Report prepared for the Ministry of Health

The Economic Costs of the Havelock North August 2016 Waterborne Disease Outbreak

David Moore, Rebecca Drew, Preston Davies, Rebecca Rippon

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Wellington	Auckland	
Level 9, 1 Willeston St PO Box 587 Wellington 6140 Ph: +64 4 915 7590 Fax: +64 4 915 7596	Level 8, 203 Queen St PO Box 2475 Auckland 1140 Ph: +64 9 909 5810 Fax: +64 9 909 5828	
Sydney	**Canberra**	**Melbourne**
Level 14, 68 Pitt St Sydney NSW 2000 GPO Box 220 Sydney NSW 2001 Ph: +61 2 9234 0200 Fax: +61 2 9234 0201	GPO Box 252 Canberra City ACT 2601 Ph: +61 2 6267 2700 Fax: +61 2 6267 2710	Level 8, 90 Collins Street Melbourne VIC 3000 GPO Box 3179 Melbourne VIC 3001 Ph: +61 3 9005 1454 Fax: +61 2 9234 0201

For information on this report, please contact:

Name: David Moore

Telephone: 04 915 5355

Mobile: 021 518 002

Email: dmoore@srgexpert.com

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Executive summary

The Ministry of Health (MoH) asked us to determine the costs of the waterborne disease outbreak in Havelock North, the largest outbreak of its kind in New Zealand. The contamination was discovered on 12th August 2016 and the primary impacts lasted for approximately four weeks, though there was a relatively long 'tail' of secondary and residual impacts felt outside that period.

The outbreak is the subject of an ongoing governmental inquiry. As much as possible, we have sought to capture inquiry costs to date, though we do treat these costs separately as they do not automatically arise from all water contamination events.

The estimation approach we took was economic in nature and focused on resource use, as opposed to financial or accounting measures. In particular, resources consumed because of the outbreak were valued in terms of their next best alternative use (i.e. their opportunity cost). We used a combination of desk-based research and interviews (both over the phone and in the field) to determine the impacts of the outbreak, and then derive estimates of cost based on those effects.

We separated the costs into six broad groupings: local government, the business sector, central government, non-governmental organisations (NGOs), health/illness-related costs, and households. In addition, we distinguished costs by the following stages:

- **Investigation/diagnosis** refers to the sourcing and confirmation of the outbreak (e.g. expert reports, testing, planning and setting up response teams).
- **Reaction** relates to costs that arose once the contamination was confirmed (e.g. provision of bottled water, communications and information provision and co-ordination costs, welfare teams).
- **Remedial** covers costs related to actions to 'make right' the water supply (treatment, engineering costs, further testing, etc.).
- **Consequential** describes costs that arise because of the outbreak (e.g. filtered water stations, safeguards, and inquiry related costs).
- **Residual** are costs that are ongoing such as monitoring, testing, rates rebates, information campaigns, and costs to respond to ongoing inquiries as to the safety of the water.

Total economic costs associated with the outbreak were estimated to be $21,029,288. The vast majority of costs relate to household inconvenience due to having to boil water, buy bottled water, and taking time off from normal activities during the outbreak (see Table 1). This is a function of the large number of households affected (5,088) and the relatively high costs per household of around $2,440.

Table 1 Total costs by sector

Sector	Costs	Proportion
Local government	$4,133,080	20%
Businesses	$1,302,179	6%
Central government	$506,576	2%
NGOs	$134,577	1%
Illness related	$2,532,619	12%
Households	$12,420,257	59%
TOTAL	**$21,029,288**	

Local government costs are the second largest and relate mainly to investigation/diagnosis and consequential stages. Costs for the latter are associated with the inquiry. The impact on the business community was noticeable, but not significantly materially. The estimated cost to business of $1.3 million is less than a week of 'normal' retail expenditure in Havelock North for the corresponding period. In saying this, we acknowledge that some businesses were particularly hard-hit (e.g. food and beverage, and accommodation providers).

Similarly, estimated health-related costs were relatively modest, given the spread of the outbreak. This reflects the prominent role that general practice played in dealing with the affected patients in an efficient and cost-effective manner. In addition, the wide array of support services that were mobilised in response to the outbreak helped reduce the potential for costly hospital stays.

When looking at costs by stage, the 'reaction' stage dominates (see Figure 1). This is due to the inclusion of household costs in this stage. Given the inquiry process is still underway, consequential costs are likely to increase significantly. Residual costs (generally associated with trust and confidence in the water supply, both from locals as well as visitors to Havelock North) are expected to dissipate over time. However, we understand (anecdotally) that publicity generated by the inquiry is positively related to concerns. That is, questions concerning water quality/safety rise at the same time as inquiry findings are published. Thus, to the extent consequential costs rise in future, so too might residual costs.

Figure 1 Total costs by stage
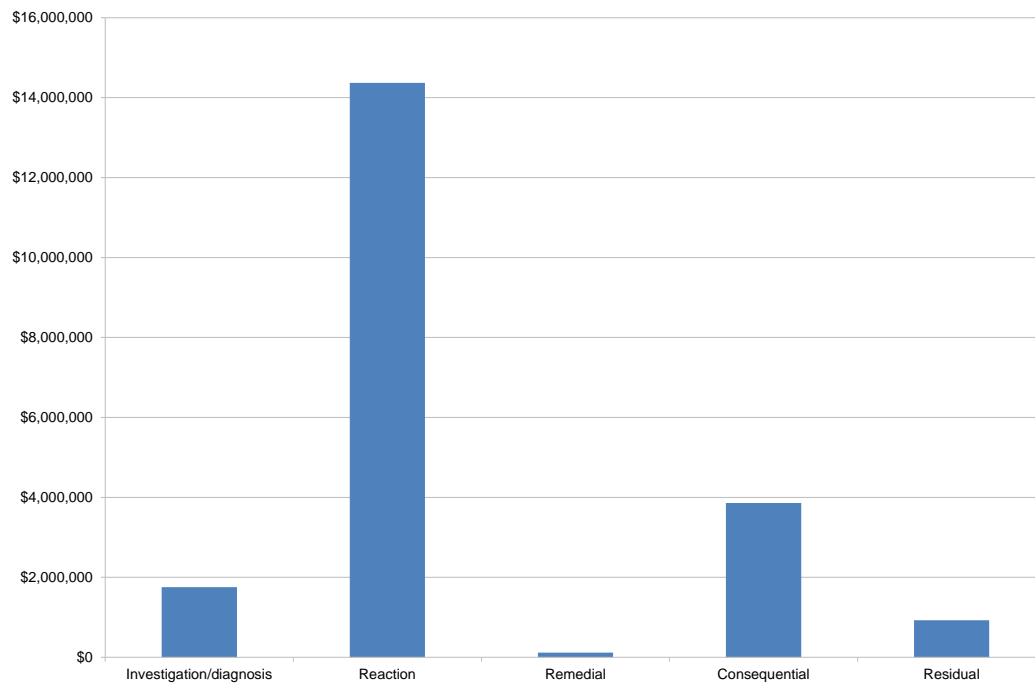
Obviously, not all costs are amenable to quantification and monetisation. For instance, public faith in the quality of water is extremely difficult to measure. There is no doubt that the outbreak caused significant stress and had a 'scarring' impact on residents. The extent to which these effects can be fully captured in an economic analysis is limited. Nevertheless, we are confident that analysis provides a reasonable approximation of the economic costs associated with the outbreak.

1. Introduction

1.1 Purpose of this report

The Ministry of Health commissioned Sapere to estimate the cost of the outbreak of waterborne disease in Havelock North. This outbreak is the subject of a two-stage Commission of Inquiry, which dwells on the cause of the outbreak, the appropriateness of response, and the wider lessons to learn about the safety of New Zealand's drinking water.

1.2 Cost of illness assessment

This report consists of a cost of illness assessment (COI). This method seeks to estimate the burden of illness to individuals and society in terms of the expenditure or resource loss resulting from the illness. We do not provide an economic analysis of possible policy decisions affecting such costs, as would be the case with a cost-benefit analysis, cost effectiveness analysis or cost utility analysis.

For our assignment, we were asked to solely consider costs, and only those costs arising from this specific outbreak. We were not asked to estimate the total burden of campylobacter on the population or to value the benefits of potential improvements to the drinking water supply. The most appropriate analytical method is therefore a COI. However, we did refer to other types of studies for determining how to value specific costs. In particular, we referred to the approach taken in our previous work estimating the costs of the 2012 Darfield waterborne disease outbreak. We found two (co-published) studies that estimated the incidence and cost of food-borne acute gastrointestinal illness (AGI) in New Zealand, as well as a variety of international studies, and drew on these to establish our cost categories and assumptions.[1]

1.3 Structure of the report

The report is organised as follows:

- Our approach to costing this outbreak.
- Understanding the disease.
- The affected population.
- Activity relating to the outbreak, e.g. inpatient and primary care attendances, business activities.
- Estimates of health costs.
- Estimates of non-health related costs.

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[1] Including G. W. Scott et al. (2000) 'Economic cost to New Zealand of food-borne infectious disease', *NZMJ*, 14 July 2000; and Cressey and Lake (2008).

1.4   The event

The water supply is from Hastings and boreholes

Hastings has ten separate water supply systems, but the primary sources are from 32 individual bores/wells that tap into underground aquifers, as well as two springs in the Waimarama area. Havelock North has the two largest reservoirs with a capacity of ten million litres each.[2]

In recent years, the source of Havelock North water is mainly from bores at Brookvale Road, with supplementary capacity offered by a bore at Napier Road, all collectively servicing around 12,000 customers.[3] These bores supply groundwater, which Hastings District Council (HDC) holds consent for bore abstraction under the Resource Management Act 1991.[4] Water from these bores is usually untreated and pumped to the 15 reservoirs in the district for local reticulation.[5]

Largest recorded outbreak in NZ of waterborne disease

Between Friday 12th August 2016 and Monday 29th August 2016, there was a widespread outbreak of gastroenteritis in Havelock North. This was the largest recorded outbreak of waterborne disease in the country. Over the course of the two weeks, daily life was seriously interrupted in the area. Approximately 5,500 individuals were affected ((based on a household survey estimate conducted by the Institute of Environmental Science and Research (ESR)). According to Mayor, Lawrence Yule, the outbreak

> *"caused a lot of grief, ill health, disruption and misery… I've got a community that is facing the biggest challenge it has ever faced."[6]*

Early results indicated faecal contamination of the water supply and an increase in campylobacteriosis. The Inquiry found that it was highly likely the heavy rainfall on 5th and 6th August inundated paddocks neighbouring Brookvale Road, causing contaminated water to flow into a pond about 90 metres from Brookvale Road bore 1. Water in the pond then entered the aquifer and flowed across to Brookvale Road bore 1 where the bore pump drew contaminated water through the bore and into the reticulation system.

Campylobacter has an incubation period of two to five days, up to ten days. Reported symptoms include diarrhoea, flu-like headaches, muscle pain, and fever.

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2   Ministry of Health National Situation Report 4 "Havelock North Gastroenteritis Outbreak", p 1.

3   MWH "Havelock North Water Supply Sources" CB 009 (May 2016).

4   Groundwater supplies are considered secure if it can be demonstrated that contamination by pathogenic organisms is unlikely because the groundwater is not directly affected by surface or climate influences and abstracted from a bore head that provides satisfactory protection.

5   Ministry of Health National Situation Report 4 "Havelock North Gastroenteritis Outbreak", p 2.

6   New Zealand Herald "Gastro outbreak: Havelock North illness NZ's largest" (16th August 2016).

Co-ordinated community and government response

The event triggered a significant co-ordinated response across local and central government, the voluntary sector, and non-government organisations (NGOs). Hastings District Council and the Ministry of Health worked together to co-ordinate public notices and support efforts, with the backing of MoH's National Health Co-ordination Centre and under the governance of Watch Groups co-chaired by the Department of Prime Minister and Cabinet (DPMC). The Red Cross and Civil Defence supported general community outreach activities. The Red Cross, with around 25 of their volunteers, established an emergency hub in Havelock North, which provided information and support to the community as well as to students and school staff.[7] Some activities included providing water tankers to rest homes, schools, and other vulnerable communities.[8]

The Ministry of Primary Industries (MPI), the Ministry of Social Development (MSD), and the Inland Revenue Department (IRD) each worked together to co-ordinate different types of responses. During the event, and by close of play on 26th August, the Ministry of Social Development had received 81 requests for financial support. The Inland Revenue Department also offered support to local businesses affected by the 22nd August tax filing for employers. Some estimates indicated that up to 500 businesses might be affected, with 400 of these likely to be dependent on a single payroll person.[9] Hastings District Council and the government committed $210,000 on 25th August to support business recovery and help bolster the reputation of Havelock North.[10]

Overall, Hawke's Bay District Health Board (HBDHB) has reported expenses of about $766,000, including $330,000 on staff cover and costs, $216,000 on staff sickness, $31,000 on clinical supplies, $18,000 on hydration management, as well as $99,000 in legal expenses.[11]

Single source outbreak curve

Data interpretation by the Ministry of Health and EpiSurv reported information that was consistent with a single outbreak and isolated to the Havelock North area. On 26th August, an EpiSurv survey reported the following outbreak curve:

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[7]   Red Cross "Red Cross helps Havelock North residents hit by gastro illness" (no date).

[8]   Ministry of Health National Situation Report 5 "Havelock North Gastroenteritis Outbreak" p 9.

[9]   Ministry of Health National Situation Report 6 "Havelock North Gastroenteritis Outbreak", p 9.

[10] New Zealand Herald "Council, Govt to give $200,000 for Havelock North businesses" (26th August 2016).

[11] Radio New Zealand "Water contamination crisis cost DHB more than $760k" (28th January 2017).

Figure 2 EpiSurv outbreak curve
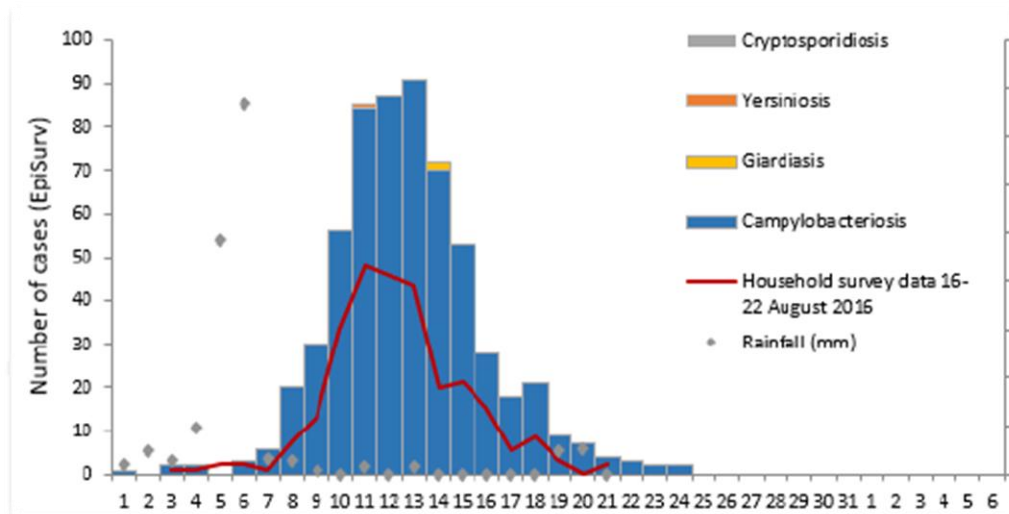
Source: Ministry of Health

As at May 2017, there had been a combined total of 964 confirmed and probable cases of gastroenteritis.

1.4.2   Formal inquiry

On 12th September 2016, as a result of the outbreak, the government announced a formal inquiry into *"the cause of the current contamination in Havelock North, whether relevant parties complied with their obligations, how local and central government agencies responded to the public health situation that occurred as a result of the contamination, and how to prevent future such occurrences."*[12] The terms also asked the Inquiry to consider whether there is potential for similar events to occur elsewhere in New Zealand and to identify key lessons for local and central government agencies.

On 10th May 2017, the Inquiry published its report on the causes and the conduct of those responsible for providing safe drinking water (Stage 1 of the Inquiry)[13].

The Inquiry found that contamination of the Te Mata aquifer, where Havelock North's drinking water was drawn, was the likely source of the campylobacter bacterium that caused the gastrointestinal illness. Prior to the outbreak, the aquifer was believed to be "confined" and therefore secure from contaminants – as such, water drawn from it was not treated. However, the Inquiry found that heavy rain in the week prior to the outbreak is highly likely to have led to contaminated water entering the aquifer via a pond near one of the Brookvale Road bores. Sheep faeces were cited as the likely source of the bacterium.

The report identified a number of parties' failings in carrying out their responsibilities to provide safe drinking water leading up to the outbreak. While these failings did not directly

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[12]   Department of Internal Affairs "Terms of Reference for the Government Inquiry into Havelock North Drinking-Water" LB001 p 1.

[13]   Department of Internal Affairs "Report of the Havelock North Drinking Water Inquiry: Stage 1".

cause the outbreak, the Inquiry concluded that a different outcome might have occurred had they not been present. Among other issues, the Inquiry found that:

- the aquifer was at best "semi-confined" and therefore vulnerable to surface contamination due to disused or uncapped bores near Brookvale Road;

- the District Council failed to meet the high standard of care required for a public drinking-water supplier, including failing to learn lessons from a similar outbreak in July 1998 and underestimating the significance of previous positive E. coli results;

- Drinking-water Assessors (DWAs) provided insufficient liaison with the District Council to report compliance with national Drinking-water Standards, and

- poor working relationships between the Regional and District Councils led to a lack of collaboration and a number of missed opportunities that may have prevented the outbreak.

Stage 2 of the Inquiry, addressing lessons learned and steps to reduce the likelihood of future outbreaks, will report back by December 2017.

1.4.3   Timeline of events

Week One key dates:

- **Friday 5th/Saturday 6th August (prior week)**: Heavy rain in Havelock North.

- **Thursday 11th**: First reports of gastroenteritis. *E. coli* presence detected in routine tests.

- **Friday 12th**: Further test of water supply. DHB notified. Boil water notices issued and water supply chlorination begins. Daily sampling begins.

- **Saturday13th/Sunday 14th**: All test results for Havelock North from Friday 12th returned positive for E. coli. Public notices issued.

- **Monday 15th**: MoH National Health Co-ordination Centre incident management team activated. Watch Group meeting with DPMC.

- **Tuesday 16th**: Second Watch Group meeting. ESR household phone survey undertaken.

- **Thursday 18th**: Third Watch Group meeting. Officials' Committee for Domestic and External Security Coordination (Governance) convenes.[14]

Week Two key dates:

- **Sat 20th**: 4 Hastings sites and one Havelock North site have low level *E. coli* presence, reclassified 'provisionally secure'.

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[14] The primary governance board overseeing New Zealand's national security and resilience, chaired by the Chief Executive of the Department of the Prime Minister and Cabinet.

- **Sunday 21st**: All sites negative for *E. coli*.

- **Monday 22nd**: Fourth Watch Group meeting. DHB transitions to recovery phase. All schools and early childhood centres open. Draft terms of reference for inquiry released.

- **Tuesday 23rd**: MoH Public Health Unit begins to take over DHB work.

- **Wednesday 24th**: Single source outbreak curve confirmed.

- **Thursday 25th**: Hawke's Bay Regional Council advise formal investigation into Havelock North water supply bores.

- **Friday 26th**: Brookvale bores removed from service. Hastings and Havelock North water supplies confirmed free from *E. coli*.

Hastings District Council undertook water tests on Thursday 11th August. Results available on the morning of Friday 12th August showed contamination in the reticulation (but not the bores themselves) of more than 10.0 organisms per 100ml of water. After notifying Hawke's Bay District Health Board, both organisations issued boil water notices by midday that Friday and the staff had begun chlorinating the water supply. Over the weekend, Hawke's Bay DHB and the District Council provided public information and briefings, and continued water sampling and chlorinating.[15]

During the week beginning Monday 15th August, there were three Watch Group meetings held, co-chaired by DPMC, to monitor the situation. On Tuesday 16th, ESR completed the first household phone survey to 250 randomised participants in the Havelock North region. On Thursday 17th, an *E. coli* indicator was found in one of the nine water tankers used to supply Havelock North residents, and officials indicated that it was the likely source of contamination.[16]

By the following weekend, on Saturday 20th, four samples taken from the Hastings water supply reported low-level presence of *E. coli* and were reclassified as 'provisionally secure'. On Sunday 21st, all sites tested negative for *E. coli*.

In the second week of the outbreak, officials began to draft terms of reference for the inquiry into the Havelock North water supply contamination and the Ministry of Health began to take over work that the DHB had been undertaking. By Wednesday 24th, officials were able to confirm that the disease showed a classic single source outbreak curve, which was coming to a conclusion. At this point, Hastings District Council decided to supply Havelock North with drinking water from the Hastings water supply, and the boil water notice and chlorination of Havelock North water supply was to continue.

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[15] Water chlorination is used when the type of contamination is not certain: Ministry of Health, National Situation Report 13, Appendix 3.

[16] Ministry of Health, National Situation Report 6, p 1.

By Friday 26th August, the Brookvale bores were removed from service and the Hawke's Bay Regional Council announced a formal investigation into the Havelock North water supply bores as a source of the contamination.

In November, the Hawke's Bay Regional Council sought legal action against Hastings District Council for resource consent breaches discovered during its investigation. This action was dropped in December and infringement notices were issued to the District Council instead for failure to fully comply with its water take permit.[17]

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[17]   Department of Internal Affairs "Report of the Havelock North Drinking Water Inquiry: Stage 1", p 19.

2.   Our approach to costing

2.1   Summary of our process

The process applied is best described as pragmatic. Rather than employing highly technical or detailed modelling, the work involved a series of (sequential) steps as follows:

- *Gaining understanding* – information seeking and fact-finding through initial desk research, as well as a series of interviews and discussions with business owners and operators.

- *Identifying relevant costs* – constructing a decision framework that clearly categorises costs that are in-scope and those that are not (i.e. establishing attribution guides to isolate only those costs that are attributable to the outbreak and are additional in nature).

- *Data gathering* – requesting and collecting identified costs from stakeholders and collating such costs into a usable and consistent form for storage and analysis.

- *Testing and analysis* – subjecting the data to the 'tests' and guidance developed earlier in the process, as well as some comparative exercises across and within relevant samples.

- *Finalisation* – summing costs and expressing these in dollar value terms across cost types.

2.2   An economic approach to estimating the costs

While we draw from our previous work in Darfield, we focus in this report on economic costs. Economic costs are based on the use of resources and include familiar costs that are out-of-pocket (financial), as well as those costs that do not involve changes to financial expenditure as such. The most relevant of these non-pecuniary costs are transactions and opportunity costs.

Transactions costs are essentially the price paid by parties when looking to make decisions involving exchange of goods or services. In loose terms, transactions costs are the costs of interacting with each other. They are important economically, as they can determine both when and how decisions are made and the resources are allocated. For our purposes, the most important (and relevant) transactions costs are associated with searching for and processing information, as well as co-ordinating response and recovery activities following the outbreak.

Opportunity costs, on the other hand, relate to the foregone chance to use resources that are deployed to the outbreak for other purposes. That is, the economic cost of the outbreak is the value associated with the next best alternative use for resources dedicated to the outbreak. For instance, staff time that is spent on activities associated with the outbreak have an opportunity cost (i.e. they could have been undertaking other activities that they would normally expect to do), even if there is no actual change in salary costs. In the context of fixed budgets and agreed work plans, diverting resources to the outbreak comes at the cost of the ability to perform their 'normal' activities, even when no additional remuneration is involved. The economic cost would be calculated as the going-rate multiplied by the

estimated hours dedicated to outbreak activities (and consequently not dedicated to other work).[18]

While we apply this principle to all of the costs resulting from the outbreak, we note that there are instances where resources used in relation to the outbreak do not have an opportunity cost as such. These are resources whose 'normal' activities relate to events that, by their nature, may or may not happen. Such resources are essentially 'on-call' and their role is to respond to events that are by their nature unforeseeable. For instance, resources contained in Emergency Departments in hospitals do not have a pre-determined workload.

Their "business as usual" situation is reactive, and hence there is no opportunity cost (foregone deployment of resources) when resources are called into action due to an outbreak event. In other words, there is no economic cost of resources used to provide services because of the outbreak. The same situation applies in respect of Healthline resources used as part of the outbreak response. This activity was essentially "business as usual" with resources specifically waiting to respond to events such as outbreaks and therefore not re-deployed from any other activity.

Measurement also includes externalities (i.e. unexpected or unintended costs incurred by parties not directly impacted) to the extent they are identified. Theoretically, the correct metric for impacts of a business interruption nature is gross profit, due to some variable costs being avoided because of business interruption/closure. For this event, it does not appear that many businesses were affected to the point of closure, so turnover was used.

We sought to quantify and monetise costs wherever possible. In some cases, this was not possible and we resorted to alternative ways of measurement, or felt it was not appropriate to quantify the impact at all (e.g. discouraged demand and faith in the quality of water).

2.3   Data gathering

We undertook a total of 41 interviews covering 49 people, both face-to-face and via telephone. The table below shows the composition of the interviews by general industry sector. An outline of the key topic areas/questions posed to businesses (and adapted for other audiences) is contained in Appendix 1.

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[18]   For simplicity, we assume that the value of activity on the outbreak is equal to the value of activity in alternative uses.

Table 2 Interviews by industry sector

Industry sector	Number of interviews (people)
Local Government	3 (5 people)
Central Government	4 (4 people)
Other retail	4 (4 people)
Accommodation	3 (5 people)
Food Services	2 (2 people)
Education and Training	5 (5 people)
Health Care and Social Assistance	13 (15 people)
Other Services	3 (4 people)
NGOs	4 (5 people)
Total	**41 (49 people)**

We requested data from ESR for notifications of campylobacteriosis related to the Havelock North outbreak. This data was provided to the Ministry of Health, where it was linked to the following administrative data sets:

• National Minimum Data Set (NMDS) – public hospital inpatient events.

• National Non-Admitted Patient Collection (NNPAC) – public hospital non-admitted (outpatient) events.

• Community laboratory datamart – medical diagnostic community laboratory tests.

• PHARMHOUSE – subsidised community pharmaceuticals dispensed.

The extracts from the data sets listed above included events for people living in Hawke's Bay, events occurring at Hawke's Bay facilities, or for people included in the notification data. We requested data for the period 1st June to 31st December, for both the year of the outbreak (2016) and the previous year (2015).

Hawke's Bay District Health Board and the local Primary Health Organisation (PHO) provided us with a record of the number of people or contacts with gastroenteritis in general practice, aged residential care, and pharmacies over a three-week period covering the outbreak. This information was manually collected and, although the best estimate available at the time for our assessment, it may not be accurate.

2.4   Categories used in our analyses

We used three broad dimensions in our calculations to attempt to capture specific insights into cost composition by sector, stage, and the nature of costs. The last dimension was

important due to the economic approach taken (i.e. opportunity costs are not always directly observable).

Figure 3 Categories used in our calculations
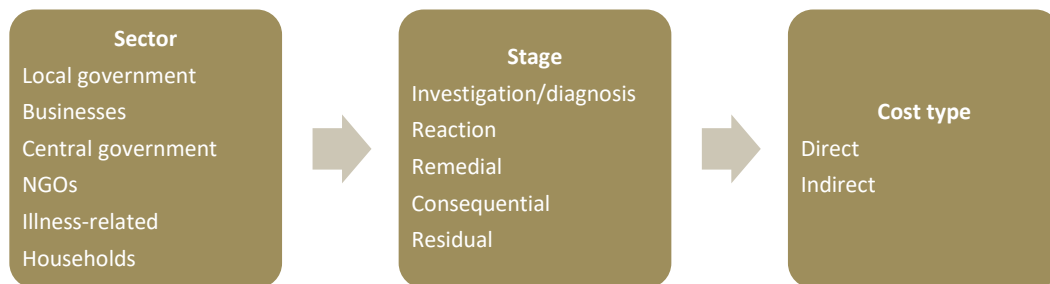
2.4.1   Sectors

We calculated costs across six sectors: local government, business, central government, NGOs, illness-related, and households.

2.4.2   Cost stages

We were interested in establishing the profile of costs over time. Such a profile provides insights into the intensity of costs at different stages (and hence lessons around possible preparatory actions and observations about the relative response performance of parties involved, for future understanding), but also gives a sense of the time-period over which costs are incurred. The various stages used in the analysis were:

•   **Investigation/diagnosis** refers to the sourcing and confirmation of the outbreak (e.g. expert reports, testing, planning and setting up response teams).

•   **Reaction** relates to costs that arose once the contamination was confirmed (e.g. provision of bottled water, communications and information provision and co-ordination costs, welfare teams).

•   **Remedial** covers costs related to actions to 'make right' the water supply (treatment, engineering costs, further testing, etc.).

•   **Consequential** describes costs that arise because of the outbreak (e.g. filtered water stations, safeguards, inquiry related costs).

•   **Residual** are costs that are ongoing such as monitoring, testing, rates rebates, information campaigns, and costs to respond to ongoing inquiries as to the safety of the water.

2.4.3   Cost types – identifying the cost categories

We sought to take a broad approach to identifying types of costs, in order to form as comprehensive an assessment as possible. Based on the literature, we used the following classification as a basis for identifying costs:

- **Direct costs**: those directly attributable to a specific case/patient (although potentially the cost is paid by someone else, e.g. the DHB);
- **Indirect costs**: costs that are not directly attributable to a specific case (instead these are costs of the fact that there is an outbreak);
- **Tangible costs**: those costs that are measurable or otherwise quantifiable (though not necessarily in dollar values), and
- **Intangible costs**: costs that are not straightforward to measure/quantify.

The following table sets out the types of costs we considered. This was used as a framework on which to base our analyses.

Table 3 Costs considered in our assessment

Cost category	Cost type

Direct tangible	• Health costs:
	   – OTC sales of anti-diarrhoeal drugs and oral rehydration products
	   – General practice visits
	   – Community pharmaceutical dispensing (prescriptions)
	   – Public hospital admissions
	   – Public hospital outpatient attendance
	   – Public hospital emergency department attendance
	   – Laboratory tests
	• Lost productivity of patients
	• Lost productivity of carers (non-patients)
	• Missed school days by pupils
	• Transport costs (to GP and hospital)

Direct intangible	• Health outcomes

Indirect tangible	• Costs for authorities dealing with the outbreak
	   – Consulting fees for reviewing the events
	• Costs of the aftermath of the outbreak
	   – Extra time spent by the Public Health Unit (PHU) dealing with the outbreak (above normal hours)
	• Costs of managing water quality during the outbreak
	   – Extra time spent boiling water
	• Costs to local businesses

Indirect intangible	• Loss of faith in water quality

Source: LECG (2010), Scott et al. (2000), Cressey and Lake (2008).

2.5 Decision framework

In order to be as precise as possible, we developed a decision framework to assist in counting only relevant costs. The 'rules' we applied to the cost data we received from stakeholders are set out below.

- *Count only those costs that relate to the outbreak*
  We asked providers of information to apply a "but for" test. In particular, we asked to what extent did costs arise during the relevant period that would not have arisen had the outbreak not occurred (equivalently, what would your financial situation have been but for the outbreak?).

  On the infrastructure and physical costs side, the general rule was to apply an indemnity approach. That is, include only those costs incurred in returning things to the same position materially as immediately prior to the occurrence (as opposed to a replacement cost approach, which would ascribe the cost of new equipment entirely to the outbreak). For example, Councils may face calls to future-proof infrastructure following the outbreak.

There are factors, if present, which would lead to costs being overstated and are therefore excluded from calculations:

- The extent to which replacing infrastructure leaves society in a better position than it was immediately prior to the outbreak;
- costs incurred in replacing the asset that would or should have been incurred regardless of the outbreak (i.e. maintenance that was deferred but only came to light as a result of the outbreak, without actually being caused by the outbreak), and
- where costs to replace assets were effectively bundled with remedial costs as a result of the outbreak for convenience reasons, then such costs would be excluded from our analysis.

If this analysis were repeated in future, the extent to which infrastructure changes have been implemented would fundamentally alter the relevant base case (or status quo) scenario. This would limit the degree to which the analyses could be compared.

- *Take respondents' at their word in the first instance*
  Unless there is clearly identifiable and verifiable evidence to the contrary, interviewees costs as stated by them were taken to be true and accurate. There were two reasons for this stance. The first is efficiency; given available time and resource, it makes sense to rely on readily available information, as opposed to looking to create such information from scratch. The second reason is our purpose – while we were able to request as much documentary proof as possible, our task is not one of compensating for losses and thus the evidential rules are less strict.

- *Only count actual, additional costs*
  Where staff absences are because of the outbreak, only those costs that are incremental will be included. For instance, if a staff member was off sick for two days but nobody else was, and that staff member had sick leave available, then no additional cost was actually incurred by the business (or the staff member). In cases where the staff member did not have adequate sick leave and was forced to take unpaid leave or annual leave, or the employer paid the absence in an *ex gratia* manner, those days/costs are additional

and therefore counted against the outbreak. In all instances, where the business hired additional staff cover for the time other staff were absent, those additional costs are included.

2.6   The calculation of total costs

The key equation underpinning our enquiry is as follows:

$$TC = \alpha_{cs} \sum_{c=1}^{5} \sum_{s=1}^{6} x_{cs}$$

where:

TC = total cost

α = a parameter with value 0%-100% representing the proportion of cost attributable to the outbreak

c = cost type:

> 1= Investigation/diagnosis
>
> 2= Reaction
>
> 3= Remedial
>
> 4= Consequential
>
> 5= Residual

s = sector (either local government, central government, businesses, non-governmental service providers, households and the health system)

χ = (inverse) of costs felt by entities

Our total cost estimate is the sum of observed firm costs indexed by type of cost and sector grouping. There is no explicit time index included, as that is covered implicitly in the cost typology. In particular, the major part of consequential costs relates to the inquiry, while the investigation/diagnosis and reaction cost types relate to the immediate costs and the remedial costs that arise following this. Residual costs are ongoing in nature and could be expected to tail off over time.

3. Understanding the disease

3.1 A common bacterial infection

Campylobacteriosis is a common infectious disease caused by bacteria of the genus campylobacter. It can be contracted by both waterborne and food-borne pathogens, with common transmission mechanisms being consumption of contaminated drinking water, poor hand-washing practices, and ingestion of unpasteurised milk or raw chicken.

Campylobacteriosis continues to be the most commonly notified disease[19] in New Zealand. In 2015, there were 6218 notified cases – a rate of 135.3 per 100,000 population, and comprising 43.5% of all notifications in that year.[20] The campylobacteriosis rate varies throughout the country and from year to year. Hospitalisation status was recorded for 3952 (63.6%) cases, of which 484 (12.2%) were hospitalised.[21]

In 2015, just over one quarter (26.2%) of people with a notification of campylobacteriosis, and who reported exposure to campylobacteriosis risk factors, consumed untreated water.[22]

The number of notified cases is understood to be far lower than the actual number of cases, for reasons we explain below. The total number of 2012 campylobacter infections in the community is conservatively estimated at 53,400 per annum (based on a widely used multiplier of 7.6 times the number of notified cases) or a rate of 1,200 per 100 000 population.[23]

3.2 Most sufferers recover quickly at home...

Most people who become ill with campylobacteriosis get diarrhoea, cramping, abdominal pain, and fever within two to five days after exposure to the organism. The diarrhoea may be bloody and can be accompanied by nausea and vomiting. Recovery usually takes between two and five days, though sometimes up to ten days.

Most people who contract the disease recover at home and do not visit a GP. Around 5% of these cases will treat themselves with over-the-counter anti-diarrhoeal and/or oral rehydration medication.[24]

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[19] New Zealand Notifiable Disease Statistics for 2016.
https://surv.esr.cri.nz/surveillance/annual_diseasetables.php

[20] The Institute of Environmental Science and Research Ltd (2016) *Surveillance Report Notifiable Diseases in New Zealand 2015* (Institute of Environmental Science and Research Ltd: Porirua, New Zealand).

[21] Ibid.

[22] Ibid.

[23] J. G. Wheeler et al. (1999) 'Study of infectious intestinal disease in England: rates in the community, presenting to general practice, and reported to national surveillance,' *BMJ* 1999 (318): 1046-50.

[24] D. Moore et al. (2010*) Cost benefit analysis of raising the quality of New Zealand networked drinking water* (LECG: Wellington, New Zealand).

According to the New Zealand literature, up to a third of people who contract campylobacteriosis will visit a GP.[25] Approximately 31% of these patients may be asked to provide a faecal sample for laboratory testing, with around a 90% compliance rate. Of the tests conducted, around 20% of these will test positive for a pathogen (Lake et al., 2009).

3.3 But some serious complications can sometimes occur

Campylobacteriosis can lead to outcomes that are more serious. New Zealand research estimates that 0.77% of cases lead to hospitalisation. There is also a small chance (0.001%) of fatality.[26]

Campylobacter infection can also result in long-term consequences (sequelae). Some people (approximately 2.86% of cases, with a 95% Confidence Interval of 1.40 – 5.61%) develop reactive arthritis (Keithlin et al, 2014).[27] Reactive arthritis causes joint pain (commonly knees, ankles and toe pain/swelling).

Others may develop a rare disease called Guillain-Barré syndrome (GBS) that affects the nerves of the body beginning several weeks after the diarrheal illness. This occurs when a person's immune system is triggered to attack the body's own nerves, resulting in paralysis that lasts several weeks and usually requires intensive care. Keithlin et al (2014), in their systematic review and meta-analysis, estimated a rate of 0.07% cases of GBS arising from campylobacter infection (95% Confidence Interval of 0.03-0.15%).

Campylobacteriosis, along with all other forms of acute gastrointestinal illness (AGI), is also understood to contribute to irritable bowel syndrome (IBS). Keithlin et al (2014) found a rate of IBS arising from campylobacter infection of 4.01% (95% Confidence Interval of 1.41-10.88%).

In people with compromised immune systems, campylobacter occasionally spreads to the bloodstream and causes a serious life-threatening infection.[28]

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[25]   D. R. Lake (2009) *Acute gastrointestinal illness (AGI) study: final study report* (ESR: Wellington, New Zealand); S. Perera and B. Adlam (2007) *Acute gastrointestinal study: general practice study* (ESR: Wellington, New Zealand); N. King et al. (2007) *Acute gastrointestinal illness study: laboratory survey* (ESR: Wellington, New Zealand); B. Adlam et al. (2009) *Acute gastrointestinal illness (AGI) study: community survey* (ESR: Wellington, New Zealand).

[26]   P. Cressey and R. Lake (2007) Risk ranking: estimates of the burden of food-borne disease for New Zealand (Institute of Environmental Science and Research Ltd: Wellington, New Zealand); P. Cressey and R. Lake (2008) Risk ranking: estimates of the cost of food-borne disease for New Zealand (Institute of Environmental Science and Research Ltd: Wellington, New Zealand).

[27]   J Keithlin et al. (2014) *Systematic review and meta-analysis of the proportion of Campylobacter cases that develop chronic sequelae.* BMC Public Health 14:1203.

[28]   Centres for Disease Control and Prevention.

4.   The affected population

4.1   The setting

Havelock North is a small township in the Hawke's Bay region and is home to around 14,000 people (2016 estimated resident population); although, a wider catchment of 18,870 was presented in an epidemiological report[29]. Hastings District Council is the local territorial authority, and Hawke's Bay Regional Council is the regional authority.

4.1.1   A high portion of the population is elderly…

The community has about 25% of the population in the Havelock North ward who are over the age of 65, based on the 2013 Census. The remainder of the population is spread between school age and mid-30s to late 50s, as shown in Figure 4below.

Figure 4 Havelock North ward demographics
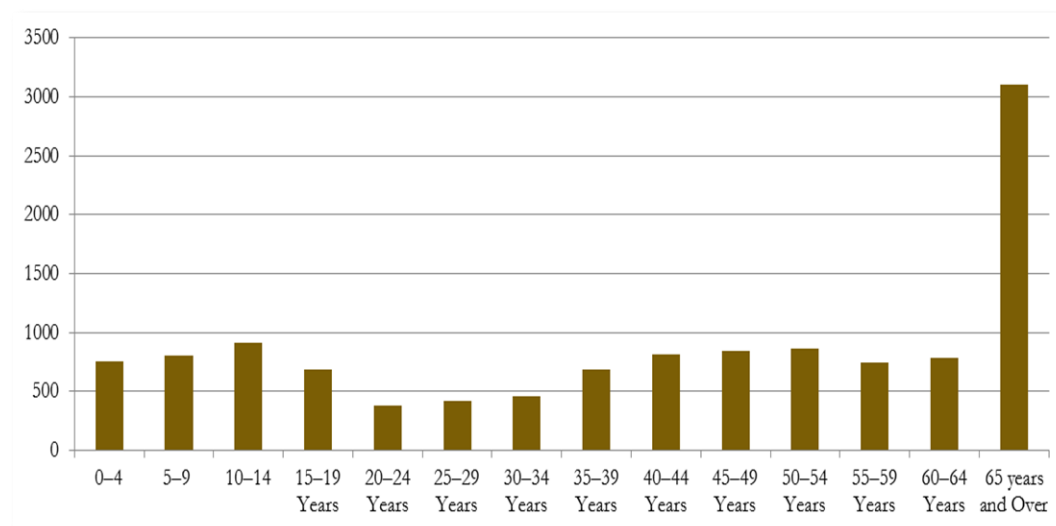
Source: Statistics New Zealand Census 2013

4.1.2   Eight schools and four early childhood centres

Within the Havelock North ward, there are a total of 2,941 enrolled students who attend one of eight schools, those being four primary schools (Havelock North Primary School, Lucknow School, Te Mata School (Havelock North), Hereworth School), one intermediate (Havelock North Intermediate), and three secondary schools (Havelock North High School,

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[29]   ESR Ltd & Hawke's Bay DHB. Havelock North 2016 Waterborne Outbreak Epidemiology Report. 21 February 2017.

Iona College, Woodford House).[30] There are also at least four early childhood centres in the ward area and 42 in the region.[31]

4.1 Case definition for the Havelock North outbreak

The local Public Health Unit (PHU) provided us with the following case definition used for the Havelock North campylobacteriosis outbreak.

Suspected

People who were in Havelock North between 5th and 12th August 2016 and drank reticulated water, who then developed gastroenteritis symptoms (must include diarrhoea) with date of onset on or between 5th August and 6th September 2016.

Probable

Same as a suspected case with gastroenteritis symptoms confirmed by a clinician.

Confirmed

Same as a probable case with laboratory confirmation or Campylobacter species isolated from a clinical specimen.

4.2 Estimating the total number of cases

4.2.1 964 cases notified

The notifiable disease schedule is a list of conditions that require public health investigation or follow up. Notification allows the appropriate public health control measures to be taken to reduce the risk of further spread, as well as for disease surveillance and monitoring of the effectiveness of control measures. The diagnosing medical practitioner is require by Section 74 of the Health Act 1956[32] to report to the Medical Officer of Health any patient they have 'reasonable suspicion' is suffering from a notifiable condition.

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[30] Ministry of Education "Schools Directory" (3 February 2017).

[31] Ministry of Health National Situation Report 1 "Havelock North Gastro Outbreak" (15 August 2016) p 4.

[32] http://www.legislation.govt.nz/act/public/1956/0065/latest/whole.html#DLM307220

Table 4 Notified cases by DHB of patient domicile

Domicile	Number of notifications
Hastings District	905
Napier City	23
Central Hawke's Bay	11
Wairoa District	2
Total Hawke's Bay	**941**
Other District Health Boards	23
Total	**964**

Source: EpiSurv

There were 233 confirmed and 731 probable cases, according to the case definition, notified to the PHU and recorded in ESR's EpiSurv[33] database. The vast majority of cases notified were from the Hawke's Bay (941), with 905 of those from the Hastings District, including Havelock North (Table 4 above). Over a third of notifications were for people aged 65 years and over (Figure 5).

Figure 5 Notified cases by age of patient
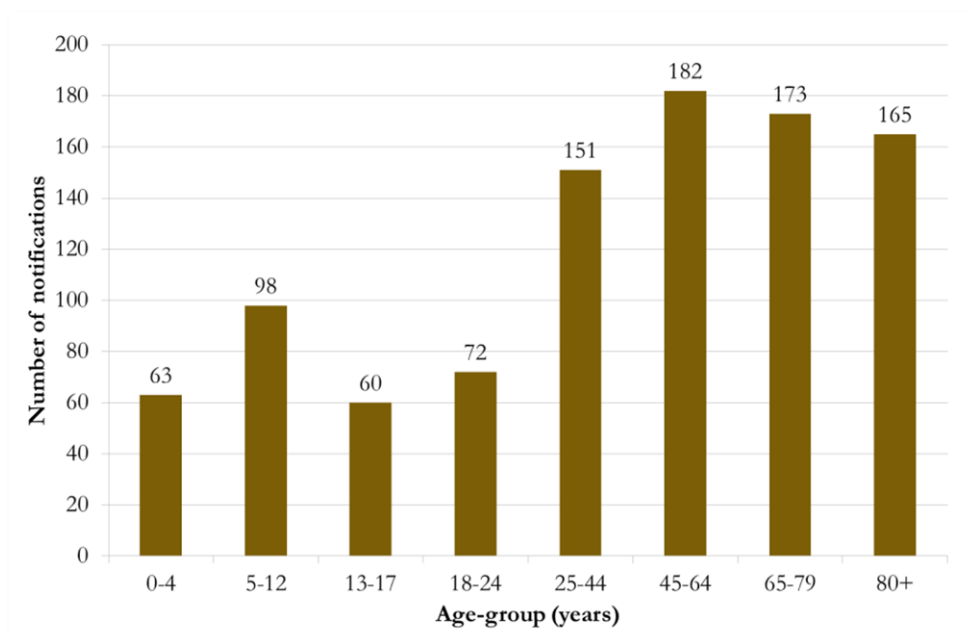
Source: EpiSurv

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[33] EpiSurv collates notifiable disease information on a real-time basis from the Public Health Services (PHS) in New Zealand. Data collected include case demographics, clinical features and risk factors. EpiSurv also incorporates an outbreak functionality that enables cases to be linked via a common cause.

4.2.2 Household surveys estimated 5540 cases

On 16th August 2016, a market research company (UMR Research), on behalf of ESR, conducted a household phone survey of a randomised sample of 250 households in Havelock North. The purpose was to estimate the proportion of households affected and the number of people affected in each household. The same cohort was surveyed again on Thursday 18th August and Monday 22nd August. Households not supplied by the Havelock North water supply were removed from the survey.

A fourth survey was conducted on 27th-28th September to identify if gastroenteritis incidence had returned to baseline levels, measure the impact of the outbreak, and recruit volunteers to participate in a study investigating the long-term effects of the outbreak (reactive arthritis).

Results from the survey estimated that 39% of residents and 56% of households had been affected with symptoms of gastroenteritis. The age-standardised estimate of the number of people affected (as at 22nd August 2016) was 5540 cases, of the estimated 14,118 residents on the Havelock North reticulated supply [34].

4.2.3 We compared this to estimates based on the literature

We consider the household survey to be the best estimate of prevalence among the community; however, there remains some debate as to the size of the affected population. In order to 'sense check' the case numbers from the survey, we compared it to estimates based on various ratios in the literature (referenced in sections 3.1 and 3.2). Presumably, these ratios reflect community prevalence in the absence of a common source outbreak, and there are a number of biases in the data for this particular outbreak. We provide a comment on each estimate in Table 5 below.

Table 5 Estimates of total number of cases

Basis	Measure	Ratio	Value	Estimated cases
Lake et al. 2009, Adlam et al. 2009, Cressey and Lake 2007 and 2008, Kemmeren et al 2006	Number visiting a GP	19.7% - 34/1% of total number of cases	1259 GP consults	3692-6391
			964 notified cases	2827-4893
Lake et al. 2009	Number of positive faecal test results	1.2% of total number of cases	233 confirmed cases	19,417
Wheeler et al. 1999	Number of notified cases	13.2% of total number of cases	964 notified cases	7326
			584 (excluding via investigation)	4438

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34   ESR Ltd & Hawke's Bay DHB. Havelock North 2016 Waterborne Outbreak Epidemiology Report. 21 February 2017.

The first estimate is based on the number of people visiting a GP. We have used both the number of GP gastroenteritis consultations and the number of notified cases to calculate a range of estimated total cases; however, neither is directly comparable to the measure in the literature. The number of consultations during the Havelock North outbreak will be impacted in both directions; people were told to stay away, which may have driven the number downwards. Conversely, the consultations recorded may include more than one consultation for the same person, and the use of telephone consultations by general practices may result in a higher volume than might otherwise be expected.

We have discounted the estimate based on the number of positive faecal test results, as it is substantially higher than the total population of Havelock North. Clearly, laboratory testing patterns during this outbreak were markedly different to the experience in the literature.

The third estimate is based the number of notified cases. We have also used the number of notifications excluding those notified through outbreak investigation, as we assume not all of those identified through public health investigation would have otherwise been notified.

This exercise produces a wide range of case estimates, from a minimum of 2827 to a maximum of 7326, with a mean of 4928. Given the imprecision of these estimates, and the likelihood that the nature of this particular outbreak resulted in case numbers at the higher end of the range, we conclude that the survey estimate is an appropriate one to use for our estimation of costs.

4.3 Campylobacter contributed to three deaths

Four deaths were notified to the Hawke's Bay Medical Officer of Health as being associated with the Havelock North outbreak. All four of these cases had confirmed Campylobacter jejuni infection prior to death, and they all died in rest homes. Dates of death were recorded early in the outbreak on 13th August, with the last on 30th September 2016. Two of the decedents' causes of death were subject to a Coroner's post-mortem investigation and in one of these cases, it was concluded that Campylobacter was not a contributing factor. Of the remaining three decedents, the Coroner has yet to rule on one (but preliminary results indicate that Campylobacter was a contributing factor). Death certificates from the remaining two indicate that Campylobacter, whilst not a main cause of death, was a contributing factor.[35]

4.4 Surveillance for sequelae

There has been surveillance for sequelae and particularly of Guillain-Barré Syndrome and reactive arthritis. Irritable bowel syndrome is not likely to show in the timeframe since the outbreak and there has been no formal surveillance for it.

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[35] ESR Ltd & Hawke's Bay DHB. Havelock North 2016 Waterborne Outbreak Epidemiology Report. 21 February 2017.

4.4.1 Guillain-Barré Syndrome

Three cases of Guillain-Barré Syndrome related to the outbreak were identified. Two mild cases presented to Hawke's Bay DHB neurology ward and a severe case presented at Wairau Hospital in Blenheim. One Hawke's Bay case was a confirmed case, and the other two were probable cases according to the case definition. All cases were discharged from hospital in good condition.[36]

4.4.2 Reactive arthritis

On Tuesday 4th October, a telephone survey was initiated from EpiSurv of confirmed Campylobacter cases, non-notified cases from the household survey, and non-cases from the household. Respondents were asked about musculoskeletal and other symptoms that are associated with reactive arthritis. 266/931 (28.5%) eligible people enrolled. Eighty-two (30.8%) reported one or more symptoms consistent with reactive arthritis, and 73 (89%) of these were available for further interview conducted by a University of Otago rheumatologist to establish a probable diagnosis of reactive arthritis.

Minimum probable reactive arthritis rates were 6.8% in confirmed, 1.6% in non-notified, and 0.5% in non-cases. Adjusting for lost-to-follow-up, maximum probable reactive arthritis rates were 23.2% in confirmed cases, 13.7% in non-notified cases, and 2.1% in non-cases. [37]

The most reliable estimate of reactive arthritis rates resulting from this outbreak is likely to be closer to the minimum[38]. The minimum rates are based on those participants that enrolled in the study and followed through to completion. The sample may have some bias if people experiencing symptoms were more likely to enrol in the study than those without symptoms, leading to higher estimated rates of reactive arthritis.

4.5 Ongoing functional effects on the elderly

Frailty arises from diminishing physiologic reserve; it is characterised by increasing vulnerability to and time of recovery from illness, and results in a progressive dependency toward the end of life.[39] We visited residential care facilities and for reasons unknown, the effect on the residents of these facilities was highly variable – from practically nil to very substantial. The DHB's community based interdisciplinary Older Person's Health Team is aware of a number of community dwelling older people affected by campylobacter who have since become significantly more dependent on community support services or who have required transfer to residential care. Both these scenarios represent potential rapid and significant progression of frailty.[40]

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[36] Ibid.

[37] Ibid.

[38] Tiffany Walker, Medical Epidemiologist, ESR. Personal (telephone) communication 19 June 2017.

[39] Clegg, A., Young, J., Illife, S., Rikkert, M.O., Rockwood, K. Frailty in elderly people. The Lancet 2013; 381(9868):752-762.

[40] Frendin, T. Health Research Council Project Expression of Interest Form – Possible Progression of Frailty – Has the Havelock North campylobacter outbreak accelerated functional decline in affected older people?

Research into the potential effects on function and independence of older people affected by campylobacter during the outbreak is being led by a Hawke's Bay physician/geriatrician. The study will identify affected individuals living in Havelock North residential care or independent accommodation (villas and apartments), detailing progress after infection and measuring changes in baseline Clinical Frailty Scale score. Costs of progression of frailty attributable to campylobacter will be determined from differences (if any) between changes in care provision for affected versus control groups.

4.6   Schools and early childhood education

Most schools and early childhood centres in the ward and some in the wider area were closed. Iona College and Woodford House boarding facilities and three early childcare centres were closed on Monday 15th August, accompanied by seven other schools on Tuesday 16th.

By Thursday 18th, eight early childcare centres were closed. Three schools, Iona College, Woodford House, and Havelock North School, opened on the Thursday while four others, Te Mata School, Lucknow School, Havelock North Intermediate, and Hereworth School remained closed for the entire week. All primary schools remained closed until Monday 22nd.

4.7   The business environment

4.7.1   Industry and employment is centred around commerce and primary and secondary industries

We also want to assess the impact on the productive capacity of the region.

In the general Hawke's Bay area, commercial services make up about a third of the local economy, followed by secondary industry (process manufacturing, utility services and construction) at 22% of regional Gross Domestic Product (GDP), public and community services at 18%, and primary production at 14%.[41] The education sector serves as the largest employer in the district.[42]

In terms of employment, about 60% of working age adults (15 years or older) are employed either full or part time, and about 38% are not in the labour force. Around 2,256 families' source of income is wages, while 975 are self-employed. In line with population distribution, 1,230 couples receive NZ superannuation or the veterans' pension. A minority, 384, receive a form of benefit (sickness, unemployment, domestic purposes).[43]

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[41]   Business Hawke's Bay "Hawke's Bay Region: Economic Monitor to June Quarter 2016", p 8.

[42]   Havelock Business Association "Education & Schooling" (22 February 2017).

[43]   Statistics New Zealand (Census 2013).

As at the 2013 Census, there were 3,048 people employed across 16 industries, for businesses or organisations located in the Havelock North ward. Most people – over a fifth of the labour force – were employed within the Health and Community Services industry. The second most common industry of employment was education, encompassing 17% of the Havelock North labour force.

Percentage of people employed by industry type
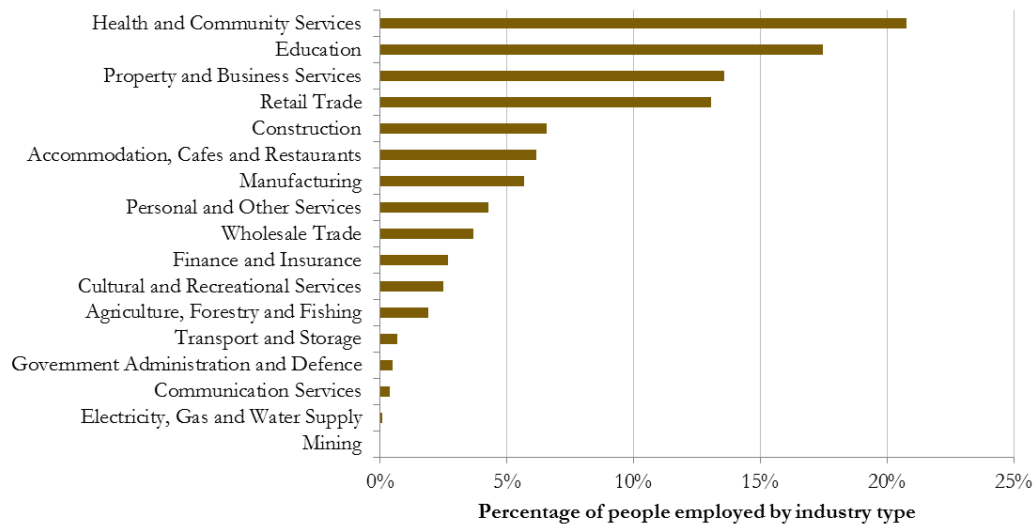
5. Activity relating to the outbreak

5.1 Hospital admissions lower than expected

We expected to identify high levels of activity in the hospital based on the high levels of infection suffered by the population. However, both our data and subsequent interviews with hospital specialists identified this was not so:

- Rheumatology identified there were less than a handful of patients who attended for issues related to the disease outbreak. Of the two moderately affected patients, one did not deem it necessary to return for a follow-up consultation.

- Neurology identified the instances of Guillain-Barré Syndrome set out in 4.4.1, but did not experience the anticipated level of attendances.

- Gastroenterology experienced a small increase in demand, but has not identified patients needing continued intervention.

We received no clinical explanation of the low rate of sequelae. One clinician speculated that the density of infection was a great deal less than from, for instance, an infected chicken. We have no comment on this matter, but reflect the outbreak could have been a great deal worse if sequelae had emerged as we would have anticipated from the literature or if the drinking water supply had been infected by protozoa or bacteria in addition to campylobacter.

5.1.1 Inpatient admissions

We requested data from the National Minimum Data Set for the period preceding the outbreak to the end of December 2016. Notifications related to the outbreak were linked to inpatient events and we limited our review of events to those for the case group, i.e. those patients with a notified case of campylobacteriosis related to the outbreak, according to the case definition.

To estimate the costs of public hospital admissions, we looked at the following ICD-10 diagnosis codes,[44] in order to capture both campylobacter and its sequelae:

- A04.5 Campylobacter Enteritis;
- K58 Irritable Bowel Syndrome;
- M02 Reactive Arthritis, and
- G61.0 Guillain–Barré syndrome.

There were 33 inpatient admissions with a primary diagnosis of campylobacteriosis. Eight of those were Emergency Department events where the patient was treated for more than three hours and discharged home. In one case, the patient was transferred to a rehabilitation ward following their initial stay, which is counted as a second event.

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[44]   ICD-10 International Classification of Diseases Version 10.

There were a further 12 inpatient events where campylobacteriosis was recorded as a secondary diagnosis (one of these also had reactive arthritis as a secondary diagnosis). For most events with campylobacteriosis as a secondary diagnosis, we assumed that the illness would have contributed to the hospital admission and attributed half of the cost of the admission to the outbreak. Primary diagnoses for these inpatient events included:

- Hypotension
- Lower leg cellulitis
- Urine retention
- Delirium on dementia
- Pneumonia
- Urinary tract infection
- Birth by caesarean section
- Colorectal cancer
- Scalp wound

We counted the total cost of one inpatient event with a primary diagnosis of 'maternal infection during pregnancy', and of both rehabilitation events that followed campylobacter related medical admissions.

We did not count the cost of two inpatient events with primary diagnoses of acute myocardial infarction, and transient ischaemic attack, as we considered that campylobacter was likely not a contributing factor to the admission.

In terms of sequelae, there were three people admitted to hospital with a primary diagnosis of Guillain–Barré syndrome. The most severe case was first admitted to Wairau Hospital, transferred over to Wellington and then Christchurch, before being transferred back to Wairau for rehabilitation. The patient in this case spent a total of 25 nights in hospital. Each of the two other cases had two hospital admissions with a short length of stay.

There were two people admitted to hospital with a primary diagnosis of reactive arthritis. Advice from a rheumatologist is that it would be unusual to have a primary diagnosis of reactive arthritis if it was not a new finding. One of these was transferred from the medical service to a rehabilitation ward, had campylobacteriosis as the second diagnosis, and spent a total of 40 nights in hospital. In the second case, campylobacteriosis was not recorded as a secondary diagnosis; however, it was subsequently notified as a probable case with an onset date prior to the reactive arthritis admission.

5.1.2 Emergency Department attendances

Emergency Departments (EDs) are busy services and, in this case, the service reported a minimal impact on the department overall. We used data from the National Non-Admitted Patient Collection (NNPAC), including those events with a Purchase Unit Code for ED attendance. As for inpatient events, we restricted our review to the case group. We then used regression analysis to estimate the number of ED attendances attributable to the outbreak. We estimated a model that controlled for both monthly seasonality and potential differential service use on different days of the week. To this model, we added 'dummy' variables for each week of the outbreak. These dummy variables detect the additional activity owing to the

outbreak over and above what would be expected given the month and day of week. The model was estimated using data from two months prior to the outbreak, to the end of 2016.

For the case group, there was a significantly higher number of ED attendances compared to what would be expected in the absence of an outbreak. Figure 6 shows this effect during week two (Friday 12th to Thursday 18th August). Our regression analysis predicted that 91 ED attendances during this week were attributable to the outbreak.

Figure 6 Actual versus expected ED attendances for the case group
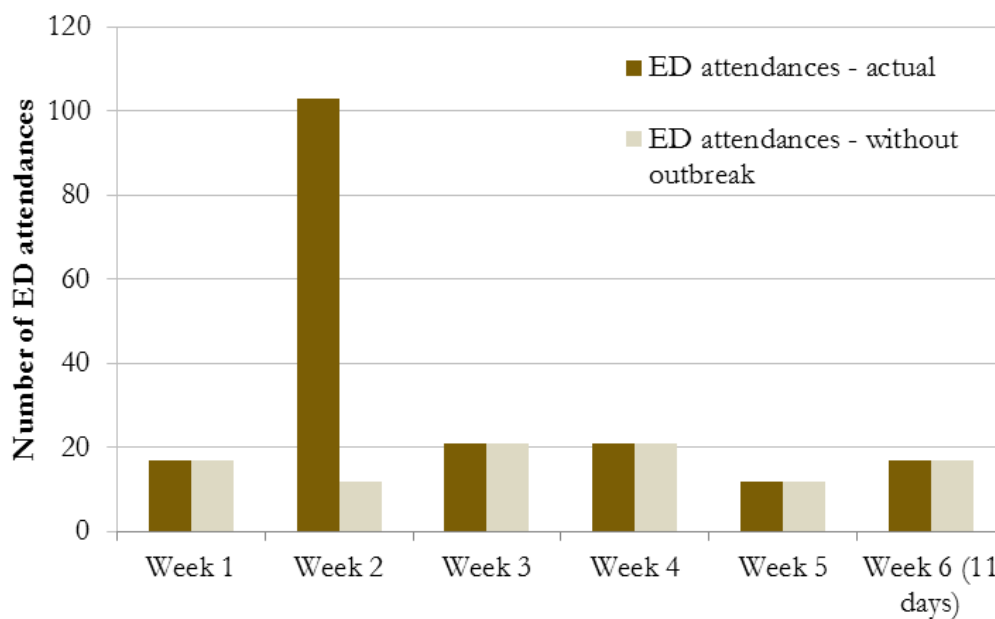
Source: Ministry of Health, Sapere analysis

5.2   A lot of primary care activity

Advice from the local PHO was that due to the extraordinary nature of the situation, consultation data was not necessarily captured in the usual way. Practices were extremely busy with the large volume of calls; many were dealt with via a telephone consultation, with only the more serious cases requiring intravenous rehydration etc., and physically brought into the practice.

During the outbreak period, data on the number of gastroenteritis consultations was manually collected each day for Sitreps. This information was reported by ten general practices in the Havelock North and Hastings area, and then provided to us by the DHB and PHO. It should be noted that, for at least some practices, the data includes only GP and not nurse activity.

Figure 7 Gastroenteritis GP consultations
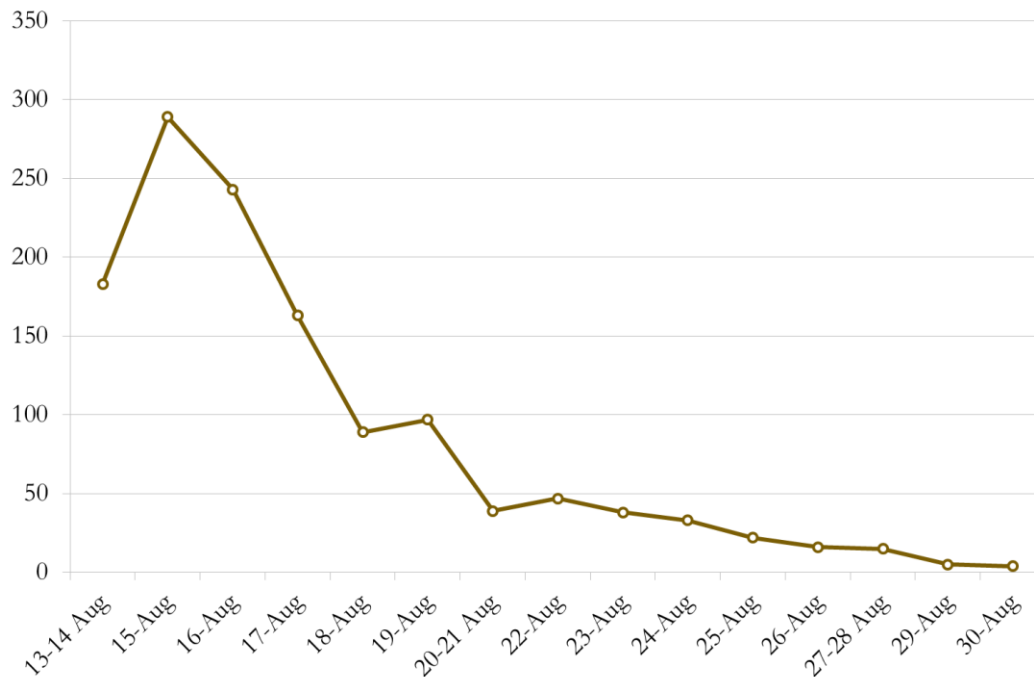
Source: Health Hawke's Bay & Hawke's Bay DHB

Figure 7 shows the greatest number of consultations occurred on the first Monday, 15th August, of the outbreak period (289). Volumes declined rapidly throughout that week, followed by a tail in the second week, and numbers were down to minimal by Tuesday 30th August. The PHO itself was also active during the outbreak period. A staff member was assigned to support each practice, all patients over the age of 80 years were followed up by telephone, and the pharmacy facilitator delivered supplies to pharmacies and practices.

The three pharmacies in Havelock North were busy providing a first-line response in the community. Pharmacies reported a large volume of walk-in patients with gastroenteritis symptoms, and supplied over the counter oral rehydration and anti-diarrhoeal medication. Advice became to stay away from anti-diarrhoeal medication and high glucose products, and the DHB supplied oral rehydration products at no cost to patients.

Healthline also received hundreds of calls from people experiencing gastroenteritis symptoms.

5.3   The scope of business activity affected

Our starting point was the relevant domain of businesses within the affected area, and within that the number likely to be affected. Business Demography data suggests there are 1,512 geographic units (business locations) in the main area of business activity in and around Havelock North.[45]

However, the impact on businesses would not be homogeneous in scale and incidence, and some businesses would not necessarily be affected at all by the outbreak. For instance, there are some businesses where impacts might be direct (e.g. staff illness), but relatively minor and indirect impacts would likely be negligible. Professional services firms and providers of other services where 'consumption' could be deferred, such as automotive repair and hairdressing, are examples of such businesses.

On the other hand, firms in sectors where perishability or synchronous exchange or safety is paramount have far less flexibility. Businesses involved in food handling, accommodation provision, hospitality, and general retail would be susceptible to immediate and noticeable effects due to both direct and indirect impacts. All else equal, the lower the ability to defer, then the higher the likely impact.

Using available public data and insights gleaned from our engagement with stakeholders, we estimated an incidence column for business impacts. It shows that businesses in the Retail and Food and Hospitality sectors accounted for over double the amount of reported impact for all other sectors combined (69% versus 31% respectively). We focus on these sectors for the estimation of costs to businesses.

Figure 8 Stylised incidence column for business impacts

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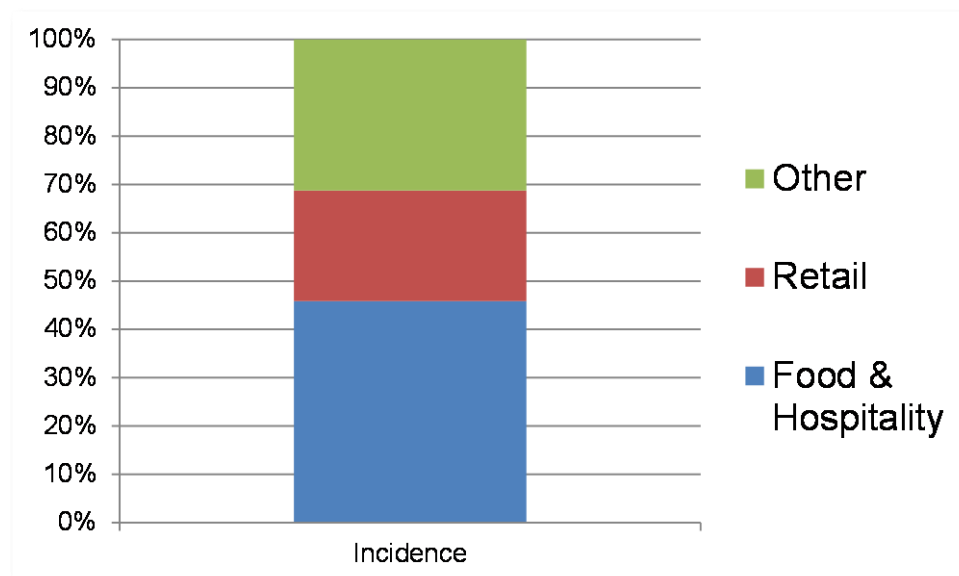
45   The relevant scope comprised businesses located in the Anderson Park, Iona, Havelock Hills, Te Mata, Havelock North Central, and Te Mata Hills area units.

6. Health costs ($2,532,169)

6.1 Havelock North is serviced by local and regional health providers

In terms of healthcare, Hawke's Bay District Health Board funds and provides services for around 161,000 people in the wider area, which includes those who live in the Wairoa, Hastings, Napier City, and Central Hawke's Bay Districts. The local Primary Health Organisation is Health Hawke's Bay. Within Havelock North itself, there are three general practices and 33 in the wider Hawke's Bay area.[46] There are three community pharmacies in Havelock North, and five aged residential care facilities.

6.2 Costs to general practice ($55,090)

While practices could be thought of in general as commercial businesses, they are part of the wider health system and respond specifically to the medically driven effects of the outbreak (as opposed to the lifestyle or welfare-related effects). Therefore, they are captured under the umbrella of health costs.

There are two forms of general practice costs: additional expenditure and reduced revenue. The former relates to extra staffing requirements and out-of-pocket costs, while the latter refers to the decision not to fully charge for consultations and a lower presentation rate for the "usual patient cohort" (including ACC related ailments) during the outbreak.

In respect of the consultations, we estimated the cost to patients through fees charged, as well as to practices through lost revenue where they did not charge. The data provided did not include a breakdown by age, so we applied the age distribution of notified cases to each practice's total volume for the period. We then multiplied the resulting volumes by the advertised fee for each age group and each practice.

The largest practice in Havelock North estimates they charged for around only 10% of consultations, and we have applied this assumption across all relevant practices to estimate the cost to patients versus the cost to practices in terms of revenue foregone.

We estimate the following costs, for **a total estimated cost to general practice of $55,090**:

- the consultation-related cost to patients as $3,485;
- the cost to practices (of lost consultation-related co-payments) as $31,362;
- additional staff costs (to cover overtime and extra staff specifically brought in) provided by practices totalled as $18,443, and
- additional consumable and sundry costs of $1,800.

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[46]   Hawke's Bay Health "Find a family doctor or GP" (22nd February 2017).

We are aware that the Hawke's Bay District Health Board and Health Hawkes Bay (the relevant Primary Health Organisation) agreed to compensate affected practices for the additional costs related to the outbreak. We consider costs to HBDHB elsewhere in this report and to avoid double counting we have netted off their contribution to the compensation of affected practices.[47]

6.3 Cost of hospital activity ($340,229)

6.3.1 Inpatient admission ($337,229)

We used two distinct methods to arrive at our estimate of inpatient admission costs, 1) an activity-based costing approach, and 2) an economic/opportunity costs approach. This is largely for expositional purposes, as the activity-based approach is used routinely in analyses that look to cost inpatient admissions on other settings.

For the activity-based approach, we used the cost weights assigned to each medical admission, and the national case weight price for the 2016/17 year, to derive a total cost for each event[48]. As previously noted, we counted half the cost of events where campylobacteriosis was not the primary diagnosis, but was considered a contributing cause. For rehabilitation episodes following an admission for campylobacteriosis or its sequelae, we applied the 2016/17 bed day price for the relevant purchase unit code.

This activity-based approach results in total estimated inpatient admission costs of $298,963. With that total, the cost of campylobacteriosis admissions was $187,035, the cost of Guillain–Barré syndrome admissions $83,052, and the cost of reactive arthritis admissions $28,876.

However, we apply an economic cost approach in this analysis that focuses on resource use and opportunity costs. This approach uses the additional resource costs identified by the finance team within HBDHB to measure the economic cost. **The cost of inpatient admission to HBDHB is estimated to be $266,426.** This estimate is the sum of actual identified costs associated with outsourced surgery, and additional staff and supplies relating to ICU associated with the outbreak.

Our interpretation is that the outbreak-related admissions consumed some of the resources that would have been used as part of the surgery that was subsequently outsourced. In addition, those admissions required additional resources in ICU and overtime elsewhere.

We note that two of the hospital episodes resulting from the outbreak occurred at hospitals outside the Hawke's Bay, and for patients not living in those local hospitals' areas. In such cases, there are payments between DHBs to reflect the resources used by patients from other DHB jurisdictions. **The total costs associated with such inter-district flows is estimated to be $70,803.**

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[47] Note, we have no data on PHO costs to hand.

[48] Weighted Inlier Equivalent Separations - http://www.health.govt.nz/nz-health-statistics/data-references/weighted-inlier-equivalent-separations

6.3.2 Emergency Department ($3,000)

While we noted the activity levels in the ED earlier in this report, our assessment is that there are no economic costs to ED that should be recorded in the analysis. This reflects not only the modest attendances at ED because of the outbreak, but also the nature of ED is such that there is effectively no opportunity cost associated with activity unless and until full capacity is reached and alternatives must be found. However, we have included identified costs of $3,000 in terms of ED staff overtime during the outbreak period.

6.3.3 No cost to public hospital outpatient attendances

Outpatient attendances were unexpectedly low and there was no economic cost.

6.4 Other HBDHB costs ($510,963)

6.4.1 Support and supplies provided ($51,223)

Clinical supplies and dehydration management products were provided by HBDHB to the wider community (i.e. outside the DHB), which are a direct cost. We also include in this category of costs the district nursing overtime paid because of the outbreak. District nurses provided support to aged residential care facilities in Havelock North. The total associated with such provision is estimated to be $51,223.

6.4.2 HBDHB operating costs ($459,740)

Costs included in this category relate to the general running of the DHB, catering, accommodation, travel, staff surveys, and non-medical staff opportunity costs. The major category of costs in this 'bucket' relates to legal fees, which total over $250,000.

The second largest component of these costs is for staff sick leave. The working assumption used by HBDHB in putting together their estimated costs is that all costs are additional to what might otherwise have been the case. On that basis, we include the full value of the sick leave component identified in our estimates (i.e. the sick leave cost estimated is a fair representation of opportunity cost).[49]

These total costs are estimated to be $459,740.

6.5 Community pharmaceutical dispensing ($3045)

We also sought to estimate the cost of medicines prescribed by GPs and dispensed by community pharmacies. We used community pharmaceutical dispensing data from the

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[49]   We have a query in with the DHB on this.

PHARMHOUSE[50]. This dataset records the dispensing of any drug subsidised by PHARMAC, as well as the 'reimbursement' paid by the DHB and the patient co-payment.

We used regression analysis to estimate the patient co-payments and DHB reimbursement costs attributable to the outbreak. We estimated a model that controlled for both monthly seasonality and potential differential service use on different days of the week. To this model, we added 'dummy' variables for each week of the outbreak. These dummy variables detect the additional activity owing to the outbreak over and above what would be expected given the month and day of week. The model was estimated using data from two months prior to the outbreak, to the end of 2016. We also included the same period for 2015, as there is strong monthly seasonality in the pharmaceutical data and we needed to ensure we correctly attributed change in cost to the outbreak (rather than confounding this change with normal seasonal changes).

For the case group, the total patient co-payments were higher compared to what would be expected in the absence of an outbreak. Figure 9 shows this effect over three weeks during the outbreak (Friday 12th August to Thursday 1st September). Our regression analysis predicted that $3045 of the patient co-payments for this period was attributable to the outbreak.

In terms of pharmaceutical costs to the DHB, our regression model showed no significant difference in actual reimbursement costs compared to what would ordinarily be expected (in the absence of the outbreak). Based on this finding, we assume the additional drugs dispensed during the period were very low cost ones, and therefore covered (at least for the most part) by the co-payments paid by patients.

Figure 9 Actual versus expected pharmaceutical co-payments for the case group
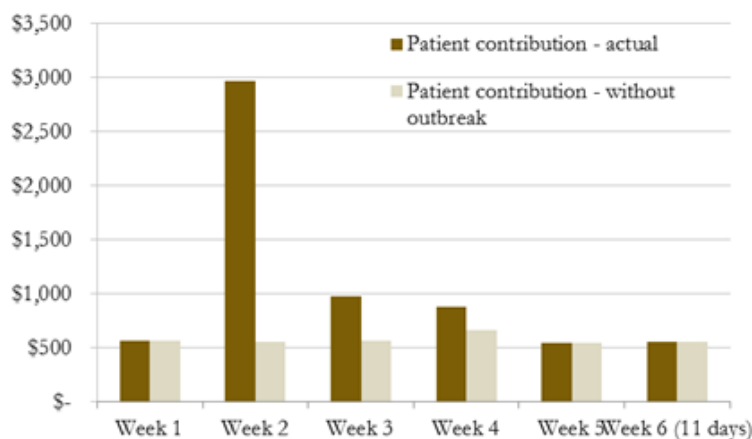
Source: Ministry of Health Pharms datamart, Sapere analysis

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[50]   The PHARMHOUSE warehouse, jointly owned by PHARMAC and the Ministry of Health, contains records of all the claims for schedule subsidised medicines dispensed from community pharmacies within New Zealand.

6.6   Community pharmacy OTC dispensing

Over the counter (OTC) dispensing is, we discovered, minor and immaterial, as the DHB supplied pharmacies so distribution could be free of charge.

6.7   Community laboratory tests ($11,214)

To estimate the costs of additional community laboratory testing, we obtained Community Laboratory testing data from the Laboratory Testing warehouse. This warehouse was originally used for financial purposes and does not contain records of the test results. However, it does provide the date, type, and estimated value of the test.[51]

As for the pharmacy dispensing data, we then used a regression model to estimate the additional test costs attributable to the outbreak. The model was estimated using data from two months prior to the outbreak, to the end of 2016. For the case group, the total value of community laboratory tests was higher compared to what would be expected in the absence of an outbreak. Figure 10 shows this effect over four weeks surrounding the outbreak (Friday 5th August to Thursday 1st September). Our regression analysis predicted that $11,214 of laboratory test costs for this period was attributable to the outbreak. It should be noted that a significant proportion of this was due testing for enteric pathogens, which is not unexpected with acute gastrointestinal symptoms caused by campylobacter.

Figure 10 Actual versus expected community laboratory test value for the case group
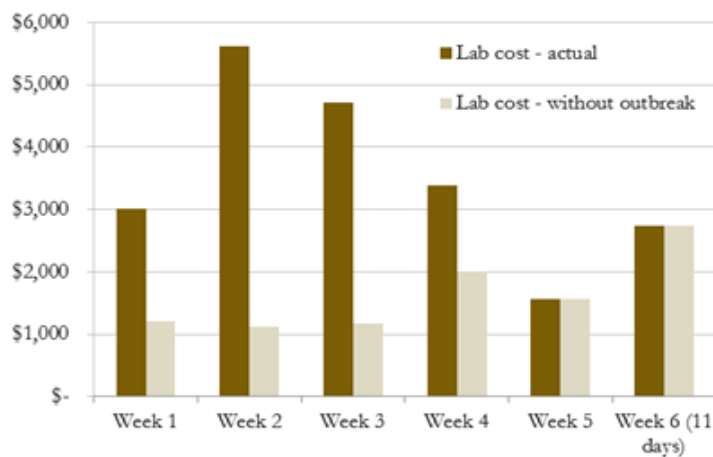
Source: Ministry of Health Labs datamart, Sapere analysis

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[51]   Estimated value of test is used, as many laboratories are funded through bulk-funded contracts.

6.8 Calculating the burden of disease ($1,612,078)

In health economics, outcomes are often expressed as the gain or reduction in quality and length of life, measured by quality adjusted life years (QALYs) or disability adjusted life years (DALYs). QALYs tend to be used to illustrate health benefits; however, to estimate the burden of disease from this outbreak, we calculated the QALYs *lost* and then put a dollar value on this loss. We followed PHARMAC's guidelines[52] to estimate QALYs lost; detail of our method and results are described below.

6.8.1 Non-fatal outcomes

We consider the quality of life loss from this outbreak in three categories:

- Acute gastroenteritis (from campylobacter) at three levels of severity
- Guillain-Barré Syndrome at different levels of severity
- Reactive Arthritis at different levels of severity

Estimated case numbers for acute gastroenteritis were derived from EpiSurv notifications and household survey estimates. Cases of Guillian-Barré Syndrome were identified through surveillance for sequelae and hospital inpatient data. For reactive arthritis, we have applied the minimum probable rates from the surveillance survey to number of notified cases and non-notified cases from the household survey. We identified two cases of reactive arthritis in the hospital inpatient data and have included the remainder of estimated cases to the least severe category.

PHARMAC recommends the New Zealand EQ-5D Tariff 2 should be referred to first when measuring health-related quality of life and should be used to describe the health states. We were unable to identify EQ-5D (3 level) values for the health states used in our analysis. To estimate quality of life lost from non-fatal outcomes, we drew upon work by Cressey and Lake (2007, 2009, 2014)[53] estimating the burden of foodborne disease in New Zealand. In the more recent publications from this body of work, they used updated disability weights from the Netherlands (Haagsma et al., 2008[54]) determined using a Time Trade-Off (TTO) method. We reviewed these, but consider the weights for acute gastroenteritis to be higher than what would be expected, and out of line with the Global Burden of Disease study

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[52] PHARMAC. Prescription for Pharmacoeconomic Analysis (PFPA) version 2.2 2015. https://www.pharmac.govt.nz/assets/pfpa-2-2.pdf

[53] Cressey, P. & Lake, R. 2014. Risk ranking: updated estimates of the burden of foodborne disease for New Zealand in 2013. Institute of Environmental Science & Research Limited: Christchurch.

[54] Haagsma JA et al. 2008. Disability adjusted life years and minimal disease: Application of a preference-based relevance criterion to rank enteric pathogens. Population Health Metrics; 7(7): doi:10.1186/1487-7954-6-7.

weights[55]. For this reason, we revert to the earlier acute gastroenteritis weights from the Netherlands (Kemmeren et al., 2006[56]) previously used by Cressey and Lake.

Table 6 sets out the health states, estimated number of cases in each category, the assumed duration and weight, and resulting QALY loss in each category.

The total quality of life loss from this outbreak is estimated to be 16.96 QALYs. Over half of the QALY loss is related to acute gastroenteritis at the intermediate level of severity.

Table 6 Estimated Quality Adjusted Life Years

Health state	Duration	QALY loss	Cases	Total QALYs
Acute gastroenteritis – do not visit a GP and recover*	3.48 days	0.0006	4576	2.92
Acute gastroenteritis – visit a GP and recover*	9.72 days	0.0105	923	9.66
Acute gastroenteritis – hospitalised and recover*	14.39 days	0.0155	41	0.64
Guillain-Barre Syndrome – mild#	1 year	0.035	2	0.07
Guillain-Barre Syndrome – severe (age>50 years)##	1 year	0.144	1	0.14
Reactive arthritis – no GP visit	6 weeks	0.023	137	3.15
Reactive arthritis – hospitalised	6 months	0.186	2	0.37
Total QALYs lost (from non-fatal outcomes)				**16.96**

*Kemmeren et al., 2006.

#(Mangen et al., 2004[57]) mild GBS first year, scaled using novel disability weights for F1 and F2 health states from (Haagsma et al., 2008).

##(Mangen et al., 2004) Severe GBS first year for cases >50 yrs, scaled using novel disability weights for F3-F5 health states from Haagsma et al., 2008).

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[55] Global health Data Exchange, Global burden of disease study 2015 (GBD 2015) Disability Weights. http://ghdx.healthdata.org/record/global-burden-disease-study-2015-gbd-2015-disability-weights

[56] Kemmeren J, Mangen M-J, van Duynhoven YT, Havelaar A. 2006. Priority setting of foodborne pathogens. 330080001/2006. Bilthoven, the Netherlands: National Institute for Public Health and the Environment (RIVM).

[57] Mangen M-JJ, Havelaar AH, De Wit GA. 2004. Campylobacteriosis and sequelae in the Netherlands. Estimating the disease burden and the cost-of-illness. RIVM Report 250911004/2004. Bilthoven, The Netherlands: National Institute for Public Health and the Environment (RIVM).

6.8.2 Fatal outcomes

There were three deaths related to this outbreak, all occurring in older people aged in their late eighties and early nineties. Cressey and Lake (2014) noted that other New Zealand studies estimating the burden of foodborne illness had only included fatalities where the microbial disease was the cause of death, rather than a comorbid factor. However, as most of these fatalities involve the very old and comorbidity is very common in this age group, they did not apply this cause of death criterion. We adopt the same approach here.

We calculated the years of remaining life expectancy at death for each case, using male and female period life tables for 2012-2014 from Statistics New Zealand, and discounting by 3.5% in line with PHARMAC practice. **This results in a loss of 12.51 years**.

6.8.3 Value of QALY loss

The total QALY loss from both fatal and non-fatal outcomes above is **29.47 QALYs**, i.e. a loss of 16.96 from reduced quality of life and 12.51 from fatal outcomes.

To value this loss, we used the dollar value per QALY from The Treasury's Cost Benefit Analysis (CBAx) Tool[58] ($54,707). This represents the average amount invested by PHARMAC to achieve a gain of one QALY in 2012, adjusted for inflation to 2017. We multiplied the QALYs lost by this amount to estimate the cost burden set out in Table 7.

The total value of QALYs lost due to the outbreak is estimated to be $1.6 million.

Table 7 Value of QALYs lost

Health state	QALY	$
Acute gastroenteritis	13.22	723,123
Guillain-Barré Syndrome	0.21	11,707
Reactive arthritis	3.52	192,732
Total non-fatal	**16.96**	**927,562**
Deaths	12.51	684,517
Total	**29.47**	**1,612,078**

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[58] http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/cbax

7. Non-health-related cost impacts ($18,496,669)

The consequences of the outbreak also affect both commercial and non-commercial organisations. In the case of commercial businesses, the impacts are likely to be:

- *Loss of revenue* – closure, cancellation of bookings, reduced volumes of demand.
- *Loss of productivity* – shorter shifts, staff distractions, staff absences.
- *Damage to equipment* – at commencement and because of alternatives.
- *Increased costs associated with operations* – even where activities were not interrupted, it simply costs more and takes longer to get things done in an environment without permanently available safe, *in situ*, water supply. This includes information gathering and distribution while the outbreak is underway.
- *Consequential effects* – for example, the extent to which visitors are bringing their own water or continuing to drink bottled water, discouraged demand, and any expenditure to mitigate effects of and from the outbreak.

In the case of non-commercial entities such as government agencies, non-governmental service providers, and volunteer organisations, relevant impacts were:

- Time costs associated with staff who were assigned to the outbreak (i.e. the extent to which they were taken away from their normal/day-to-day activities). We sought information on both the total volume of hours spent on outbreak-related activities and the best approximation of the relevant hourly rate.. We are particularly interested in whether any backfilling costs were incurred (i.e. where additional staff were required to perform the roles of staff dedicated to the outbreak).
- Out-of-pocket costs for any travel, accommodation, consumables, information provision etc.

Before outlining the cost estimates (and their basis), a number of points that limit the nature and scale of information that can be reported should be noted:

- *Confidentiality* – participants were assured that not only would comments not be ascribed to any particular person or organisation, but also that commercial sensitivity would be maintained. This is especially important in the context of sectors where there are relatively few competitors.

  The consequence of this limitation is that cost estimates are highly aggregated.

- *Observability* – while every effort was made to capture and verify as much information as possible, it is likely that a number of costs remain unseen either because the scale or incidence of costs were not in the immediate consciousness of interviewees or they were thought of, but seen as just part of "pitching in".

  The consequence of this visibility limitation is that cost estimates may be understated (i.e. actual costs may be higher than those estimated). While this is a risk for most studies of this type, in the case of unusual events that involve a high degree of implicit or indirect impact the risk may be more acute.

- *Verifiability* – for many of the costs (e.g. staff time), either systems do not exist to accurately capture all of the time costs or the time was simply not recorded, as that time was not being paid, or else through oversight or because timekeeping was a low priority activity in the midst of the event.

7.1 Household costs ($12,420,257)

In addition to health-related and business costs, the outbreak also imposed costs on households in terms of their ability to go about their 'normal' activities in life. That is, due to the unavailability of a safe, secure source of water for use around the house an impost was placed on households.

7.1.1 Inconvenience used as main cost measure

The main source of costs to households was inconvenience. Household use of water and the extent to which day-to-day living was impacted are described as follows:

- *Nutrition* – hygienic preparation of food, the cooking process, and the ability to keep dishes cleaned/free of disease.
- *Laundry* – regular washing of clothes, linens and towels.
- *Hygiene* – both personal hygiene (showering/bathing) and household hygiene (toilet flushing).
- *General cleaning* – internal surfaces.
- *Transport and time costs of accessing replacement water supplies.*
- *Stress and other mental health factors.*

In addition, household members may have become ill themselves or were required to stay at home to look after children who either get sick as a result of the water contamination or who are unable to go to school or day-care due to those organisations being closed. Thus, the total costs of inconvenience experienced by households relate to time away from normal activities and the "hassle" involved in either boiling water or sourcing bottled water.

Ideally, we would estimate costs in the respective categories through a survey of residents (e.g. a time and motion study). However, the confines of the budget and time available for this work do not allow for such an undertaking.

Fortunately, the ESR-commissioned survey mentioned in section 4.2.2 included questions from which we can derive estimates of inconvenience. The relevant questions relate to the time households spent off normal activities and the time spent on obtaining alternative sources of potable water, either by boiling or purchasing bottled water. We apply the survey-based findings to the total population of households in the study, which is 5,088 according to 2013 Census data for the relevant area units.[59]

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[59] The area units used in the household analysis are Anderson Park, Iona, Havelock Hills, Te Mata, Havelock North Central and Te Mata Hills.

In addition to the time costs associated with inconvenience, we include direct financial costs to households who purchased bottled water during the outbreak.

7.1.2   Descriptive statistics

Table 8 shows that the relevant sample of the population of households used in our analysis was 169 and that three people on average resided in the household. The vast majority (89%) of the surveyed households boiled water. In addition, just over two-thirds of households purchased bottled water due to the outbreak. Around 44% of households in the survey had at least one person in the household who took time off from their normal activities (e.g. work, school, other study).

Table 8 Household sample characteristics

Measure	Number	Proportion
Households surveyed	169	
Average number of people per household	3	
Households who boiled water due to outbreak	151	89%
Households who bought bottled water due to outbreak	113	67%
Households who had time off normal activity due to outbreak	75	44%

Source: ESR (2017)

The relevant time-period in this section refers to the interval between the time households started and finished using boiled water for drinking because of the outbreak. This period differs slightly among households, and is mostly contained between 12th August 2016 and 15th September 2016. The end date for this period is later than the lifting of the boil water notice on 3rd September 2016, reflecting the fact that some households continued to boil water and/or source bottled water until they felt comfortable themselves to discontinue the practice. For households that did not know or did not indicate when they stopped boiling water, the end date of 15th September was assumed.

7.1.3   Determining value

Establishing the cost of inconvenience involved two steps:

• The first step is calculating the time spent boiling water, sourcing alternative drinkable water sources or taking time off normal activities.

• The second step is to determine the value of the time spent on those activities.

We take a "cost of leisure" approach. In our view, the inconvenience cost due to forfeited leisure is best proxied by the minimum wage ($15.25 per hour at the time), given that partaking in leisure activities implies giving up the opportunity to earn at least the minimum income. We acknowledge that for those who were in paid employment, the value of time from not being able to carry out job activities is foregone income at the prevailing wage rate. However, our data does not allow us to estimate sufficiently the proportion of people who were in work and the rate at which they are paid. Furthermore, our interviews with

businesses suggested that the majority of workers who took time off had adequate sick leave available to cover that time.

Time spent away from normal activities

We separated the 75 households in the survey who had time away from normal activities into those with young people (i.e. people under 14) and those who did not. We also calculated the average time away from normal activities for the two groups of households and multiplied by the relevant number of households to estimate the total time away from normal activities for all relevant households. We then multiplied the total time across relevant households by the hourly minimum wage. **The total costs to households relating to time away from normal activities is estimated to be $7,419,595** for the population of households included in the study (see Table 9). This equates to an average of around $3,286 per affected household.

Table 9 Costs of time spent away from normal activities

	Households with young people		Households without young people	
	Survey	**Population**	**Survey**	**Population**
Proportion of households	51%		49%	
Number of households	38	1,144	37	1,114
Average time away from normal activities (days)	9.81[60]		8.12	
Average time away from normal activities (hours)	235.52		194.88	
Total time away for all relevant households (hours)	8,950	269,446	7,211	217,085
Hourly rate	$15.25		$15.25	
Costs	$136,484	$4,109,052	$109,961	$3,310,543

7.1.4   Direct and time costs

We estimate two elements of direct costs faced by households: the cost of buying bottled water, and the cost associated with ambulance transport and care.

In estimating the time spent securing bottled water, we made the following assumptions:

- During the outbreak period (which differs among households, but is mostly contained between 12th August and 15th September 2016), a trip was made every day to buy bottled water.

- The duration of each trip was of 30 minutes.

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[60]   This total includes both the young people who had time off normal activities and the same amount of time assumed to be taken by adults in a care role.

Based on the above, we estimate that on average, each household spent the equivalent of 0.52 days (around 12.38 hours) securing bottled water. We applied this figure to the population of households who bought bottled water (3,402 households), which resulted in a total of 42,105 hours. We then multiplied this figure by the hourly rate of $15.25 to come up with an estimate of total costs associated with securing bottled water of $642,100, an average of around $189 per household.

To estimate the direct financial costs of buying bottled water, we assume that households who bought bottled water would spend $10 a day doing so.[61] On average, households who bought bottled water did so for 25 days. **For the estimated 3,402 households who bought bottled water, the total direct costs of doing so was $861,988.**

In relation to costs associated with ambulance transport and care, we understand from interviewing the Acting Operations Manager for St John at the time that the **additional costs of vehicles provided during the outbreak was approximately $7,000**. These costs were recovered fully through charges and are thus included under the household category.

7.1.5   Additional time spent boiling water

We assumed that each household spent an additional 1.5 hours a day on boiling water because of the outbreak (i.e. half an hour three times a day on average). Almost all households (89%) indicated that they specifically started to boil water due to the outbreak, which we take to mean that households spent extra time on boiling water as a result, even if they were in the habit of boiling water prior to the outbreak. Our estimates relate to this *additional* time specifically.

We estimate that the additional time spent on boiling water during the outbreak period applied in this analysis was 2.10 days (50.34 hours) per household. The relevant number of households in the study population is 4,546, meaning the total time spent boiling water across households was estimated as 228,825 hours. We then multiplied this figure by the hourly rate of $15.25 to come up with **an estimate of total costs associated with boiling water of $3,489,574**, an average of around $768 per household.

Summing across the three categories of 1) inconvenience cost, 2) the direct financial cost of ambulance transport and care, as well as 3) buying bottled water, we estimate total household costs of $12,420,257.

7.2   Local government costs ($4,133,080)

The Hawke's Bay Regional Council (under the Resource Management Act 1991) and the Hastings District Council (under the Health Act 1956) have responsibilities around the safety and security of drinking water. This report is not the place for a detailed treatment of those responsibilities; however, it is clear that such responsibilities are a key driver of costs incurred due to the outbreak.

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[61]   While this may seem conservative, we are also mindful that bottled water was provided by Hastings District Council and others at times during the outbreak.

Using data sourced directly from the two Councils, we estimate costs to date total just over $4.1 million (with approximately half the costs relating to the Government Inquiry). The vast majority (79% or around $3.3 million) of these costs are direct in nature (i.e. actual expenditure). Indirect costs relating to staff time total around $0.9 million. Figure 11 shows the profile of costs by stage. Most of the costs were incurred after the outbreak had been remedied (i.e. in the consequential stage costs were almost $1.7 million). These costs relate primarily to the inquiry and involve both external legal fees and internal staff time costs.

Considerable internal and external costs (i.e. over $1.9 million) were incurred in terms of testing, sourcing, and other investigative activities relating to the outbreak. Residual costs (at $0.63 million up to 31st March 2017) relate to chlorination and testing of the water supply and ongoing water quality monitoring.

Of further import is the ongoing and changing landscape around the supply of drinking water. Interviews have revealed that the inquiry process had a significant effect on activities undertaken. For instance, the testing regime was both widened (to include tests for contaminants that were not previously tested for) and deepened (i.e. more frequent testing). To the extent that this testing regime is the 'new normal', then establishing additionality becomes much more difficult.

Our approach was to estimate costs relative to the situation where the outbreak did not occur and as a result count all costs accordingly. In future, the relative base case or counterfactual may be different (i.e. existing or status quo costs are automatically higher) and the actual/additional costs imposed will need to be measured against that backdrop.

Figure 11 Profile of Local Government Costs
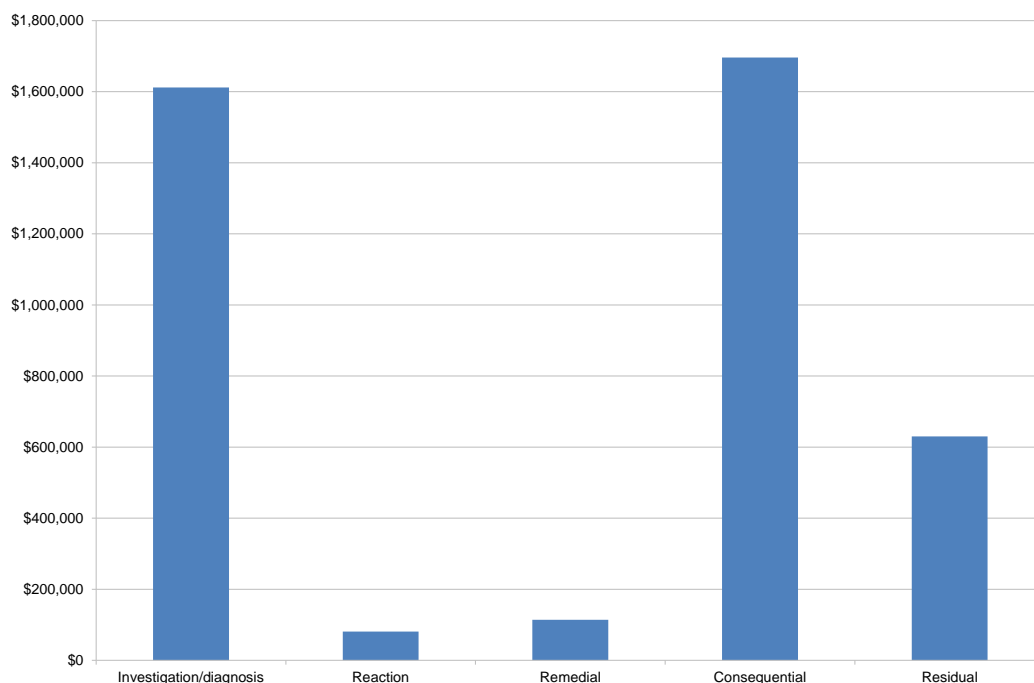
7.3 Central government costs ($506,576)

A range of central government agencies were involved in and responded to the outbreak. The agencies identified as having some relevance to the study are shown below.

Table 10 Government agencies' involvement

Agency	Involvement
Ministry for Primary Industries (MPI)	Supply of information and support around food safety, liaison with Horticulture businesses who may have been processing produce during the outbreak, participation in watch group meetings.
Ministry of Social Development (MSD)	Provision of support/welfare to affected residents.
Ministry for the Environment (MFE)	Oversight of drinking water standards, participation in watch group meetings while outbreak underway and subsequently the inquiry, commissioning external expert advice.
Inland Revenue Department (IRD)	Provision of tax relief to affected organisations and individuals.
Ministry of Health (MOH)	Staff participation and support across range of areas (e.g. Public Health, Communicable Disease), commissioning of expert advice and guidance.
Ministry of Education (MOE)	Reimbursement of additional staffing costs to schools and kindergartens.[62]

In total, we estimate central government costs of just over $0.5 million. Figure 12 shows the profile of costs by stage. Like the local government cost profile, the major stage where costs were incurred was post-event (i.e. inquiry-related costs for expert reports and legal advice dominate). Central government resources were mobilised in the 'reaction' stage in the form of welfare and support to community residents, as well as the provision of compensation for additional costs of service provision (i.e. Ministry of Education costs for relieving staff). The Ministry of Health accounts for almost 60% of the total estimated costs, with the largest single cost stage being for investigation/diagnosis (i.e. testing).

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[62] Note that reimbursement costs to kindergartens are not yet known and thus not included at this stage.

Figure 12 Central Government cost profile
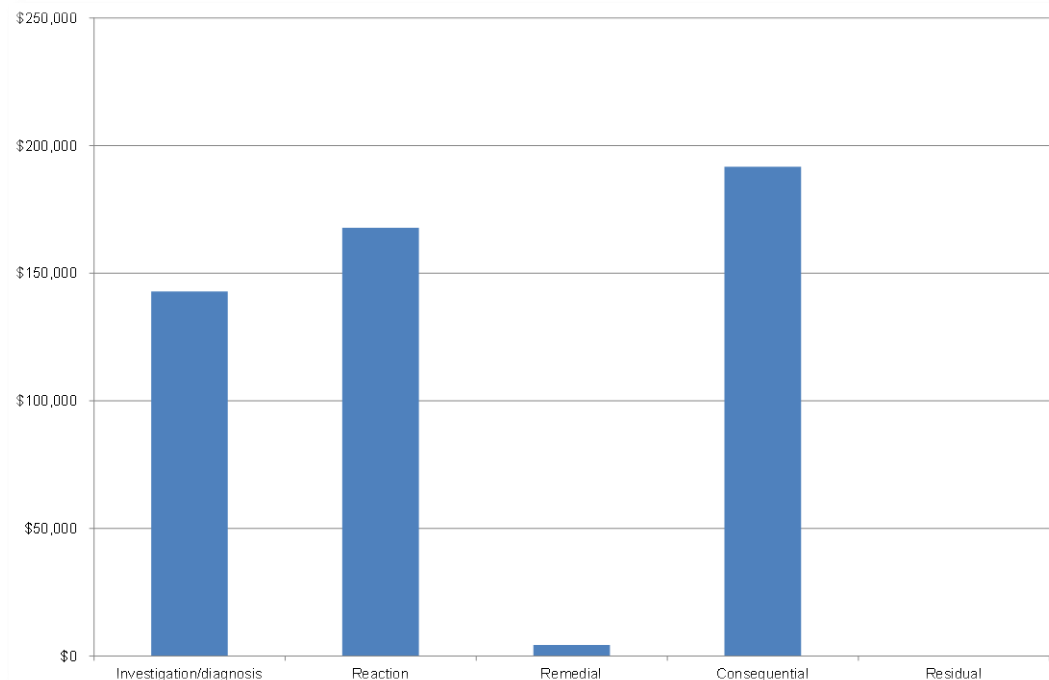
We were unable to speak to anyone from the IRD or MSD. In the case of MSD, we relied on a news report claiming that almost $17,000 in Civil Defence payments were made to cover cost of food, water, medical bills, and loss of income.[63] Given the possibility of some of these costs being counted elsewhere in the analysis, we reduced the direct costs incurred by MSD by half. In terms of indirect (staff) costs, we proxied possible costs by applying the same basic commitment of volunteers from the Red Cross and multiplied the total time volume of support provided (1658 hours) by the average wage of $29.75 and used the direct costs associated with travel, accommodation, etc. that Red Cross identified. In the case of IRD, we were unable to determine an appropriate basis from which to derive cost estimates, so have not included any costs for IRD.

7.4   Non-governmental costs ($134,577)

The non-governmental organisations (NGOs) that provided services because of the outbreak are summarised below (see Table 11).

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[63]   http://www.radionz.co.nz/news/national/313017/thousands-in-grants-paid-to-havelock-north-residents

Table 11 NGO Involvement

Organisation	Involvement
Red Cross	Provision of welfare support to affected residents.
New Zealand Fire Service	Involvement in watch group, and continuity of fire service availability.
Healthline	On-call health advice over the phone.
St John	Gastro-related transport and care initially. Some further involvement in control/operations centre.
Institute of Environmental Science and Research (ESR)	Health Intelligence (Surveillance, epidemiological analysis, informatics). Labs (testing water samples, clinical isolates and genomic typing of isolates). Investigation coordination (cross ESR collaboration with Public Health Unit of Ministry of Health to collate and interpret epidemiological information).

While the Institute of Environmental Science and Research (ESR) is a Crown Research Institute, it is not a part of the core public service (i.e. there is some distance between the organisation and Ministers) and hence is included here rather than under central government agencies.

Further, the treatment of ESR costs highlights the need to factor in the possibility of double counting, as discussed earlier. ESR undertakes a mix of 'public good' and commercial work.[64] For the purposes of this study, ESR undertook work based on an existing agreement with the Ministry of Health, as well as being commissioned to undertake testing and the like on a commercial basis for both the Hawke's Bay Regional Council and the Hastings District Council. Both sets of activities meant that ESR used resources that could have been deployed elsewhere. In total, just over 2,700 hours were spent by a range of ESR staff on the outbreak investigation and subsequent inquiry.

Therefore, there is an economic cost of ESR's involvement. However, the costs are not necessarily to ESR (as they receive revenue from the agencies with and for whom they work). The assumption we have used is that the opportunity cost of the resources ESR devoted to the outbreak are reflected in the 'prices' they receive for those resources. The 'price' for a commercial piece of work is likely to differ from a 'public good' piece of work.

Rather than establish a single 'price' for any hour worked by ESR resources to establish the economic/opportunity cost (for instance the going commercial rate representing the foregone commercial income from undertaking 'public good' activity), we use the prices paid

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[64] Note that we refer to 'public good' in this instance as being for the good of the public (or equivalently as a public service) as opposed to the more strict meaning of public good in the lexicon of economics.

by the respective commissioning agencies as the relevant economic cost. These economic costs are counted as part of local government and central government groupings. We include in the grouping the remaining ESR resource costs associated with internal and external legal costs, travel expenditure, and staff time related to the inquiry.

Costs for St John were estimated by the Acting Operations Manager at the time, covering backfilled personnel costs and the opportunity cost of his time whilst involved in the outbreak response control centre. The Manager identified some sick leave costs during the outbreak, but these were effectively absorbed by the service and were therefore not included in our analysis.

The total costs estimated to accrue to NGOs was $134,577. Figure 13 shows that the costs were reasonably even-spread across the reaction and consequential (i.e. inquiry-related) stages.

Figure 13 NGOs Cost profile
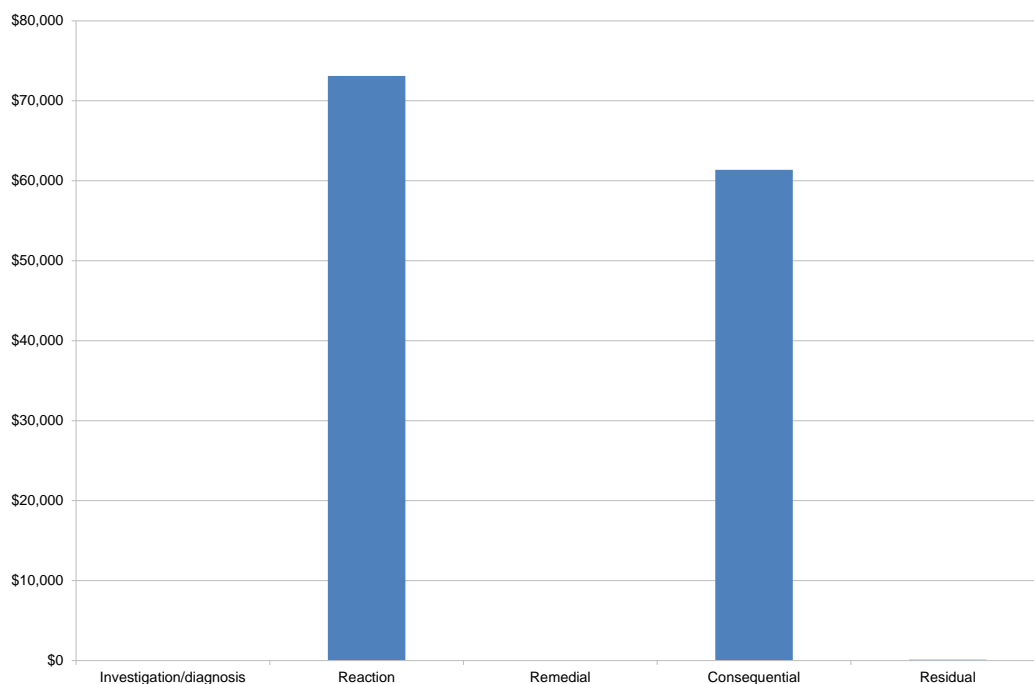
The relatively low level of economic costs recorded for NGOs is largely due to the costing approach adopted. In essence, the activities undertaken by the organisations do not involve significant opportunity costs. In other words, they are part of 'business as usual", either because the organisation has no other role outside of response functions or the scale of activities undertaken is so vast that those associated with the outbreak are easily absorbed.[65] Having said this, the total hours dedicated to the outbreak (and consequent inquiry) by the organisations in this grouping was estimated to be 4,972 (including ESR).

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[65] Healthline in particular mentioned that the current centrally delivered structure of the organisation increased the ability of Healthline to absorb costs.

7.5 Costs to businesses ($1,302,179)

Ultimately, estimating costs to commercial entities is an exercise in judgment. Earlier in the report we outlined some general principles and a decision framework to guide choices about the inclusion or otherwise of costs and their quantum. This section presents the results of utilising that guidance in a practical sense to determine likely costs to business from the outbreak.

7.5.1 Information sources and calculation steps

We used the following key sources of information in the estimation process:

- Official statistics on Business Demography in the relevant study area – to estimate the population of businesses who might have been impacted. [66]

- Interviews with businesses – to determine specific cost impacts and their duration.

- Data received from the Hastings District Council in relation to the Business Assistance Package[67] they offered by in the immediate aftermath of the outbreak and Paymark data on electronic transactions in Havelock North in the study period.

Obviously, the need to protect the commercially sensitive information highly restricts the level of specificity that can be reported. In the case of the Business Assistance Package, we use some data received from the Hastings District Council that has not been made public for our calculations, but present in the report only information that is already in the public domain. Similarly, we used Paymark data on electronic spending in relevant sectors to assist in our determinations, but do not present the actual Paymark-specific numbers in the report. That is, the cost estimates in this report represent the tip of the analytical iceberg – much of the analysis underpinning their derivation remains unseen.

Reflecting the role that judgment plays in this process, the calculation proceeds in a number of steps. Where the interview process produced sufficient data on costs to businesses in the relevant industry sector (i.e. accommodation), we applied the average estimated cost in our sample to the population in that industry sector.

For the other industry sectors, we apply the average business assistance provided in the Council Business Assistance Package to the relevant number of businesses (geographic units) in the study area. A total of 48 businesses applied to Hastings District Council for assistance and 37 were successful. Total assistance provided under the package was $180,000 and the average amount paid to each successful business was $4,783. This is a global average across sectors as the composition of businesses in the package is confidential.[68]

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[66] Recall that the area units for the business analysis are the same as those for the household analysis, namely Anderson Park, Iona, Havelock Hills, Te Mata, Havelock North Central, and Te Mata Hills.

[67] While Hastings District Council provided the financial assistance, it was for business impacts and is thus included here (i.e. netted out from local government costs). Further detail on the Business Assistance Package is available at: http://www.hastingsdc.govt.nz/havelock-north-water-contamination-business-assistance

[68] http://www.scoop.co.nz/stories/BU1612/S00476/havelock-north-financial-assistance-package-results.htm

Where our interview process suggested that the assistance provided by the Council was in line with actual losses, we applied the average to all affected businesses. Where the interview process suggested that the assistance provided by the Council did not necessarily cover the full loss, we applied a scale factor to the average and multiplied by the number of businesses affected.

In determining the extent to which we can extrapolate reported or proxied losses more widely, we also considered the Paymark data, which compared electronic spending between 1st August 2016 and 18th September 2016 to a similar period the year before. Where there appeared to be major discrepancies between what was being reported and the Paymark data, we scaled down the wider application. Furthermore, we used the Paymark data as an initial indicator of the degree to which sectors were affected (i.e. where there was a rise in spending relative to the previous year, we discounted the possibility that discernible business impacts from the outbreak arose and removed those industry sectors from our calculations).

Table 12 summarises the relevant sectors, process used and decisions applied.

Table 12 Prominent sectors where extrapolation was applied

Sector	Initial conditions	Treatment in study
Accommodation	15 Accommodation providers identified in relevant area; we interviewed three providers, two of whom applied to Council for assistance.	Applied the average cost estimate from our interviews to the remaining firms that either did not apply to Council or were unsuccessful, adjusted to reflect the extent to which assistance represented actual loss and possible incidence of loss.
ECE centres	Five centres closed; indications are that those who applied to Council and were successful were happy with assistance level. Ministry of Education also seemed to provide further support.	Assume that Council assistance is additional to that provided by the Ministry of Education and apply the average Council payment across all sectors to all centres that closed.[69]

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[69] Recall that the assistance provided by the Hastings District Council has not been included in the estimate of their costs. Hence, to include the costs here for those centres that successfully applied is not double counting.

Sector	Initial conditions	Treatment in study
Food and beverage	36 Cafes, Restaurants and Takeaways identified in relevant area; interviewees who applied to Council and were successful suggest that assistance amount was bare minimum and did not reflect true costs.	Assume actual loss is three times the average Council assistance payment across all sectors; applied to all 36 businesses (based on indicative number of applications to Council); 75% of costs incurred in initial reaction stage, remainder in residual stage.
Retail trade	63 retailers identified in relevant area; 43 were removed, either because they were separately included (i.e. the 36 food and beverage retailers above, and pharmacy retailers considered elsewhere) or there was no discernible impact (i.e. furniture/hardware and recreational retail).	Assume average Council assistance payment across all sectors sufficient to account for costs to remaining retailers who were not successful in receiving Council assistance. No residual effects included.
Other services	597 non-public and non-education service providers identified in relevant area; low application rate by services firms to Council for assistance from such large firm numbers.	Assume those services firms that did apply represented half of services firms affected. Apply the average Council assistance payment across all sectors to those firms.

7.5.2 Composition of costs

In total we estimate costs to businesses from the outbreak were just over $1.3 million, comprised of $180,000 in assistance provided by the Hastings District Council to affected businesses and around $1.1 million in estimated costs derived from interviews and extrapolation. Almost all of these costs (around 98%) relate to 'direct' costs associated with loss of revenue and out-of-pocket costs, while the remainder relate to 'indirect' opportunity and transaction costs of time spent by businesses and their staff dealing with the consequences of the outbreak (e.g. sourcing and disseminating information, coordinating actions).

Figure 14 shows that, not surprisingly, the reaction category is responsible for 75% (around $984,000) of the estimated total business costs, with 23% (around $298,000) of costs in the residual category, and 2% (around $20,000) in consequential costs.[70] Thus, over a fifth of the estimated business costs are ongoing in nature, such as preparing information, responding to enquiries about the safety of water, and 'discouraged demand' for services such as accommodation.

Figure 14 Business costs profile
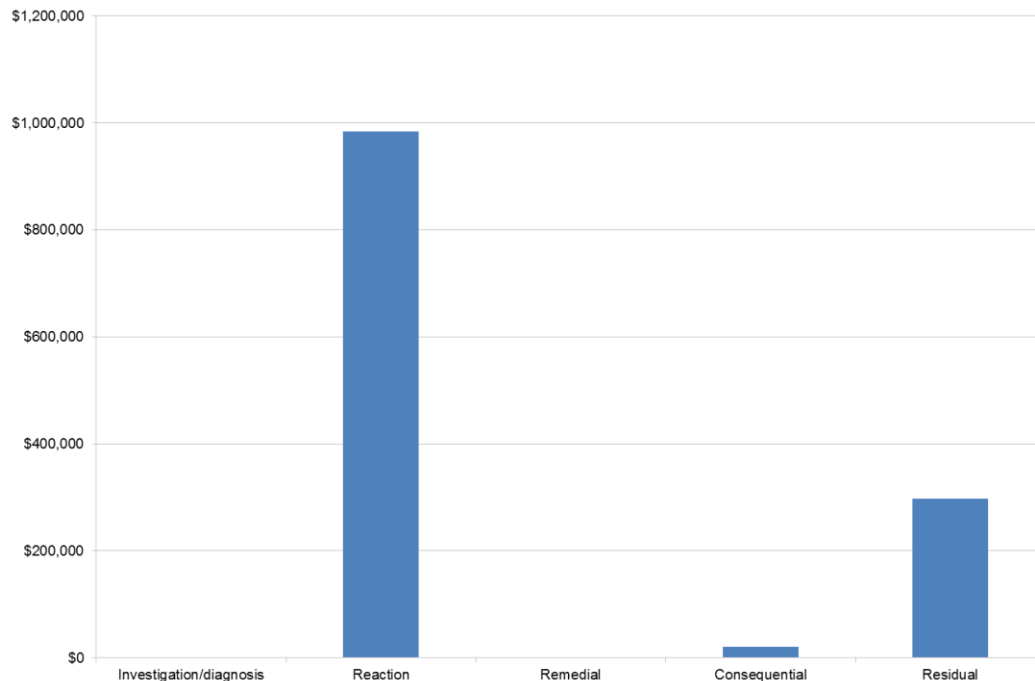
The 14 interviews we undertook with businesses in Havelock North resulted in a cost estimate of $310, 143, which was 28% of total business costs excluding the $180,000 relating the Business Assistance Package offered by Hastings District Council. This means that the 'extrapolated' judgments applied to the wider relevant business population in the area under study are responsible for the remaining 72% ($812,036) of Business Assistance Package-exclusive costs.

This split reflects the relatively conservative approach to estimating costs to businesses who were either not part of our interview programme or were not successful in securing assistance from the Hastings District Council. It could be argued that such an approach underestimates the true costs to businesses. In our view, the estimates we derived are based

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[70] These consequential costs relate to one-off expenditure on equipment needed to deal with the effects of chlorination following the outbreak.

on the best available information and evidence, given the confidentiality provisions around access to information and the fact that it is not possible to survey/interview all businesses.[71]

The sectoral composition of total estimated costs (excluding the Business Assistance Package) is shown in Figure 15. Food and Beverage businesses accounted for 59% of the costs (around $659,000), with Accommodation businesses being responsible for 25% (around $278,000) of the estimated costs. The remaining 16% (around $184,000) is accounted for (in order of size) by the other retail, services, and early childhood education and primary sectors respectively. When compared to the stylised incidence column (Figure 8), this breakdown by sector highlights the size of the estimated cost impact in the accommodation sector relative to the number of businesses.

Figure 15 Cost share by sector

Excludes Business Assistance Package costs
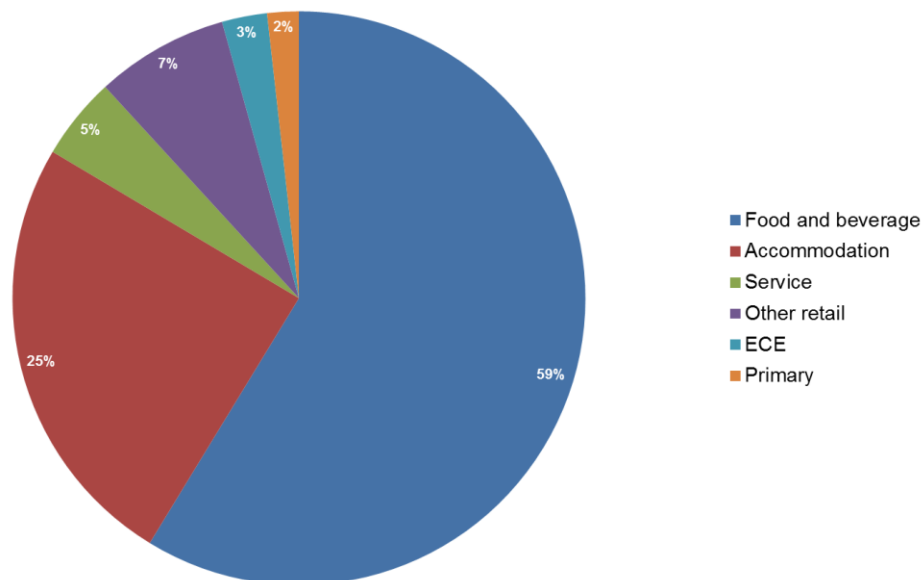
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8. Total costs ($21,029,288)

We estimate the total economic costs to society resulting from the outbreak to be just above $21 million. The vast majority of these costs, almost 60%, relate to impacts felt by households (i.e. inconvenience). Local government accounts for around a fifth of the total costs. The business community incurred around 6% of costs while illness related costs accounts for 12% (see Figure 16).

Figure 16 Composition of total costs
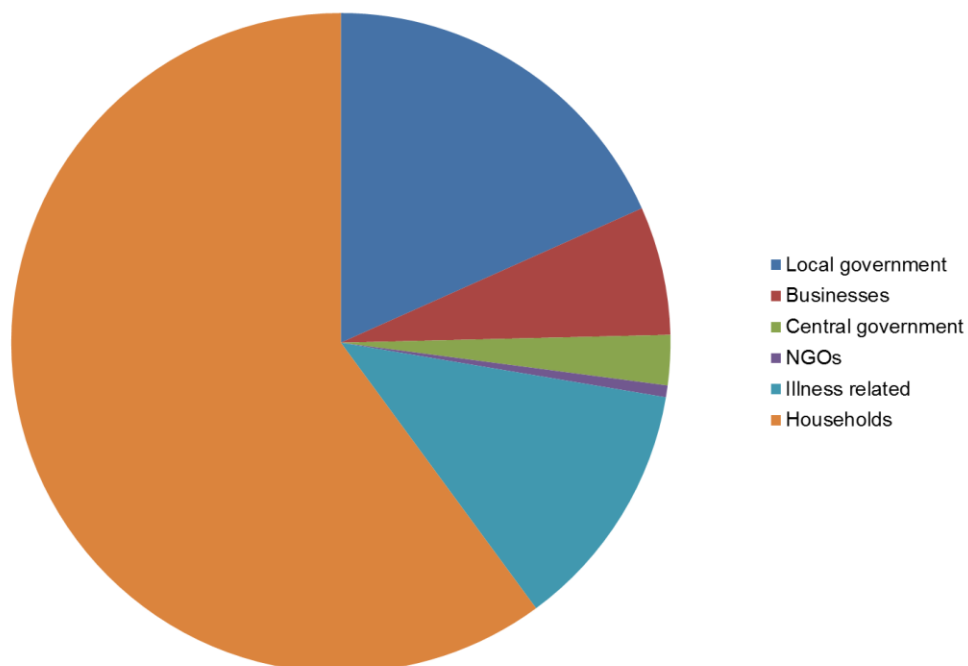
Direct (out-of-pocket) costs make up 38% of the total estimated costs ($8.1 million) while indirect costs total around $12.9 million. This is explained by the large contribution household costs make to total costs, as almost all of the costs to households are indirect in nature (see Figure 17). When looking at costs by stage, again the household cost component underpins the dominance of the 'reaction' stage (see Figure 18).

Nearly half of the consequential costs are from the burden of disease cost estimated as quality adjusted life years. Given the inquiry process is still underway, consequential costs are likely to increase significantly. Residual costs (generally associated with trust and confidence in the water supply from both locals as well as visitors to Havelock North) are expected to dissipate over time. However, we understand (anecdotally) that publicity generated by the inquiry is positively related to concerns. That is, questions concerning water quality/safety rise at the same time as inquiry findings are published. Thus, to the extent consequential costs rise in future, so too might residual costs.
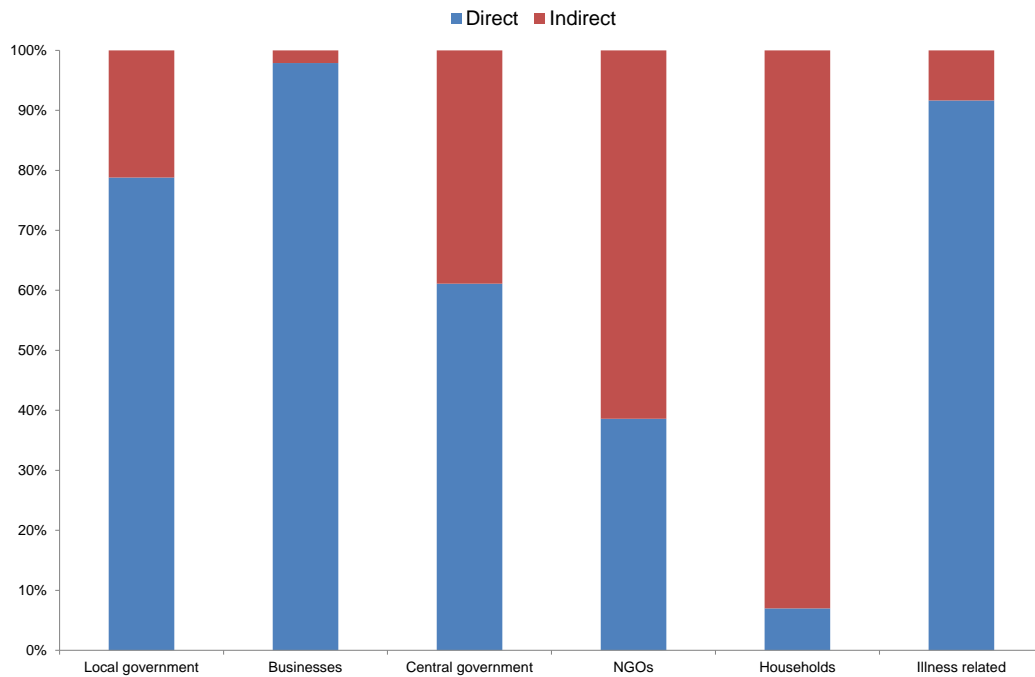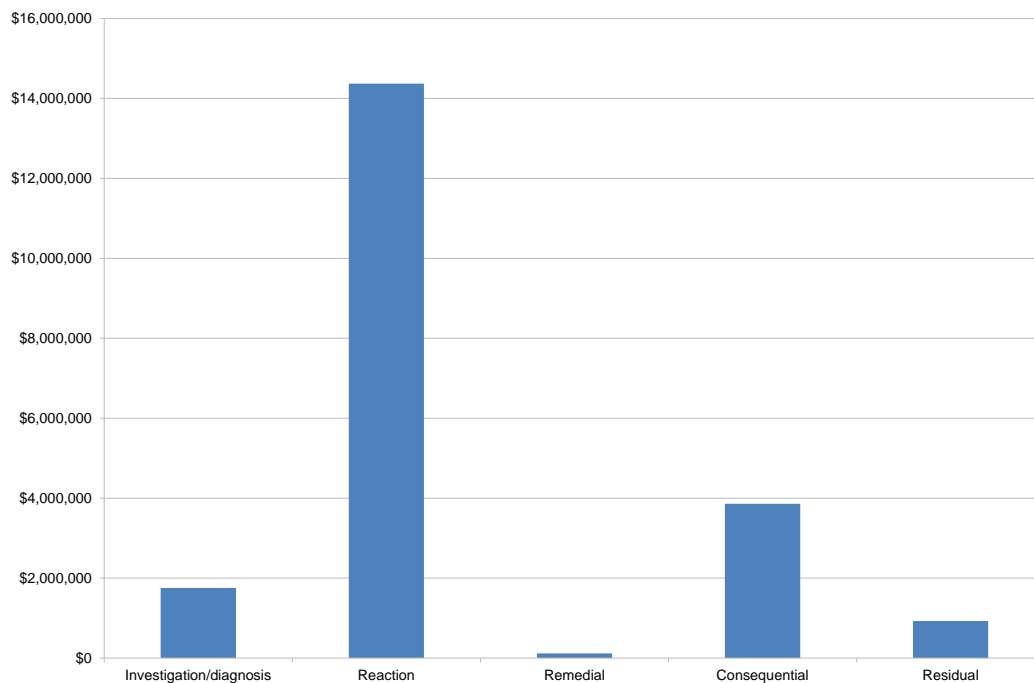
Figure 17 Indirect/direct costs

Figure 18 Total costs by stage

Appendix 1 Questions for business interviews

Estimating the (economic) costs of the 2016 Havelock North Water Contamination

Sapere has been commissioned by the Ministry of Health to estimate the costs to society of the 2016 outbreak. The focus is on economic costs – that is to say, how much worse off society is because of the contamination. The study is not solely concerned with financial costs, though these will be considered.

All answers are confidential and will not be reported specifically in the final report (i.e. costs will be aggregated). Only staff directly involved in the project will have access to relevant data.

Impacts

1. Could you please describe the impacts on you/your business (in dollar value terms)?

   (a) Direct: turnover/revenue; business disruption

      (i) Customers not purchasing

      (ii) Additional costs of operation, including possible workarounds needed that would otherwise not be; costs of mitigation

      (iii) Not being able to operate at all (i.e. close down) – sanitary conditions, etc.

      (iv) Staff productivity

      (v) Donated products

      (vi) Can you give a profile/distribution of impacts in terms of magnitude and incidence over time?

   (b) Indirect: time costs

      (i) Staff absences

      (ii) Information sourcing and co-ordination (e.g. attending meetings)

2. Recovery:

   (a) Did you apply to the Hastings District Council Financial Assistance Package?[72]

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[72] We understand that the settlement terms of any assistance are confidential – we do not need to know the exact amounts as such. We have received some aggregate data from Council on total amounts paid and the

(b) If you did and were successful, to what extent do you consider the assistance provided covered your estimated loss (in percentage terms)?

(c) Are impacts still being felt? Please describe.

3. To what extent were there personal costs as well (e.g. at home) – what is the relative weighting between personal and business costs?

4. Are other businesses being impacted because of this – actual and potential?

(a) Suppliers

(b) Downstream purchasers (locally and elsewhere)

(c) Other businesses in town?

5. Can you recommend other people/businesses that we should talk to?

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numbers of applicants. The Council acknowledges that there may be a divergence between any Council settlement amount and the actual estimated costs to your business.