODOLOGY

An initial list of critical actors was developed through seven key informant interviews, reference to media coverage of the focal event and consultation with the relevant PHU.

Data collection involved documentary analysis, in-depth interviews, data triangulation and thematic analysis.

In particular, key documentary sources included an outbreak report written for the DHB (Jack 2012), a published article on the case (Jack et al 2013), a published article on an earlier outbreak at Cardrona (Hewitt et al 2007), a report prepared by the Medical Officer of Health on the water supply from Cardrona Water Supply Limited (Bell 2012), a report by Mr Harry Kegel who had maintained the Cardrona Water Supply Limited system and took samples of local water for laboratory testing (Kegel 2013), and a range of notes and emails made by key actors at the time of the outbreak. Key informants by interview included the medical officer of health, a local community leader from the Cardrona valley, Mr Kegel, Institute of Environmental Science and Research (ESR) scientists involved in the case, and the Manager, Environmental and Border Health, Public Health at the Ministry of Health.

Data from the case study have then been compared with themes developed in earlier stages of this project (outlined below).

3.1 FRAMEWORK FROM EARLIER WORK

We have compared our earlier case study findings with international literature to derive a set of robust insights to inform public health practice (Nicholas and Weaver 2015a). In particular, we used findings and concepts from three sets of authors:

- Jalba and colleagues (Jalba et al 2010; Jalba et al 2014), who have established what they describe as a 'preventive framework' of how agencies need to work together to protect public health
- Axelsson and Axelsson (2006), who build on the work of Lawrence and Lorsch (1967) on differentiation and integration in organisations, and discuss what is required for co-ordination, co-operation and collaboration between agencies in public health management
- Woo and Vicente (2003), who draw on the work of Rasmussen (1997), who established a framework for risk analysis and management based on levels of organisation in a complex sociotechnical system.

The insights gained from the case studies and the literature suggested a framework of three inter-related elements that influence effective inter-agency response to public health events:

- the mix of roles and expertise
- the quality of relationships between key actors[4]
- how the situation is framed, both initially and over time.

This finding is illustrated by Figure 1. Each element will now be described further.

[4] Key actors, in this sense, are any individuals, groups or agencies that can affect how the risk is managed or what the outcome is.

Roles and expertise are considered complementary but distinct from one another. The role of the medical officer of health is, typically, instrumental in fronting key decisions and public communication. However, other key roles found to contribute to outcomes include health protection officers, environmental health officers, local authority management, Ministry of Health advisors, facility owners and managers, voluntary informants from the public, clinicians, science advisors and science service providers. While personnel in each of these roles can be assumed to have expertise commensurate with their role, the particular mix of expertise "around the table" was seen to shape the response to each event.

The **quality of relationships** necessary for effective inter-agency response refers to the combination of history (institutional and personal), knowledge (of one another's operating environments, skill sets and attitudes) and attitude (of trust and respect in regard to what the other brings to the relationship). The importance of the quality of relationships relates to all the key actors that may influence how the event is managed and the outcome, not just the formal relationships between professionals and experts charged with managing the event. Quality of relationships, therefore, includes members of the wider community and the media.

How the situation is framed, refers to the choice of how to see the current event. An event can be approached through different lenses. A microbial disease outbreak may initially be viewed as an example of a communicable disease, a drinking water quality issue, and food handling issue, or an environmental contamination issue.

Depending on who is considering the event, an outbreak of disease may be seen as a public health risk, a commercial risk, a financial risk, a reputational risk, a legal risk, or a personal risk (Jalba et al 2010).

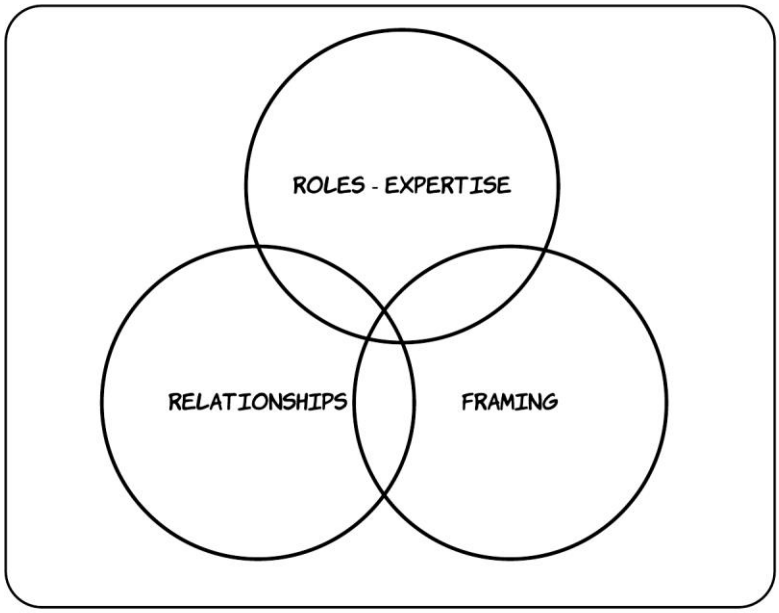

Figure 1: Elements for effective public health risk management (Nicholas and Weaver, 2015a)

Each of these three elements of effective public health response is interdependent on the other two. The particular mix of role and expertise that needs to be engaged to respond to an event depends on how that event and the task of responding is framed, and pre-existing relationships between potential participants. How the event and task is framed depends, in turn, on who contributes to that framing, and from what perspectives and expertise, and on

the quality of relationships that exists between those involved. Also, the quality of relationships between key actors depends on which set of roles and expertise are thought to be relevant, and that depends on how the situation is framed.

Each of the three elements also depends on factors unrelated to the other elements: the quality of relationships also depends on the historical relationships existing, framing also depends on finding a frame that makes sense to all the key actors, and the roles and expertise readily available to the response will be limited by the general availability of roles and expertise in the context. The perception by key actors of their ability to make an effective response to the situation, be it in the short or long term, may also influence how a situation is framed, and what expertise is considered by them to be relevant.

4. FINDINGS

A socio-technical review of the 2012 outbreak and its historical and geographical context suggests a number of complexities that could inform any proposal to improve public health practice. We discuss six topics arising from the current case study.

4.1 PROXIMITY OF DRINKING WATER SUPPLIES TO WASTEWATER DISPOSAL SITES

The water for the Cardrona Hotel is supplied by Cardrona Water Supply Limited, a company owned by the owners of the hotel. It supplies the hotel and residences nearby. It is chlorinated. The main bore for the supply is within 60 meters of the hotel wastewater disposal field, close to the wastewater disposal field for the Benbrae Resort, and within 30 meters of two private septic tanks. At the time of the outbreak the bore was not completely secure. The bore is down-gradient of the wastewater disposal fields.

If demand for drinking water suddenly increased it would be possible, in effect, to draw contaminated water into the drinking water bore. Increased chlorine demand and increased particulate matter in the water because of contamination could reduce the disinfection efficacy of the chlorine.

Some of these irregularities can be regarded as legacy issues from earlier, less regulated times. However, we discovered evidence of considerable local feeling about the consent given to the Benbrae Resort to site a disposal field on a terrace above drinking water bores, and on land that is known to be very porous. Local informants expressed the view that the consent 'defied common sense' and 'put people's health at risk'. Test results reported as part of the 2012 outbreak investigation suggest faecal contamination was, at least, entering the Benbrae water supply (from a different bore to that supplying the hotel). We were also informed that there had been breaches of the conditions of the discharge consent that constituted a threat to human health and that these are not routinely notified to either Queenstown Lakes District Council (QLDC) or PHS.

The issue relevant to this report is an apparent disconnect between agencies in not adequately relating a discharge consent (and possible breaches) with health issues related to drinking water bores.

4.2 PRIVATE OWNERSHIP AND OPERATION OF COMMUNITY WATER SUPPLIES

Cardrona Water Supply Limited was, at the time, not a registered community water supply. It supplies some neighbouring properties and the hotel. Maintenance on the scheme has been done by a self-taught, self-styled 'maintenance-man' (Mr Harry Kegel). He has installed and operated a chlorination system and has undertaken regular water sampling from the supply and from neighbouring surface water. The samples have been analysed by a certified laboratory. Mr Kegel has shared his knowledge and his misgivings about the safety of the water supply with public health officials. He reports being insecure in his competence in relation to the burden of responsibility for public health.

Meanwhile, chlorination of the drinking water at the bore was shown to be inadequate in the 2012 investigation. There was an air lock in the system that meant in the recent history no chlorine dosing had occurred. In addition, when this was rectified it became apparent that the chlorine dosing pump could not adequately dose the supply against the flow of water meaning residual chlorine levels would have historically been below recommended levels.

There is also the factor that norovirus is robust and more resistant to UV treatment than *E. coli* so even if *E. coli* was effectively eliminated there could be norovirus present.

Of importance to this study, is that the proprietor of a water supply used by patrons of the hotel and local residents was not subject to any quality assessment or regulation.

4.3 SPECIFIC CHALLENGES OF LOCAL TERRAIN AND THE POPULATION SERVED

An obvious challenge for infrastructure and the provision of safe drinking water in the Cardrona valley is the ratio of the small permanently resident population (and local rating base) to the large numbers of visiting tourists passing through. To sustain the tourist traffic the village and local resorts need investment in suitable infrastructure. In terms of regulation, the unregistered community supply for the hotel and neighbouring residents also serves a large transient population. In terms of epidemiological investigation, illness among a transient population is hard to trace and, in the 2012 incident, 'locating and contacting all those who may have been exposed to conduct a cohort study was unsuccessful despite multiple contact attempts' (Jack et al 2013).

The wastewater in the ski field is treated using an oxidation pond. Considering that peak usage occurs during winter, low temperatures make it unlikely that much treatment would occur. In effect wastewater is being held before being discharged post season (spring/ summer). Oxidation ponds require high ultra violet radiation from sunlight to be effective for disinfection, coupled with long retention times. At low temperatures, with the ponds potentially covered in ice/snow there is the potential for prolonged survival of pathogens present in the wastewater. If subsequent treatment is not used, and the wastewater is discharged to the river, there is a risk of elevated levels of pathogens entering the river. The Little Meg stream runs from the ski field down to the Cardrona River. There is some evidence that the oxidation pond overflowed in 2010. The impact this would make on both recreational water and drinking water quality in the township is not clear as there would need to be an assessment of the flow rate and depth of the river, and connection of surface water (river) to the groundwater supplying the drinking water.

A further challenge presented by the local terrain is that the valley includes some areas of hard rock and parts of the valley have been 'turned over' in the past for gold mining. Photos of excavation for the hotel drinking water bore show land that is very porous and with evidence of 'tunnels' that would facilitate rapid flows of water into and through the sub-soil. Considering the proximity of drinking water bores to septic tanks and discharge fields, the potential for contamination of drinking water is heightened.

4.4 BUSINESS INTERESTS

The economic life-blood of the village, local resorts and surrounding region is tourism. We were reminded by local informants of the importance of 'brand Cardrona'. We were refused opportunity to interview some business operators and community representatives. Protecting the reputation of 'brand Cardrona' was said to us to be vital. We were told that 'the valley has been burned' by publicity around previous outbreaks. This was used to explain to us local reluctance to be part of our study. The owners of several of the hospitality and tourist businesses are non-resident investors.

So, there appears to be a combination of a small permanently resident population, business interests dependent on high numbers of tourists, no publically owned infrastructure for water and waste, investors seeking to maximise financial performance of their businesses, and investors that may see themselves as not part of the local community. This combination presents a challenge to options for engaging stakeholders in collective approaches to managing common resources and interests, whether such approaches are driven by the regulator (regional and district councils) or by more collaborative processes such as those described by Ostrom (1999). These issues also present a challenge to engaging the full range of stakeholders early in managing an outbreak.

4.5 MIXED AND MULTIPLE PERSPECTIVES AND PURPOSES

We discuss later the importance for effective collaboration in public health of considering how situations are explicitly or implicitly 'framed'. Framing is a matter of perspective. Stakeholders are likely to have discrete perspectives, and may also be working toward discrete purposes or outcomes. Our findings in this case study illustrate some potential challenges to effective public health collaboration arising from mixed and multiple perspectives and purposes. We comment here, particularly, on the perspectives and purposes of the Ministry of Health ('Ministry') and the medical officer of health.

The Ministry:

A key responsibility of the Ministry is accountability to the Minister for 'protecting the public from environmental and disease risk factors that lead to ill health' (Ministry of Health 2015). 'It undertakes a range of activities to coordinate public health protection and related regulatory functions across the country and between DHBs. The Ministry [administers and provides] advice on environmental health-related aspects of legislation as required' (Ministry of Health 2015).

In the case of the Cardrona 2012 outbreak, Ministry advice had two focuses: to interpret the options available under legislation to the medical officer of health in line with current government policy, and to ensure that any position taken by the PHS investigation on the cause of the outbreak could be defended with sufficient evidence. In general, the approach of the Ministry is to encourage PHUs and medical officers of health to work pro-actively and collaboratively with relevant local agencies (such as regional councils and territorial authorities). The Ministry takes the view that PHUs should not look at a single issue in isolation but look at the health impact of any issue in its wider sense. It encourages PHUs to look at the key determinants of health, including, for example, income inequalities, quality of housing, and education, rather than focus solely on discrete public health issues.

In relation to Cardrona 2012, the Ministry was concerned that the PHU was contemplating a compliance and enforcement approach. In the view of the Ministry that approach would have been open to challenge due to insufficient evidence of the immediate cause of the outbreak, and insufficient evidence of engagement with the relevant businesses and agencies on the broader issues of discharges, consents and compliance actions. Two reference points for the Ministry appear to be the ability to defend actions by designated officers from criticism by local government and other agencies, the public or media and the confidence to defend actions in any court proceedings. Advice was sought of the Ministry by the PHU on options for responding to the outbreak, and formal advice was given by the Ministry on 26 September 2012. The advice recommended a non-regulatory approach but also provided an outline of regulatory options "for completeness".

Medical officer of health:

For the medical officer of health, it seems, the 2012 outbreak occurred within a history of frustration that known risk factors in the Cardrona valley had not been addressed. He had made representations to both Otago Regional Council (ORC) and QLDC at various times, highlighting the environmental health risks, but there had been little response. As part of responding to the 2012 outbreak he commissioned a scientific report on possible risks from exotic organisms, citing the example of a typhoid outbreak in 1964 at the European ski resort of Zermatt. Although the commissioned report suggested that the risk in the New Zealand situation was low, it served to highlight a potential threat to human health and reputation for tourism.

In addition, the medical officer of health was very aware of the strong vested interests pertaining to consents, compliance and reputation in the Cardrona valley. He had experienced business owners apparently misinterpreting his involvement. He had also

sensed a diffidence by the ORC to use compliance and enforcement, and sensitivity of QLDC to the reputational risk to the district.

It had clearly been frustrating to see the two councils 'bouncing responsibility back and forth'. He also felt that progress in addressing the risks was too slow.

The 2012 outbreak, therefore, appears to have come as no surprise to the medical officer of health, particularly once it became clear that the likely source of infection was drinking water. He had come to the view that the combination of consents for building and effluent discharge in Cardrona were a 'recipe for disaster'. With epidemiological investigation eliminating food sources as the common factor among those affected, with faecal samples found positive for a NoV strain prevalent in waterborne outbreaks, with the history of the area and the vulnerabilities known, and knowing that ESR had a capability of detecting NoV in water, the medical officer of health thought it appropriate to request testing for NoV in the water supplies. In his terms, this was simply 'completing the picture' which would not only provide evidence of the likely cause of the outbreak, but provide information to hand over to the other agencies to deal with. Once evidence was put forward from ESR scientists that the same genogroup of NoV was present in clinical samples and water samples, the medical officer of health and PHU felt it appropriate to put in place a boil water notice for the township.

From what we discern of the perspective of the medical officer of health, he saw the latest outbreak as part of a larger and important story about an on-going threat to public health, and regarded the evidence that the cause of the outbreak was wastewater contamination of the drinking water as robust and based on triangulation of evidence. While he is clear that he was not contemplating a "regulatory and compliance" approach to solving the wider issues, he sought advice from the ministry as part of considering how to see beyond the latest outbreak to ways of addressing the on-going treat to public health.

The medical officer of health, in this case, has practiced in the district for 25 years, seven years as a General Practitioner (GP) and 18 years as medical officer of health. As he commented, it is a small community, and he knows many locals well.

In summary, the medical officer of health puts a high value on being 'in the field' and taking account of the knowledge and relationships that come from being in the field. From that perspective the Ministry's view seems more cautious.

Of interest to the current research, the views of this medical officer of health have been echoed by others in our previous case studies, and may reflect a systemic issue around the role and professional perception of medical officers of health. At stake here is a functional and mutually trusting working relationship between the Ministry and designated officers; a relationship in which each party is clear about their own and the others distinctive roles, responsibilities and accountabilities. To be avoided is any sense of working around or in spite of the other, or either party assuming there is a fundamental disconnection between those in the field and the Ministry.

4.6 THE USE AND INTERPRETATION OF SCIENCE IN THIS OUTBREAK

Specific scientific testing and advice was used in managing the Cardrona 2012 outbreak. In addition to microbial analysis of leftover food (negative for target pathogens), tests were conducted on eight faecal samples and water samples from the hotel tap, the hotel bore, an outside tap and bore at a neighbouring resort, and local surface water. The discovery of NoV in the faecal samples prompted the use of recently developed testing (RT-PCR) also for NoV in water samples. NoV GI and GII were detected from faecal samples of cases, from the hotel and resort drinking water taps, the hotel bore water, and the wider environment. The NoV GI in the samples is an uncommon genotype. This was seen as supporting the

epidemiological conclusions pointing to waterborne wastewater contamination as the source for the outbreak (Jack et al 2013).

We found residual differences between key actors in how to interpret and use the evidence of NoV in the water samples. ESR scientists expressed confidence that the coincidence of the epidemiology of outbreak, the specific genotyping of NoV from faecal and water samples, and the observable location of wastewater disposal in relation to drinking water provided robust evidence for the conclusion that the illnesses were a result of waterborne faecal contamination. This interpretation was accepted by the medical officer of health and the PHS coordination group, and was written up as their findings.

The Ministry, on the other hand, viewed the PCR-based water tests as not necessarily attributing causality. PCR can only detect the DNA/RNA of a virus, and does not prove viability or infectivity, and the presence of NoV RNA in the water at a later time does not prove it was there at the time when people became infected. This view was compounded by the water samples testing negative for *E. coli*, the standard indicator organism for faecal contamination.

The PHU attempted to balance the two views, that of the Ministry with that of the ESR advice. The PHU experienced the contrast between the two views as a source of tension between it and the Ministry.

Our understanding of the Ministry position is that reliance on the PCR-based tests of water, along with other aspects of the investigation, would not withstand challenge in court. This position may not have been fully understood by the other actors, who interpreted the Ministry's view as over reliance on the *E. coli* standard test, which in this case was not reliable. Viruses can persist in the environment for longer than bacteria, and treatment may remove bacteria without removing viruses. From the perspective of those managing the incident, the idea of a legal challenge was hard to imagine, and they were confident in their findings.

5. DISCUSSION

The purpose of this report, as already indicated, is twofold:

- to use the incident management of the Cardrona 2012 outbreak as both an illustration of, and lens to test the conclusions drawn in our earlier reports
- to consider how the framework proposed in our earlier reports may illuminate or explicate important aspects of the Cardrona 2012 case.

We discuss our findings under the framework developed from the earlier work, the three inter-related elements that influence inter-agency response to public health events:

- The mix of roles and expertise
- The quality of relationships between key actors
- How the situation is framed, both initially and over time.

The point here is not to suggest that the process was flawed, but to ground and test our advice by imagining its application in an historical example.

5.1 ROLES AND EXPERTISE

We identified a rich matrix of roles and expertise relevant to the management of the Cardrona outbreak.

- Response was led by the medical officer of health based in Queenstown. He was assisted by a public health registrar, health protection officers (HPOs) and personnel from PHS, the regional PHU. Expertise within PHS included a drinking water assessor, a manager (mobilizing human and other resources) and infectious disease nurses. Most of this pool of expertise was in Dunedin and participated in a coordination group by frequent teleconferences (Jack 2012).
- The DHB Communications team played a part. The PHU had delayed the media release until test sample results were available and the PHU had a clear picture of what had happened. When the PHU did prepare a media release the DHB communications team moderated it by consulting the Ministry on its content. While this is a contractual requirement for DHBs, it appears to have taken the medical officer of health by surprise that that obligation might include his ability to issue public communications directly. He had only involved the communications team for technical assistance.

  We suggest that, in this case, the DHB involvement of the Ministry, risked what family systems theorists refer to as triangulation or triangling (Bowen 1978; Brown 1999; Kerr and Bowen 1988). Triangling is a response to anxiety between two parties by involving a third party who “either takes sides or provides a detour for the anxiety” (Brown 1999).

  > ‘Triangling can become problematic when a third party's involvement distracts the members of a dyad from resolving their relationship impasse. If a third party is drawn in, the focus shifts to criticising or worrying about the new outsider, which in turn prevents the original complainants from resolving their tension’ (Brown 1999).

  In this case, we suggest, the decision by the DHB communications team to consult the Ministry may have distracted from, and made more complicated, existing tension between the medical officer of health and the Ministry. A triangle is created involving the DHB, the medical officer of health and the Ministry. We wonder if the policy of consulting the Ministry on media releases could have been implemented in a way that maintained

direct dialogue between the Ministry and the PHU on any differences of view, and thereby avoided the triangling effect.

- Personnel from the Ministry of Health provided expertise on options available under current interpretation of legislation.
- Mr Harry Kegel provided his records of water tests for the area, and provided experience of the Cardrona Village drinking water and sewage disposal infrastructure.
- ESR scientists provided laboratory testing for faecal and water samples, and provided advice on sites for sampling and on interpretation of results.
- QLDC water engineers, water engineers from Veolia (QLDC contractors) and a water technician from Watercare were involved in assessing the drinking water system and the waste water systems associated with the hotel.

We consider this matrix of expertise in the light of a key question generated in our earlier work:

> What range of expertise, experience, knowledge and decision-making authority (including from the private and community sectors), if it were accessed, would ensure effective decision-making for this incident?

In this case, there appears to be an adequate range of expertise involved. What this case suggests, however, is that some experts that were used as informants could be considered as full collaborators in managing the incident. The collaboration we have in mind is what Axelsson and Axelsson (2006) have described: "inter-organisational collaboration [that] allows organisations to constructively explore their differences and find solutions that go beyond their own limited visions of what is possible". For example, although a range of stakeholders were consulted and informed during the outbreak, the 'co-ordination group' that managed the outbreak appears to have been entirely DHB PHS personnel. That situation is likely to be typical practice in PHUs. However, we recommend critical reflection on who is invited to be part of the problem solving, not just who is needed to provide key information. For example, in this case, how might outcomes have been changed (improved?) if the teleconferenced co-ordination group had included (at least sometimes) community level expertise such as Harry Kegel and the chair of the Cardrona Residents and Ratepayers Association, and a DHB communications expert? We note that the medical officer of health met with the Cardrona Residents and Ratepayers Association early in the outbreak, and received expressions of appreciation for the work of the PHU in the community. We suggest that that relationship could have been used strategically in understanding and managing the incident and local practice.

A further possible inclusion in the co-ordination group discussions would be the technical expertise of regional and district council staff. Again, council staff were actively involved in managing the outbreak, but consideration needs to be given to including such expertise in planning and strategy meetings during an incident. It may or may not have added anything in the current case, but the perspective, history and technical knowledge of council staff could be critical to understanding and managing a local outbreak.

Finally, in this matter, the case shows potential for confusion and tension affecting public health personnel managing an incident, in that they felt caught between science expertise provided by ESR and policy advice on how to describe probable causality of the outbreak, from the Ministry. As the medical officer of health commented, it "felt like being the meat in a sandwich". In terms of the right mix of roles and expertise, this aspect of the case suggests highlights the particular role of interpreting scientific advice. The question suggested by this example is whether that interpretation be done at local level or mediated through the Ministry. While reconciling different emphasise in coming to conclusions about outbreaks is

seen, by the medical officer of health, as a typical part of the job, we suggest it would have been better in this case if any debate that the Ministry may have had with the advice from ESR had happened more directly between the Ministry and ESR rather than leaving the PHU to interpret and balance what was seen as conflicting advice from ESR and the Ministry.

5.2 QUALITY OF RELATIONSHIPS

Our earlier report posed three questions to ensure relationships between key actors in managing an incident are as functional as possible:

1. What existing inter-agency networks, groups or structures can be adapted for managing this incident?

2. How can relationships that have been developed during this incident be nurtured and deepened beyond the current incident so next time there is more knowledge, understanding and trust of one another?

3. What organisational communication, feedback and structures would enable, support and nurture the critical relationships for managing this and other incidents?

The Cardrona 2012 case demonstrated the value and potential of existing inter-agency relationships. Critical to this case were relationships between the Queenstown office of the PHS and, respectively, QLDC, Otago Regional Council (ORC), the Ministry of Health (Ministry), ESR, and the Cardrona Residents and Ratepayers Association. Inevitably, these relationships varied in quality and readiness for the incident, and each had a history that had influenced its quality and readiness. We comment on just two.

The relationship between PHS (through the medical officer of health) and QLDC appears to be marked by mutual respect. For example, the medical officer of health was accorded opportunity to present his concerns to the council, and the council provided ready assistance in mitigating the drinking water risk that was identified in the 2012 investigation. While there is evidence of a good working relationship during the management of the 2012 incident, the relationship overall appeared to be something less than collaborative. For example, the mode of engagement over the previous years appear to have been that of the PHS submitting concerns, with little evidence of joint planning, action or problem solving; and the medical officer of health experienced frustration at the lack of heed given his historic submissions.

The relationship between the PHS and the Ministry might be characterised as “mutually managed”. By this we mean that each party clearly recognises the jurisdiction and style of the other, but, it is apparent, each attempts to manage the relationship in ways that work around the other. We have raised the possibility that that dynamic is not peculiar to the current case. In our opinion, history and structures may have shaped the way in which the Ministry relates to PHUs, and vice versa. However, it is possible that something closer to collaboration could be achieved. The PHU was in the position of balancing advice from the ministry and the scientific advice given by ESR.

We offer no judgement about the functionality or otherwise of any of the relationships listed here. The case does, however, demonstrate how the particular history of relationships and the extent of knowledge, understanding and trust of one another within those relationships become material to managing an incident.

5.3 HOW THE SITUATION IS FRAMED

The concept of framing refers to the set of assumptions or perspectives brought to a question or situation.

As Bolman and Deal describe the term,

> 'Frames are both windows on the world and lenses that bring the world into focus. Frames filter out some things while allowing others to pass through easily. Frames help us order experience and decide what to do' (Bolman and Deal 1997).

Our earlier report posed three questions to be asked throughout the incident management. The purpose is to select and revise how the incident and response is to be framed. The questions are:

1. What kind of incident does this seem to be?
2. How widely do we need to define the task triggered by this incident, to balance public health outcomes with other types of outcomes and effective use of available resources?
3. Who to involve, and how?

The Cardrona 2012 outbreak illustrates the importance of these questions.

Different parties would, from our evidence, answer these questions in different ways.

For the medical officer of health the incident could be framed as an expected episode of an on-going threat to public health posed by poor infrastructure. Thus, the medical officer of health assumed that identifying and managing the immediate source of infection was only part of the job. The wider task was to name and stimulate action on the 'cause of the cause'. Evidence of faecal contamination of drinking water served both purposes: to ensure the immediate source of the outbreak was ameliorated, and to add weight to the need for longer term solutions for safe drinking water. The choice to involve ESR capacity to test environmental samples of water for norovirus made sense within this frame. The medical officer of health attended a community meeting around the time of the outbreak. Contact was also made regularly with Harry Kegel although he was not present at the community meeting.

For local residents and ratepayers, the incident had several overlapping frames. It was an immediate threat to the health of some residents, it was a threat to 'brand Cardrona' (the reputation of Cardrona as a tourist destination), it was further evidence of problems with consents and infrastructure that had been a concern for some time, and it was a threat to business. For some in the residential and business communities the boundaries of incident management were best kept narrow: stop the outbreak and quickly return to normal. For others the incident was merely a symptom and called for more extensive, preventative, action. We heard suggestions from local residents that they felt they had been kept in the dark, and could have played a more active role in managing immediate exposure and, possibly, longer term solutions.

For the Ministry, the incident is an outbreak to be managed. Wider issues, such as planning, consents and infrastructure up-grades, are the responsibility of other agencies and subject to public health advice outside the management of an incident. PHUs are encouraged to be pro-active in their communities and with their regional and territorial councils as a matter of course. Health impacts in planning and consents can be highlighted quite independently of a particular outbreak.

For Harry Kegel, the incident was 'a time that somebody has to draw a line in the sand … health and safety is at risk'. He was moved to produce a five page document outlining his experience and his concerns, and the emphatic statement, 'Cardrona is a ticking time-bomb, waiting to go off' (Kegel 2013). He put the 2012 outbreak in a wider context and attempted to show a pattern of failures. For Mr Kegel, the cast of participants in responding to the

problems should have included property developers, proprietors of the various tourist and accommodation businesses, ORC and QLDC.

> 'The main "players", and that includes all local businesses and ski fields, all have to be incorporated in a long term solution that benefits all' (Kegel 2013).

6. CONCLUSION

In terms of the findings from our previous investigations and subsequent reports (Nicholas and Weaver 2015a; 2015b) there are a number of notable factors that could be considered in managing an outbreak such as this.

1. The initial investigation outbreak team appears to have consisted of only (a limited number of) health related personnel. No regional, local council, or proprietor presence is noted. It is unclear when these non-health related personnel became involved but the first definitive instance is the site visit (7th September) when the Cardrona Hotel manager, a community resident with historic knowledge of the water system, and a member of staff from QLDC were present. This is 11 days after the initial notification occurred. It is not clear whether there was involvement between the PHU and the council prior to this meeting. It has been noted that resources were tight at the time and the first small outbreak reported appeared as an isolated event. An HPO began investigating it as an isolated event.

   One of the conclusions drawn from our previous investigations was the importance of involvement of all key participants from the outset. Especially in outbreaks such as this where the cause is not immediately obvious and there is a history of previous cases and outbreaks in a community.

   Previous findings from historic outbreak investigations highlighted the importance of on-site inspections as soon as possible/practicable. It is especially important to conduct early site visits in outbreaks where those affected may leave, such as the case for Cardrona where most people are transient, visiting the hotel or the ski field.

2. It is not clear whether the same water samples were tested for faecal indicator organisms (namely *E. coli*) and norovirus. This is especially pertinent when discussing the implications of the presence or absence of faecal indicator organisms and viral pathogens.

3. Tensions between parties may also have influenced assessment and management of risk in the village. When looking at the tensions in active community members who felt they were having the finger pointed at them it again relates back to the importance of involving representatives from all parties affected by the outbreak from the outset. For example, using notes from Harry Kegel, local resident and maintenance operator for Cardrona Water Supply, it appears there is an ongoing feeling that local residents are being made responsible for the contamination through failing wastewater treatment systems. Mr Kegel also adds a note that he feels Cardrona residents are being kept on a leash by QLDC with continuing postponement of decisions relating to the water supply and wastewater treatment.

   There appears to have been some tension between the conclusions drawn by the public health unit (from scientific advice given by ESR) and the Ministry of Health. While there is no doubt that the issues raised by both parties were relevant it did appear to have caused delay in the publication of the media release prepared by the PHU.

The Cardrona 2012 outbreak provides a case study of the way in which three elements can shape public health practice. The three elements are:

- The mix of roles and expertise
- The quality of relationships between key actors

- How the situation is framed, both initially and over time.

The response to the 2012 outbreak was framed, in part, by the memory and experience of an earlier outbreak in the same area. It was also framed differently by different stakeholders, depending on their particular interest in the incident. As such the 2012 outbreak poses the theoretical question of how the mix of roles and expertise that was engaged in understanding and managing the outbreak and the surrounding issues could have been expanded, and what effect that might have had. Finally, the outbreak provides some insight into the importance of existing relationships between key agencies at a time of incident management.

In the light of these conclusions, and drawing on insights gained through the earlier case studies, we suggest giving consideration to the way PHUs conceptualise their role, and how this matches the framing of the role in legislation and government policy. The purpose of this would be to find any basis for misunderstanding, systemic tension and unproductive friction, and to propose new ways of relating the Ministry imperatives to the professional and field imperatives of PHUs.

APPENDIX A: PUBLIC HEALTH IN NEW ZEALAND

In New Zealand, public health services are administered through public health units (PHUs) owned by district health boards, and through some non-governmental organisations.

> "Public health units focus on environmental health, communicable disease control, tobacco control and health promotion programmes. Many of these services include a regulatory component performed by statutory officers appointed under various statutes, though principally under the Health Act 1956." (Ministry of Health 2014)

Health protection officers and medical officers of health are designated by the Ministry of Health in each region. Although employed by district health boards, they are accountable to and receive direction from the Director General of Health in respect of legislative authority[5] (Ministry of Health 2014).

Local government bodies also have responsibility for health protection. In New Zealand, the Health Act 1956 states that 'it shall be the duty of every local authority to improve, promote and protect public health within its district' (Section 23).

[5] For the historical development of these positions, see Walker. 2013. *A Job Worth Doing: Tales from Health Protection in New Zealand*. Blurb

APPENDIX B: RESEARCH PROJECT BRIEF

The research programme of which the present report is a part was commissioned by the Ministry of Health as part of its contract with the Institute of Environmental Science and Research Limited. Terms of reference for the research is contained in a 'project brief'. The following is extracted from the project brief dated 12 December 2013.

B.1 ISSUE/OPPORTUNITY:

We have useful understanding of risk management in terms of microbiological hazard, dose-response, vulnerable populations, exposure pathways, risk characterisation and risk assessment. This state of understanding provides an opportunity to examine the issues of risk perception, risk communication, and risk management. The interaction between public health units and other decision-makers is likely to be critical to risk management.

B.2 PURPOSE

To identify effective public health practice for managing environmental microbial risks at a local or regional level.

B.3 OBJECTIVES

1. To identify up to three case studies of public health events caused by exposure to environmental pathogens.
2. To identify transferable insights to improve inter-agency collaboration in responding to environmental pathogen risks at local and regional levels.
3. To field test the lessons learned (if resources permit)
4. To prepare a report that provides practical advice that can be applied by the Ministry and public health unit staff.

B.4 SCOPE OF PROJECT

- A set of specific agreed public health events. These events can include community exposure to environmental pathogens or public health inputs into local government planning around such risks.
    - Past public health events that have been resolved (ie their investigation is complete) whether satisfactorily or unsatisfactorily.
    - Events need to be local or regional and involve interaction between a public health unit (PHU) and local government (LG). Other interactions may be found to be relevant and should be included in the analysis
- A set of agreed case studies for each event.
    - Case studies will include examples of interaction between PHU and local government on very local events and urban/rural or regional events.

Excluded:

- Non-microbiological risks
- PHUs that are not interested in engaging.

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