Supporting the COVID-19 pandemic response: Surveillance and Outbreak Analytics

Prepared for the Ministry of Health

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https://www.otago.ac.nz/wellington/departments/publichealth/research/heiru/index.html
https://www.otago.ac.nz/wellington/departments/publichealth/research/bode3/index.html

NOTE

Although this report was correct at the time of writing, the information it presents may no longer be current because of continuing evolution of the COVID-19 pandemic and our understanding of it.
Unless otherwise indicated, peer review and full consultation with relevant agencies was not always possible in the timeframe available for producing this report.

Table of Contents

Key findings

- COVID-19 is a respiratory infection caused by a novel coronavirus, SARS-CoV-2. This coronavirus is different from previous pandemic viruses: effective reduction of impact will depend on **rapid collection and assimilation of COVID-19 data** to guide action.
- Decision areas aimed at reducing pandemic impact are outlined in New Zealand's Influenza Pandemic Plan. Experience from China indicates that **non-pharmaceutical measures to reduce transmission** will be critical to the initial pandemic response.
- As incident cases start to accelerate in New Zealand, the essential evidence for action will come primarily from **surveillance** and **modelling,** using an **outbreak analytics** approach.
- Until these systems are fully operational New Zealand will not be able to design, prioritise and evaluate effective **control strategies**, or assess the impact of COVID-19 on **populations of interest** including Māori, Pasifika, older adults, and those with comorbidities. Current information gaps also introduce a risk that **signals for transition between phases** will be missed.
- The rapid escalation of COVID-19 globally has also highlighted the importance of having **pandemic preparedness** systems in place that reflect **lessons learned** in previous pandemics.
- Finally, New Zealand is benefiting from a tremendous global collaboration to understand and manage COVID-19 infection. Collecting information is important not only to meet international reporting requirements, but to **contribute in turn to the international effort**.

Recommendations

Surveillance

1. Urgently implement the **WHO First Few X (FFX) Cases protocol** as an extension of the notification system (EpiSurv) to inform the pandemic response, particularly the design of social distancing strategies to reduce transmission
2. Urgently implement a nationally consistent system for **surveillance and management of contacts**
3. Activate and enhance **SARI surveillance** (in hospitals) to monitor trends in serious respiratory morbidity and mortality
4. Activate and enhance sentinel **ILI surveillance** (primary care and emergency departments) to identify the level and extent of community transmission, with an initial focus on areas with high proportions of travellers
5. Consider additional information that could be used to **monitor COVID-19 impact in communities and populations of interest**, including existing measures (e.g. school absenteeism) and existing platforms (e.g. the New Zealand Health Survey)

Modelling

6. Model scenarios under varying assumptions to design and prioritise control strategies

Evidence to action

7. Develop a cohesive approach to outbreak analytics. Actions could include:
    - Systematise rapid analysis and reporting of the above surveillance and FluTracking data
    - Integrate data from multiple sources to generate input parameters for modelling (e.g. build the severity pyramid)
    - Conduct a brief stocktake of additional data sources both within and external to New Zealand that can contribute evidence for action
    - Use the New Zealand Health Survey infrastructure to collect additional data to guide the response.

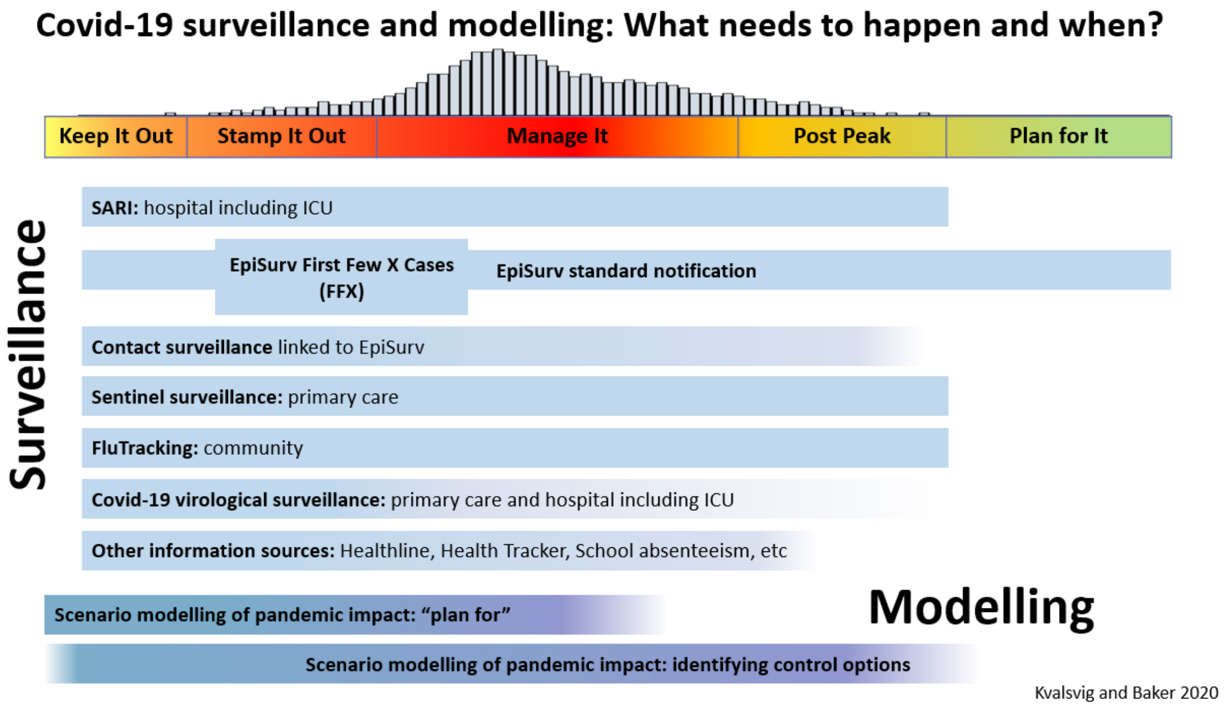


Figure 1. Overview of surveillance and modelling timelines over pandemic phase transitions. This diagram is further discussed on page 25.

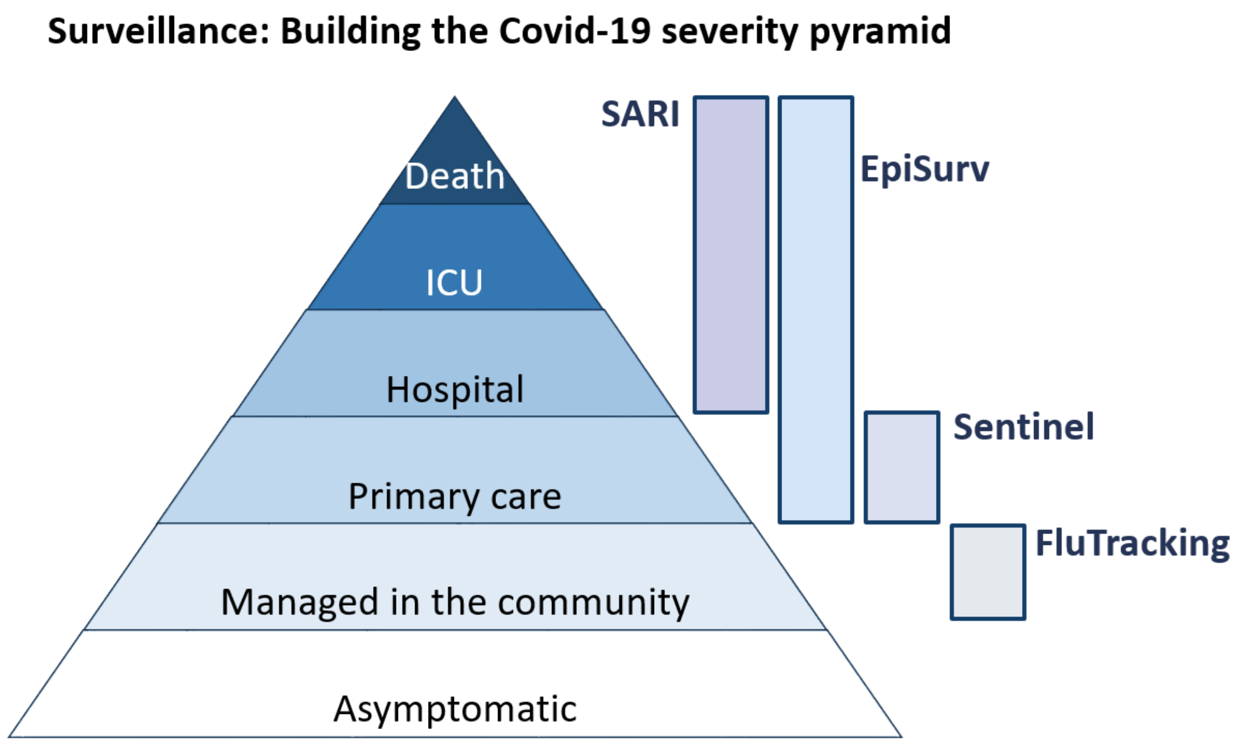


Figure 2. Surveillance systems for understanding severity. This diagram is further discussed on page 26.

Introduction

COVID-19 is a respiratory infection caused by a novel coronavirus, SARS-CoV-2. The virus emerged in Wuhan, China, in late 2019 and as of 20 March 2020, over 200 000 cases have now been identified in 168 countries, areas, or territories, including 39 in Aotearoa New Zealand.

Goal of this review

The goal of this review is to support rapid optimisation of the evidence-to-action cycle. Recent experience in China and beyond has demonstrated the importance of timely information to guide an effective public health response.[1-3] The information plan presented here is designed to support decision-makers to anticipate information needs and prioritise information resources to align with the relevant pandemic phase.

Because this information will be acquired in different ways depending on the pandemic phase, we also review the activities required to generate the information, with a strong emphasis on surveillance. These activities can be thought of collectively as belonging to an emerging data science, *outbreak analytics*, whose purpose is to inform an effective response to outbreaks.[4]

Scope of the review

We have prioritised consideration of the evidence-to-action cycle relevant to current and near-future pandemic phases. We have given less consideration to other phases, for example Plan For It, that do not require action at present. However, the findings of this review are intended to contribute insights and 'lessons learned' that will inform preparation for future outbreaks.

Global context: Lessons learned from the Chinese experience

China was the first country to experience COVID-19 cases, and to date (20 March 2020), China has experienced the largeset number of cases of any country (approximately 80 000). New Zealand's relatively late acquisition of COVID-19 cases means that we are well-positioned to learn from experience in other regions. The international pandemic response, particularly as coordinated by the World Health Organization (WHO), has generated a number of useful information resources; examples occur throughout this review.

Report from the WHO-China Joint Mission

An important and up-to-date resource for New Zealand is the detailed report on the China's COVID-19 experience, produced by members of the WHO-China Joint Mission and released on 24 February.[3] The intention of this high-quality and detailed report is to share knowledge and recommendations to assist preparedness in geographical areas that are not yet experiencing widespread infection.

Key recommendations from the Joint Mission report include the following:

- COVID-19 response planning needs to be anchored in a thorough assessment of local risks to inform differentiated strategies for areas with no cases vs. sporadic cases vs. clusters of cases vs. community-level transmission
- "Extremely active surveillance" is therefore fundamental to the response
- Countries are advised to "Prioritize early investigations, including household transmission studies, age stratified sero-epidemiologic surveys including children, case-control studies, cluster investigations, and serologic studies in health care workers".

Implications for New Zealand

These recommendations support the focus in the current review on urgent activation of New Zealand's existing surveillance systems, as well as implementation of early investigation of the first cases to enable rapid adaptation of the response to transmission patterns in this country. A vital aspect of China's response has been the emphasis on non-pharmaceutical measures to reduce transmission. This approach relied on high-functioning surveillance systems to generate a rapid and responsive understanding of transmission dynamics. Requirements for New Zealand's surveillance system and implementation of the First Few X (FFX) Cases protocol in EpiSurv are discussed in later sections of this review.

New Zealand's contribution to global knowledge

As New Zealand benefits from the experience of other countries and from the work of the international scientific community, we have a reciprocal obligation to contribute information about COVID-19 in New Zealand to the international community. Actions to take include meeting reporting requirements and adding New Zealand data to cross-country data collaborations such as FFX.

Pandemic planning in Aotearoa New Zealand

Pandemic planning in Aotearoa New Zealand has commonly focused on influenza preparedness as evidenced by the Influenza Pandemic Plan published by the Ministry of Health in 2017;[5] this plan is soon to be superseded by a specific COVID-19 response plan. In the same way, existing influenza infrastructure can generally be adapted for the COVID-19 response. However, there are aspects of COVID-19 that are different from previous outbreaks experienced in New Zealand and from seasonal influenza and these differences have important consequences for decision-making. In this review we outline existing systems and knowledge that can be applied to the current situation, and also key systems and knowledge gaps where new information is required that is specific to COVID-19.

Table 1. Six-phase strategy of New Zealand pandemic planning. Reproduced from the New Zealand influenza pandemic plan.[5]

Phase	Potential trigger	Specific objectives
Plan For It Planning and preparedness	Level of influenza at normal seasonal levels	Plan and prepare to reduce the health, social and economic impact of a pandemic on New Zealand Deal with disease in animals, if required
Keep It Out Border management	Sustained human-to-human transmission of a novel influenza virus overseas in two or more countries	Prevent, or delay to the greatest extent possible, the arrival of the pandemic virus in New Zealand
Stamp It Out Cluster control	Novel influenza virus or pandemic virus detected in case(s) in New Zealand	Control and/or eliminate any clusters found in New Zealand
Manage It Pandemic management	Multiple clusters at separate locations, or clusters spreading out of control	Reduce the impact of pandemic influenza on New Zealand's population
Manage It: Post-Peak Transition to Recover From It phase, and planning for a resurgence or second wave	New Zealand wave decreasing	Expedite recovery, and prepare for a re-escalation of response
Recover From It Recovery	Population protected by vaccination, or pandemic abated in New Zealand	Expedite the recovery of population health, communities and society where affected by the pandemic, pandemic management measures, or disruption to normal services

Developing an evidence-based response to COVID-19

The rapid evolution of the COVID-19 epidemic presents challenges for evidence-based action, because the evidence itself is evolving.

Table 2 is based on the action table of the New Zealand Influenza Pandemic Plan (p62[5]), but further extends it. In addition to showing the phases and objectives, we identify key decision areas and for each of these we summarise decision inputs, information required, and information sources. We focus on three current phases: Keep It Out, Stamp It Out, and Manage It. When the new COVID-19 plan is completed, these phases will still describe important strategic approaches, but two differences may be seen in the COVID-19 response, compared to influenza pandemic responses. The first is that for a maximal response, activities relating to each of these phases may be in operation simultaneously. The second is that experience from China suggests that there may be a need for regional variation in approaches to pandemic control, depending on levels and types of transmission in different parts of the country.[3]

As Table 2 shows, multiple information types and sources contribute to decision inputs. The table also shows that several types of information can be used in different ways to inform a range of decisions. In a later section we describe the information in more detail and identify fundamental types of information whose collection should be prioritised.

The decision areas identified in Table 2 are not exhaustive, as decision needs will not be predictable. However, it will be important to anticipate likely future information needs where possible, to enable appropriate systems to be put in place. The Recommendations on the first page of this review thus focus on current and imminent information requirements.

Table 2. Systematic public health decision-making during the COVID-19 pandemic.

Phase	Main objective	Key decision areas	Decision inputs	Information	Information source
Keep it Out	Prevent, or delay to the greatest extent possible, the arrival of the pandemic virus in New Zealand Action focus: Border management	Control measures relating to travel in and out of NZ and advice to travellers	Global distribution	Number and location of cases internationally	International surveillance,
			Potential impact of pandemic in NZ	• Transmission dynamics • Severity estimate	• Rapidly published research reports (publisher and preprint sites) • Modelling
			Impact assessments of specific border measures	• Transmission dynamics • Travel patterns	• Modelling
		Identify signals for moving on to next phase	Onset of cases in NZ	Number and location of cases nationally	• Multiple surveillance activities
Stamp it Out	Control and/or eliminate any clusters found in New Zealand Action focus: Cluster control	Ongoing border measures	As above	• Cases arriving and leaving • Number and location of cases internationally • Travel patterns	• Border surveillance • International surveillance e.g. WHO coronavirus dashboard
		Managing and containing the pandemic within NZ	Control measures in general population	• Number and location of cases nationally	• Multiple surveillance activities
			Targeted control measures in higher-risk populations and settings	• Population distribution of cases and severity in NZ	• Multiple surveillance activities
			School closures	• Population distribution of cases and severity in NZ • Transmission in children	• Multiple surveillance activities

Phase	Main objective	Key decision areas	Decision inputs	Information	Information source
Stamp it Out			Activation of health sector pandemic policies and plans	• Population distribution of cases and severity in NZ • Population distribution of cases and severity in health workforce • Transmission dynamics within healthcare settings • Impact on health workforce • Experience from other countries	• Multiple surveillance activities • Scenario modelling • International research
			Activation of a range of other pandemic policies and plans	Current and future impact of pandemic on sectors	• Surveillance • Modelling
			Case management and containment policies e.g. isolation	What works	• International agency advice e.g. WHO • Rapidly published research reports (publisher and preprint sites) • Scenario modelling • Peer-reviewed literature relating to past pandemics
		Purchasing and using antivirals and vaccine (if/when available)	Cost-benefit assessment	• Severity estimate • Population distribution of cases and severity in NZ	• Scenario modelling • Surveillance
		Identifying signals for moving on to next phase	Escalation of cases in NZ	• Incidence and mortality rates • Sector overwhelm	• Surveillance • Sector capacity analysis

Phase	Main objective	Key decision areas	Decision inputs	Information	Information source
Manage it	Reduce the impact of pandemic influenza on New Zealand's population Action focus: Pandemic management	Review need for containment measures across multiple sectors and populations	Case management and containment policies	• What is working? • Cost-benefit implications	• International agency advice e.g. WHO • Surveillance
		Change the overall emphasis in surveillance activities from detection of cases and clusters to population distributions	National-level approach or ongoing need for containment in specific populations	• Severity estimate • Population distribution of cases and severity in NZ	• Multiple surveillance sources • Analysis of operational resources and capacity
		Re-evaluate border measures	As previously	As previously	As previously

Information requirements

In an evolving pandemic, assessments of impact drive decisions about the response and how to manage resources. The impact of COVID-19 on New Zealand's communities, health services, and populations will depend on three main factors relating to the infection:[6]

- The **number of people** who become infected,
- The **transmissability** of the infection, and
- The distribution of **clinical severity** among those infected.

These factors are summarised in Table 3. Many of the data measures listed in Table 3 are useful for a range of decisions and the table could be adapted as a spreadsheet to collate up-to-date information for multiple end-users. The table can also be used as a checklist for identifying information gaps. Interested readers are also referred to Table 5 in the WHO First Few X (FFX) Cases protocol.*

Data for decisions

Data measures relating to **number** (e.g. the number of cases admitted to hospital on a given day) and **severity** (e.g. the case fatality risk) are readily accessible as indicators of impact. Data measures relating to **transmission** (e.g. the serial interval, which is determined by contact tracing) are generally more useful as input parameters for mathematical modelling, but knowledge of transmission dynamics also directly informs decisions about control measures, particularly measures that seek to reduce contact rates e.g. through cancellation of mass gatherings and work-from-home arrangements.[7] One known information gap is that transmission dynamics in children are not yet well understood and this gap makes it difficult to assess the potential value of school closures.[6]

Interpretation and monitoring

Indicators of number, transmission, and severity are not likely to be stable through the course of a pandemic. Some (e.g. the basic reproduction number, R_0) are difficult to measure in the early stages of a pandemic: early estimates will need to be revised as better evidence becomes available.[8] Some information (e.g. the number of incident cases) is highly variable and may need to be updated on a daily basis. Estimates of case fatality risk that focus on hospitalised cases may be biased upwards because mild cases re not included in the denominator, while estimates of severity that use health service levels as an indicator may become distorted if services are operating in conditions beyond their surge capacity.[6] These variations indicate a need for a **critical appraisal of estimated and measured data** as part of a cohesive data analytics approach. The use of overlapping systems to capture the same measure in different ways is an effective strategy to understand and adjust for these limitations. The severity pyramid illustrated in a later section is one such example.

Information sources will also be changeable over time. A major impending watershed is the emergence of a substantial number of cases in New Zealand. Until then, estimates of potential impact will be based on information from mathematical models or from surveillance and research reports originating in other countries and in previous outbreaks (frequently from a combination of these sources). Once transmission of COVID-19 is established in New Zealand, the same information will need to be directly observed

* https://www.who.int/publications-detail/the-first-few-x-(ffx)-cases-and-contact-investigation-protocol-for-2019-novel-coronavirus-(2019-ncov)-infection

from surveillance and case series data. The need to pivot swiftly from externally-derived estimates to NZ-based measures further emphasises the importance of timely **activation of surveillance systems**.

Table 3. Key information needed to measure and model pandemic impact

Category	Measure	Meaning	How it is used	Source
Case numbers	Overall count	Number of cases matching the case definition	• To model impact under varying assumptions • To inform decisions about transition to the next pandemic phase • To model or evaluate control measures	• Can be estimated from transmission dynamics using mathematical modelling • Measured using surveillance systems
	Population distributions (person, time, place)	• Disaggregation of total case numbers to understand population differences (e.g. incidence in Māori and non-Māori) • Key descriptors for COVID-19 include age, sex, ethnicity, occupation, deprivation, date of illness, geographical area	• To understand differential impact on different populations and direct resources and control measures accordingly • Monitoring inequities in disease incidence and control • Monitoring high-risk populations e.g. the health workforce	• Multiple sources, particularly line list data e.g. EpiSurv/FFX for person descriptors
Transmission dynamics	Basic reproduction number (R_0)	The average number secondary infections per case in a completely susceptible population	• Key input parameter (and highly influential) when modelling epidemic scenarios • $R_0 < 1$ indicates a containable epidemic	Estimated from surveillance and/or case data
	Serial interval	The time from onset of symptoms in one case to onset of symptoms in a close contact	• Essential parameter for modelling the epidemic curve • Once established, can be used for contact tracing	Requires detailed information from case clusters e.g. FFX
	Time from infection to symptom onset	The time from infection to symptom onset	• Essential parameter for modelling the epidemic curve • Once established, can be used for contact tracing	Requires detailed information from case clusters e.g. FFX

Category	Measure	Meaning	How it is used	Source
	Pre-symptomatic transmission	In some types of infection, cases can be infectious before they display symptoms	• Key input parameter for modelling scenarios – outbreaks become much harder to contain in the presence of pre-symptomatic transmission • Can be an important factor in decisions about control measures e.g. school closures[9]	• Can be inferred from viral shedding or contact exposure[10] but the relationship between viral shedding and transmission is often unclear[11] • Household surveys and studies of closed systems are the most useful sources
	Susceptibility	Lack of immunity to an infection	• Key assumption for modelling the epidemic curve	• Can be estimated using serological surveys or vaccine records (not currently relevant for COVID-19: populations are assumed to be fully susceptible when the virus is introduced)
	Natural history/clinical symptoms	Disease progression, symptoms and signs in the absence of specific treatment	• Basis of the case definition, used particularly for syndromic surveillance • Can be compared with existing syndrome definitions e.g. ILI to determine sensitivity and specificity of using influenza surveillance measures	• Observed from case series
Severity	Severity levels	Often defined in terms of health system need, e.g. requiring hospitalisation or ICU care	• To model health service demand under varying scenarios • To model the epidemic curve (which is sensitive to the case fatality risk)	• Observed via multiple sources including health services, case series, mortality data • May itself need to be modelled in the early

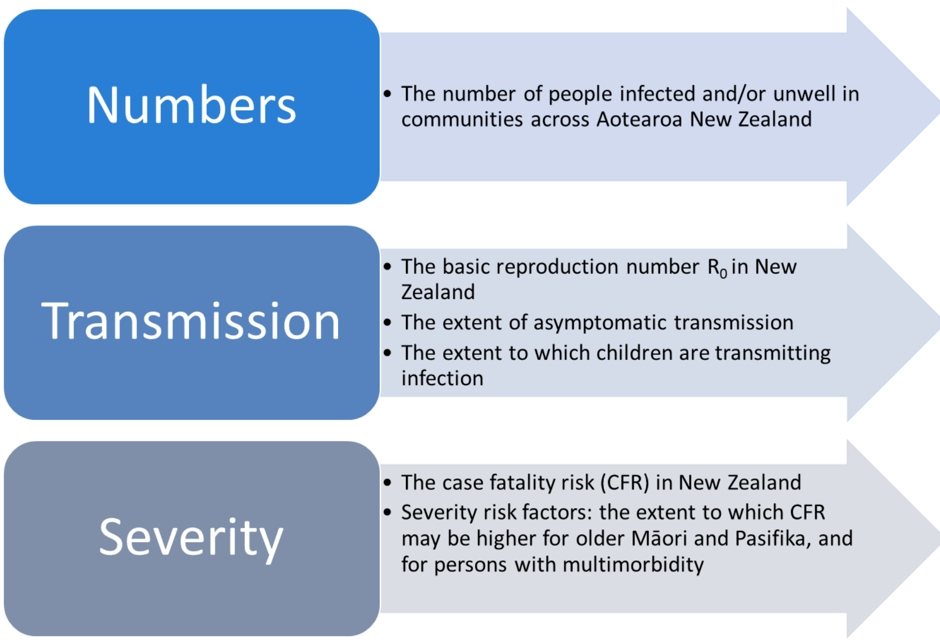
Category	Measure	Meaning	How it is used	Source
				phases of a new pandemic
	Severity pyramid	Relative proportions of severity levels, ranging from large numbers at low severity (e.g. infections managed in the community) to small numbers at high severity (e.g. cases requiring ICU)	Once it has been reliably constructed, case counts at one level can used to infer numbers at a different level (e.g. hospitalisations can be used to infer total case numbers)	Typically constructed from multiple sources. See Figure 6 for more detail of NZ surveillance sources
	Case fatality risk	Proportion of cases with a fatal outcome	This is a key indicator of pandemic impact	Multiple sources including notification and mortality data

Number, transmission, and severity: current information gaps in Aotearoa New Zealand

Although many aspects of COVID-19 infection are still unclear and require active research,[6 12] there are some **specific information gaps (**Figure 3**)** for the New Zealand population that make it very difficult to assess current and future impact, and hence to determine an appropriate set of response strategies. In addition to assessing impact, lack of knowledge about the number of people currently infected in the New Zealand population introduces a risk that **the signals for intensification of the response may be missed.**

In the next section we consider information sources that can be deployed to fill these gaps.

Figure 3. Current information gaps that are barriers to response planning.



Information sources: an overview

The rapid evolution of a novel coronavirus pandemic has generated an urgent need for evidence to guide action.

Because of the relatively late occurrence of COVID-19 cases in New Zealand, this country has been well-positioned to learn from experience in other regions. The international pandemic response, particularly as coordinated by the World Health Organization (WHO), has generated a number of useful information resources.

International experience and information sharing

The normal timeframe of research communication - where journal articles typically take months to appear - does not align well with the urgent information requirements of a pandemic response. However, several international organisations and publishers now have set up online resource centres for COVID-19 (Table 4). These sites are generally a mix of audiovisual resources (e.g. interviews or maps), fact sheets, and links to papers from publishers' own journals. Preprint sites publish papers that have not yet been peer-reviewed; they are a useful form of rapid research dissemination, although the lack of quality control requires cautious interpretation of findings. The WHO site (the first listing in Table 4) has begun to collate links to other sites, making it a useful information hub as well as providing primary content.

Table 4. Selected online resources for COVID-19 news and information.

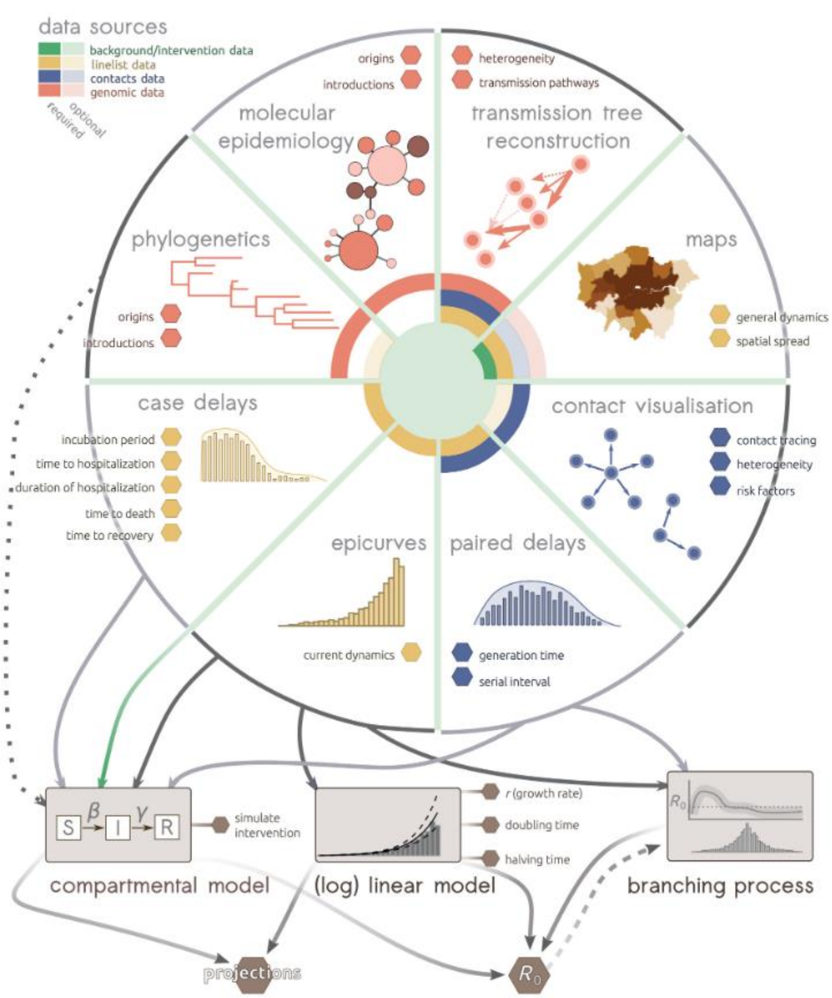
Organisation	**Scope**	**Link**
World Health Organization	COVID-19 research articles, updated daily	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov
BMJ	General resources and BMJ articles	https://www.bmj.com/coronavirus
Elsevier	General resources and Elsevier articles	https://www.elsevier.com/connect/coronavirus-information-center
JAMA Network	General resources and JAMA articles	https://jamanetwork.com/journals/jama/pages/coronavirus-alert
The Lancet	Lancet articles	https://www.thelancet.com/coronavirus
New England Journal of Medicine	Mainly NEJM articles; some other resources	https://www.nejm.org/coronavirus
Oxford University Press	OUP articles (multiple journals and books)	https://global.oup.com/academic/category/medicine-and-health/coronavirus/?cc=us&lang=en&
SSRN	Preprints	https://www.ssrn.com/index.cfm/en/coronavirus/
medRxiv	Preprints	https://www.medrxiv.org/search/COVID

Integration of outbreak data

As seen in earlier sections, information for decision-making is drawn from multiple sources. The complex diagram shown in Figure 4, reproduced from Polonsky et al. gives some examples of different information types (colour-coded to represent background data, linelist data, contacts data, and genomic data) that contribute to understanding about an outbreak.

At present, the need to acquire this information from surveillance is paramount. In the remainder of this section we briefly identify other information issues, but the surveillance section that follows reflects the most pressing information need at the moment.

Figure 4. Example of outbreak analytics workflow, reproduced from Polonsky et al.



Additional information for assessing impact and response

This review focuses on information about COVID-19 in the population, as the key starting point of evidence to guide the response. However, decision processes require a much wider range of information that covers not only the impacts and risks of the disease itself, but also of the response. In addition, there is a need for information about interactions between the disease and the response. Examples of such information might include:

- How health services are managing (e.g. staff absenteeism, surge capacity)
- How communities are managing (community cohesion, self-imposed control measures)
- Impacts other than direct health impacts, e.g. employment and income
- Effectiveness of health promotion messaging
- Sources of online information on COVID-19 that people trust and commonly access
- Health-seeking behaviours that are not captured by health service administrative processes
- Documenting the pandemic response for future learning.

In Aotearoa New Zealand, these types of information can be derived from a wide range of sources including:

- Health delivery systems
- Qualitative research and community consultation
- Quantitative data e.g. from surveys
- ‘Big data’ e.g. social media and communications
- The Integrated Data Infrastructure (IDI)

The New Zealand Health Survey

The New Zealand Health Survey is a continuous survey of the health and wellbeing of New Zealanders. The target population is the ‘usually resident’ population, including those in non-preivate accommodation. All ages are represented. An important aspect of the survey is the sampling design, which is structured to increase representation of Māori, Pacific, and Asian populations.

The New Zealand Health Survey infrastructure and expertise is thus a valuable resource for collecting additional information needed to understand the impact of the COVID-19 pandemic and guide the response, and this work is currently being planned.

Reporting obligations and responsibilities

A final note is that, having benefited from the experience of other countries, particularly China, we have a reciprocal obligation to contribute our information about COVID-19 to the international community. The systematic collection of information in New Zealand, particularly (as in the case of FFX) information that is designed for global application, will enable this country to both benefit from and contribute to new knowledge about COVID-19.

Surveillance

Public health surveillance is the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice.[13]

Pandemic surveillance has functions additional to routine surveillance and these additional functions are considered in a later section. We first review New Zealand's existing infrastructure for influenza surveillance, as these platforms can be mobilised quickly. We then consider specific demands of COVID-19 surveillance and case-finding and the additional infrastructure and informations-gathering activities that may be required.

Influenza surveillance: Existing infrastructure

Seasonal influenza is a respiratory illness phenomenon that occurs predictably during the winter months in both hemispheres. Internationally and in New Zealand, surveillance systems monitor incidence and other parameters, with reporting cycles set to short timeframes (e.g. weekly) to inform rapid action.

Influenza surveillance both globally and in New Zealand uses surveillance case definitions developed by the WHO to identify influenza-like illness (ILI) and severe acute respiratory infections (SARI). These definitions are shown in Table 5. In the context of COVID-19 surveillance, it is important to note that the primary intention of these case definitions is not to capture every case but to maximise consistency, allowing agencies to track variations over time and by geographical region.

Table 5. WHO case definitions of influenza-like illness (ILI) and severe acute respiratory infections (SARI). Note: these definitions differ slightly from COVID-19 case definitions.

ILI case definition	**SARI case definition**
An acute respiratory infection with: • measured fever of ≥ 38 C° • and cough; • with onset within the last 10 days.	An acute respiratory infection with: • history of fever or measured fever of ≥ 38 C°; • and cough; • with onset within the last 10 days; • and requires hospitalization.

New Zealand's existing surveillance systems for respiratory viruses

ESR coordinates several surveillance systems that use data about healthcare use to identify changes in respiratory virus infections in the population. These methods generally use a sentinal approach, i.e. they are based in selected sites around the country. Settings include:

<u>Hospital and Intensive Care Units</u> (Auckland region):
This setting identifies severe acute respiratory infections (SARI), i.e. cases requiring overnight stay in hospital as well as the other features described in Table 5. This system is part of the Southern Hemisphere Influenza and Vaccine Effectiveness Research and Surveillance Project

(SHIVERS) and includes testing for a range of of viruses. This type of surveillance is designed to support pandemic preparedness as well as seasonal influenza control measures.[14]

Emergency departments (Wellington region):
This setting identifies clinical presentations of acute respiratory illness (i.e. without laboratory identification of organisms; a form of 'syndromic monitoring').

Primary care (HealthStat and sentinel surveillance, i.e. selected practices across New Zealand):
This setting identifies patients presenting in primary care with influenza-like illness (ILI). In the sentinel sytsem, selected patients are tested for influenza and non-influenza respiratory viruses.

Healthline
Healthline is a free 24-hour telephone advice service administered by the Ministry of Health. An additional number has now been set up to give health advice on Coronavirus. Calls to Healthline can be coded to identify ILI.

FluTracking (Australia and New Zealand)
FluTracking (https://info.flutracking.net/) is an online surveillance system that monitors influenza and ILI in Australia and New Zealand by crowdsourcing data. Flutracking participants sign up and then receive a weekly email during the winter months. The system collects data on demographic descriptors including ethnicity, vaccine status, symptoms, healthcare visits, postcode, and results of laboratory tests. FluTracking is now active and they have collected data for the week ending March 15. Over 27 000 people are now registered with FluTracking in New Zealand.

Flutracking was used effectively as a surveillance channel in Australia during the 2009 (H1N1) pandemic, where it proved to be accurate for detecting influenza activity and had the advantage of being less susceptible than other systems to biases from treatment-seeking behaviour and laboratory testing protocols.[15]

Other New Zealand systems for monitoring infectious diseases
COVID-19 is now a notifiable condition under the 1956 Health Act. Surveillance and monitoring of notifiable conditions is coordinated by ESR.

How will COVID-19 surveillance differ from seasonal influenza surveillance?

The WHO revised guidance on global surveillance for COVID-19 infection (dated 27 February 2020) states the surveillance objectives as follows (text reproduced verbatim):

1. *Monitor trends of the disease where human-to-human transmission occurs*
2. *Rapidly detect new cases in countries where the virus is not circulating*
3. *Provide epidemiological information to conduct risk assessment at the national, regional and global level*
4. *Provide epidemiological information to guide preparedness and response measures.*

This interim guidance also includes case definitions and recommendations for follow-up of contacts, laboratory testing, reporting to WHO, and specimen collection. The full document can be accessed on the WHO website[†] and may be subject to revisionThe above objectives indicate a need for surveillance information about COVID-19 that is different from or additional to routinely collected influenza data. COVID-19 surveillance needs to be:

- **In place as early as possible** to to establish baseline measurements for accurate interpretation of the epidemic curve (seasonal influenza surveillance is not usually operational at this time of year so we do not have a readily available historical comparison)
- **Sufficiently scaled-up** to provide an accurate assessment of incidence in the population (i.e. measurement sensitivity) and to identify cases for contact tracing and other control measures
- **Diagnostically accurate** enough to distinguish COVID-19 infections from other causes of viral respiratory tract infections, particularly as the winter flu season advances (i.e. measurement specificity)
- **Comprehensive** enough to provide critical epidemiological information about this novel virus to inform a range of control measures. There is a large amount of information still required to understand this emerging infection but not all of it is captured by existing influenza data systems. Transmission dynamics, in particular, are not well understood and this information gap makes it difficult to design control measures. Related to tracking of transmission is the need for highly active contact surveillance to support control, as illustrated by the China's experience.

COVID-19: What needs to happen and when?

Resource constraints indicate a need to align information-gathering activities to the pandemic phases where they can most usefully contribute to decisions. Figure 5 summarises recommended timeframes for surveillance and modelling of the COVID-19 pandemic. Features of this summary include:

Surveillance

- Surveillance systems need to be already activated by the time the first few cases appear. For COVID-19 this is especially important to establish a baseline
- Detailed contact surveillance (linked to EpiSurv) will be a key component of the containment response
- Surveillance should continue until no new cases are identified, but the notification system may need to remain in place to identify the emergence of future waves
- The WHO First Few X Cases (FFX) would be implemented within the notification system, reverting to standard levels of information capture once an appropriate number of cases have been evaluated; FFX has a strong focus on contacts including household and health service
- Virological surveillance is particularly important in early stages when the need is for high sensitivity case-finding, but could be stepped down over time
- Recruitment of other sources e.g. Healthline would be stepped down as the need for highly detailed information declines

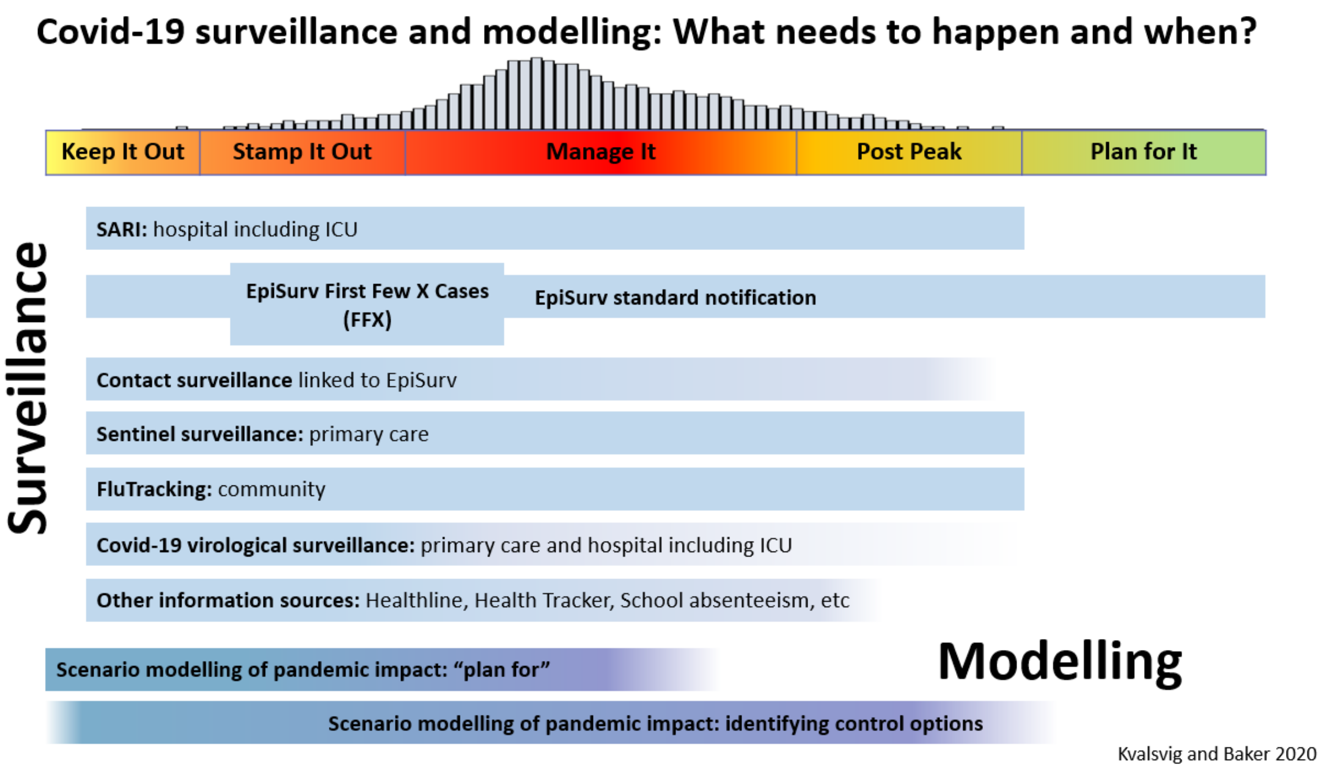
Modelling

- Scenario modelling of pandemic impact (e.g. potential numbers of ICU beds required in a day) become less important as the Manage It phase progresses

[†] https://www.who.int/publications-detail/global-surveillance-for-human-infection-with-novel-coronavirus-(2019-ncov)

- Scenario modelling of control options remains a priority for modelling, and continues through the Post Peak phase to explore the potential impact of stepping down of outbreak responses.

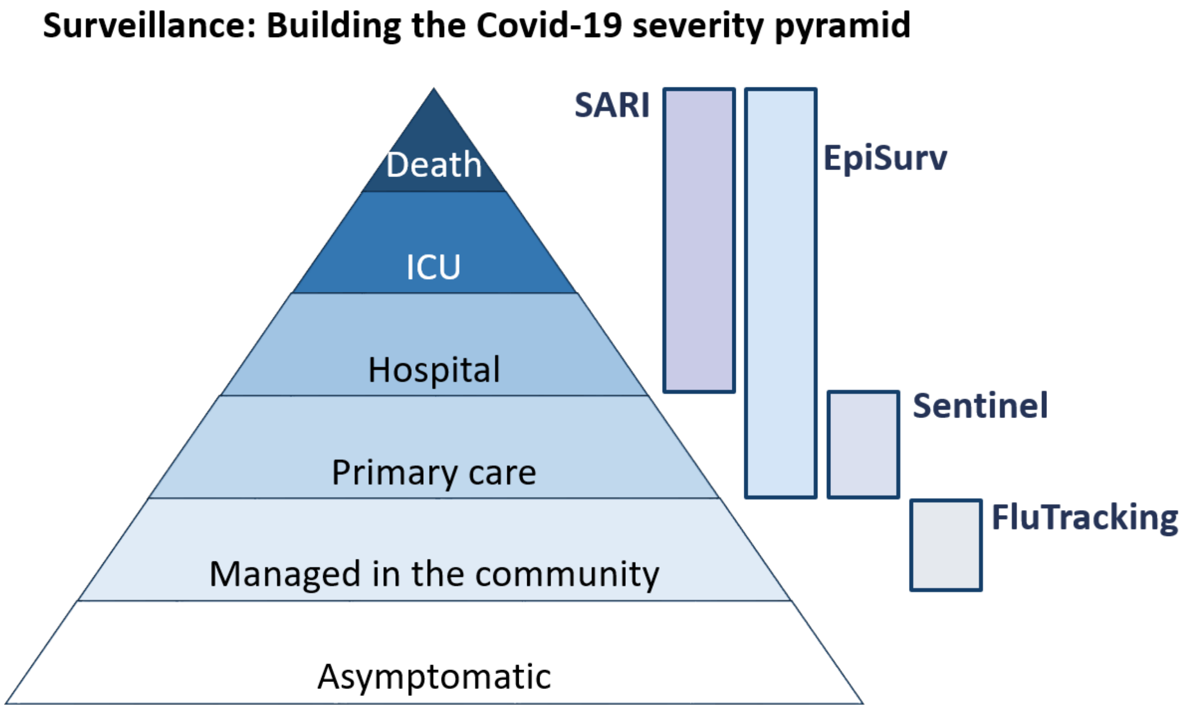
Figure 5. Surveillance and modelling requirements by pandemic phase.



Integrated information: Building the surveillance pyramid

Different surveillance acitvities generate data from different settings, with different strengths and biases. This information needs to be integrated to provide a complete view of the population. A key task for this type of analysis is contructing the severity pyramid to understand the relative proportions of severity levels in the New Zealand population, including the case fatality risk. Figure 6 illustrates this procedure for COVID-19.

Figure 6. The COVID-19 severity pyramid for New Zealand will need to be constructed from multiple surveillance sources operating at different levels.



This information, once collated, can be compared with international experience, for example as reported in Wuhan, China, where the case fatality risk has recently been estimated as 1.4% (0.9–2.1%),[16] considerably lower than previous estimates. However, case fatality risk in this pandemic is likely to be strongly influenced by contextual factors, underlining the need for local information.

In summary: current status of COVID-19 surveillance

1. Systems that **are already in place** or are able to be activated quickly include:
   - Several existing influenza surveillance platforms as outlined above
   - Virological testing for SARS-CoV-2 in major centres
   - The notification system
2. Systems that **can be scaled-up** include:
   - Any system that uses a sentinal approach (surveillance points can be increased in number and/or extended into other geographical areas)
   - Healthline
   - Laboratory testing of specimens (up to a point, as discussed above)

3. **Diagnostic specificity** can be maximised by:
    - Applying standardised case definitions
    - Recording and updating indicators of diagnostic certainty (e.g. probable, confirmed) in EpiSurv
    - Appropriate laboratory testing

- **Comprehensive information** required for effective control, particularly about transmission, is not currently available. This information can best be ascertained by a First Few X Cases (FFX) investigation implemented within the notification system. This investigation needs to commence urgently.

First Few X (FFX) Cases: Closing a key information gap

WHO guidance emphasises the importance of understanding COVID-19 transmission patterns, severity, clinical features, and risk factors as early as possible. To this end, WHO has developed a series of protocols and forms to enable data to be collected and shared within and between countries. An important component of this effort is the First Few X (FFX) cases and contact investigation.

Overview of FFX

FFX is a prospective study of confirmed COVID-19 cases and their close contacts. The aim of FFX is to identify clinical, virological, and epidemiological characteristics of cases in near real-time.

How FFX data can be used

- To refine and update recommendations for surveillance (e.g. case definitions)
- To characterise the key epidemiological transmission features of the virus
- To help understand geographic spread, severity, and impact on the community
- To inform non-pharmaceutical interventions and (in time) medical interventions

In New Zealand, we would also aim to monitor and report on inequities.

Data collection and timeline

The trigger for initiation of the study is identification of a confirmed case in the country. The study population is the first few cases of COVID-19 and their contacts; the sample size will depend on power calculations but according to the WHO protocol, previous FFX studies have been 300-400 cases.

The protocol recommends information and specimum collection at enrolment and 2-3 weeks later, but the study participants could be asked for consent to remain contactable and/or for data linkage into NZ's Integrated Data Infrastructure for further follow-up.

Data to be collected are fully itemised in the protocol form. The information is similar to that collected for other notifiable conditions in New Zealand, i.e. case identification, demographic data, symptom data, contact data. However, contact information is more detailed than is usual for notification reporting, and additional forms are available to investigate household transmission and risk factors for healthcare workers.

FFX project management

The protocol has been fully worked up and is available online.[‡] Resources include:

- A discussion of ethical considerations
- Study procedures including case definitions

‡ https://www.who.int/publications-detail/the-first-few-x-(ffx)-cases-and-contact-investigation-protocol-for-2019-novel-coronavirus-(2019-ncov)-infection

- Laboratory procedures
- Use of the Go.Data software
- Recommendations for reporting (within country and globally)
- Questionnaires and guidelines.

Value of this system for New Zealand

Transmission dynamics of COVID-19 are still not well understood, and are likely to vary from country to country. An understanding of transmission during the early phases is fundamental to the design and priortisation of control measures. We currently do not have another data source for collecting this information.

Looking forwards, this case series can be analysed as a cohort to answer additional questions about the emergence of this virus in the New Zealand population and its long-term consequences for those affected. These insights can be applied to outbreak planning into the future as a useful component of "Plan for It" activities.

Modelling

We have separately provided scenarios produced using mathematical SEIR modelling, and have discussed the principles and practice of outbreak modelling in our report "Modelling of the Potential Health Impact from COVID-19 on the New Zealand Population Using the COVIDSIM Model: Confidential Preliminary Report to the NZ Ministry of Health".

The value of outbreak modelling in directing the response

As noted in the modelling report, outbreak modelling has a number of important applications for the COVID-19 response. These include (direct quote from the report):

- The investment in, and timing of, "keep it out" interventions eg, travel restrictions and other border control measures (which are particularly relevant to island nations such as New Zealand)
- The investment in, and timing of, "stamp it out" interventions eg, contact tracing, isolation of imported cases and quarantine for those potentially exposed
- The investment in, and timing of, "manage it" interventions eg, hygiene and social distancing interventions as well as adapting health services to the increased demand
- The investment in research on treatments and vaccinations. The latter is particularly relevant if the disease is likely to become seasonal (eg, as per past pandemic strains of influenza).

The limitations of scenario modelling

- Transmission dynamics are extremely complex and require expertise and computing resources to design, run, and interpret models
- There is high uncertainty around input parameters for COVID-19 (such as the reproduction umber R_0), and small variations in parameter settings can result in profoundly different outputs where it may not be be able to be determined which is the "best guess"
- Some known biases around how input parameters are derived from early cases in an evolving epidemic, especially before diagnostic testing is available.

Evidence to action: Outbreak analytics

As noted by Morgan in May 2019, leadership decisions made during an outbreak can feel like operating in a ‘data-free’ zone where there are many important unknowns and information gaps, particularly early in the response. However, rapid decisions will need to be made in a number of areas including prioritising public health interventions, redeploying staff and resources, and developing “Plan for” scenarios based on potential impact.

Outbreak analytics is an emerging data science that is focused on informing the outbreak response.[17] One of the central challenges of implementing an evidence-based response to outbreaks is the need for data collection, analysis, and reporting to occur in real time so that decision makers have optimal situational awareness. Outbreak analytics approaches relevant to COVID-19 therefore include:

1. **The design and rapid implementation of data infrastructure** to facilitate information flow and cohesion; examples include REDcap-based contact tracing linked to EpiSurv. For a helpful evaluation of lessons learned from contact tracing during the recent measles outbreak, readers are referred to a detailed report by the Public Health Clinical Network Business Requirements for National Case and Contact Management to Inform Information System Development Working Group.[18]
2. **Descriptive analyses** based around the standard epidemiological parameters of person, place, and time. These analyses can be rapidly generated from any surveillance data, but linelist data sources such as EpiSurv will be particularly important for understanding the spread and impact of COVID-19 by **ethnicity** (with Māori and Pasifika likely to experience both higher incidence and higher severity disease); by **geographical area** (including travel history); by **age** (particularly older adults, including a need to understand whether inequites of outcome for Māori and Pasifika are worse in higher age bands, as for influenza); and by **time** (with daily updates for some analyses). Mapping is a type of descriptive analysis that can be an easily accessible way to present information (e.g. the COVID-19 dashboard operated by WHO).
3. **Quantitative analyses** provide insights that are more strongly directed towards specific questions and solutions. Examples include:
    a. **Scenario modelling** to optimise the design of large-scale control measures and develop “plan for” scenarios
    b. **Building the severity pyramid** for health services planning
    c. **Estimating transmission dynamics** with a number of applications for decision-making, as previously discussed
4. **Reporting** needs to be rapid and responsive to information needs. Formats may include automated reporting systems, highly-focused topic briefs, or regular situational reports (sitreps). Managing the COVID-19 ‘infodemic’ – an immense amount of rapidly-changing information – in such a way as to present coherent evidence to decision-makers has been a major challenge of this outbreak globally, and will require ongoing development of innovative systems for communication and collaboration.

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