

Health Sector Response to the 2019 Measles Outbreaks

Final (including response to participant feedback) 1 July 2020

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Contents

Contents.....	2
List of Figures	4
List of Tables	4
Executive Summary.....	5
1. Introduction	11
Background	11
Purpose of the review.....	11
Scope of the review	11
The Reviewers.....	12
Review approach.....	12
Acknowledgements.....	13
2. Measles Epidemiology and Vaccination.....	14
Context.....	14
Vaccination history and epidemiology of measles in New Zealand	14
Immunity and immunity gap.....	15
World Health Organisation Global Vaccine Action Plan	16
3. The 2019 measles outbreak.....	17
Epidemiology of the 2019 measles outbreak	17
TOR Question 1: Preparedness in place prior to March 2019 to respond to measles outbreaks	19
Prevention of measles outbreaks	19
Actions after a measles case is notified.....	22
Actions in case of an outbreak - Health Emergency Plans.....	23
4. Health System Response.....	28
TOR Q 2: How well did the health system respond to the measles outbreaks in March 2019 and onwards?	28
Canterbury Outbreak.....	28
Auckland Outbreak	28
The ARPHS MMR Protocol and TAG recommendations	28
Sustained Transmission of Measles in the Community in the Auckland Metro Region	29
5. Monitoring	35
TOR Q3: The effectiveness of monitoring activity	35
6. Ministry of Health Response.....	36

TOR Q4: The activation of an incident management response by the Ministry of Health on 30 August 2019.	36
i. Timeliness of Establishment	36
ii. Delivery of the Incident Management Response	39
iii. Effectiveness of Communication and Information Flow, Including Information Provided to Decision-Makers	41
i. Resourcing of the Incident Management Team	43
7. Measles Vaccines	45
TOR Q5: Supply and distribution of measles vaccines.	45
8. Equity	50
TOR Q6: Equity considerations including the extent to which at-risk groups and individuals were targeted and reached.	50
9. Conclusions	53
10. Recommendations	57
Appendices.....	60
Appendix 1: Interviewees	61
Appendix 2: List of abbreviations.....	62
Appendix 3: References	63

List of Figures

Figure 1: Measles notifications (confirmed and probable cases) in NZ from 1997 to 2014 (Source Hayman et al. Ep Inf 2017).....	15
Figure 2: Weekly numbers of measles cases reported to Auckland Regional Public Health Service (ARPHS), by District Health Board Region, 2019. (Source: NDCSM Daily Surge Report 1 January 2020 ARPHS).	18
Figure 3: The four DHB Regions as described in the National Health Emergency Plan 2004 (Source: NZ Health Partnership).....	24
Figure 4: Examples of activation thresholds for local, regional or national response to emergencies. (Source: Auckland District Health Board Health Emergency Plan 2014-2017).....	25
Figure 5: Weekly number of MMRO doses given to children under 12 months old in the Metro Auckland region. (Source National Immunisation Register, provided by ADHB).	49
Figure 6: Weekly number of MMR doses given in the Metro Auckland region, by age. (Source National Immunisation Register, provided by ADHB).....	49

List of Tables

Table 1: Timeline of key events	36
Table 2: TAG/EAG recommendations 3 September	39
Table 3: TAG/EAG recommendations 10 September	40
Table 4: Estimated Incidence of Measles in New Zealand by ethnicity.....	50

Executive Summary

In 2019, New Zealand experienced its largest measles outbreak since 1997, after at least 18 virus introductions, with 2185 notified cases spread over 17 District Health Board regions. The outbreak started in February and lasted more than a year. The majority of cases were reported in the Auckland region. Māori and Pacific populations were disproportionately affected with incidences 4 times and 14 times (respectively) the incidence in the New Zealand European population.

The measles outbreak has now ended. A formal evaluation is yet to be completed.

The Ministry of Health commissioned this review which reports to the Director General, to make an informed assessment of New Zealand's preparedness and response to the 2019 outbreak focused on the greater Auckland region and with special consideration for equity issues. Specifically, the review team was tasked with:

1. reflecting on how the system responded, and continues to respond, to the outbreak, and to identify opportunities to strengthen future responses; and
2. identifying what went well and what could be improved to help manage future disease outbreaks.

This report is based on a desktop review and interviews with, and information provided by key informants. The information was collected and analysed using the six elements of the scope of the review outlined in the Terms of Reference. These were evaluated against national and international measles protocols and guidelines, as well as various outbreak management and equity evaluation frameworks.

Measles Vaccination History and Epidemiology New Zealand

Due to its highly infectious nature, measles effectively seeks out unvaccinated individuals and is considered to be the 'indicator disease' able to identify individuals and subpopulations who have not been reached by immunisation programmes. Population immunity of around 95%, that is evenly distributed throughout the population, is necessary to interrupt measles transmission after introduction of the measles virus.

The measles vaccine for children was introduced in New Zealand in 1969. Until 2005, when a National Immunisation Register was introduced, there was no central register and the coverage was unknown. It is estimated that, of the New Zealanders born between 1980 and 2005, around 80% are immune, leaving a large and well-known 'immunity gap' in the population. The coverage in New Zealand children has increased to over 90% after introduction of the NIR, however it has never reached the required 95%. Immunisation coverage has remained insufficient amongst Pacific and Maori children.

Regular measles outbreaks have therefore continued to occur over the past decades. These have been followed by ad hoc vaccination campaigns.

The World Health Organisation Regional Verification Committee for Measles and Rubella Elimination in the Western Pacific (RVC) granted New Zealand 'measles and rubella elimination status' in 2017, defined as 'the absence of endemic measles transmission for at least 12 months in the presence of a well performing surveillance system'.

In recent years, and following a world-wide trend, the vaccination coverage in the National Immunisation Programme has declined.

The only way to prevent future measles outbreaks is to increase the immunity of children and to close the 'immunity gap' in the New Zealand population.

In response to a report from RVC in 2017, the Ministry of Health initiated an analysis on various strategies to close the immunity gap and shared this document with the sector at a symposium in 2017. In 2019, however, only some of those recommendations had been actioned. The actions taken were insufficient, or not sufficiently timely, to close the immunity gap and prevent the 2019 measles outbreak.

Infectious disease control and preparedness to respond to measles outbreaks prior to March 2019

Measles is a notifiable disease. Each case of measles has to be reported to the regional Public Health Unit (PHU), who then report cases for national surveillance. The PHU reports to ESR for national surveillance, and is responsible for source and contact tracing and for all other actions concerning cases and contacts (vaccination, isolation, quarantine) to prevent spread of the disease.

The Coordinated Incident Management System (CIMS) structure is the model adopted in New Zealand for the coordination of an emergency; it forms the basis for operational response. Emergency services at all levels use a CIMS structure to staff their Emergency Operations Centres allowing the multiple agencies or units involved in an emergency to work together as a team and to facilitate communication between the organisations involved.

The Auckland Regional Public Health Service (ARPHS) had well prepared standing protocols and guidelines for source and contact tracing of measles. ARPHS communicated to the Ministry of Health that they had tailored a 'Measles, Mumps and Rubella' protocol for outbreaks, adjusting this in the beginning of the outbreak. Three phases for action in the outbreak management response across the Metro Auckland region were introduced, 'Stamp it Out' (objective: to trace and protect all contacts to elimination the disease); 'Manage it' (objective: to mitigate disease by targeting risk high groups when there is widespread community transmission) and 'Outbreak and Epidemic Management' (objective: to increase the immunity in the entire population when there is a rapid increase in cases and focused control is no longer likely to contribute to outbreak management).

In the Auckland region, frequent and recent outbreak exercises, and consequent adaptations of emergency plans, had been published on the DHB websites. However, by 2019, the ADHB Health Emergency Plan was out of date.

At the National level, only two exercises had been held in the preceding decade. The recommendations of the most recent exercise in 2018 had yet to be implemented in the Emergency Plan that was used for the measles outbreak.

Government had devolved vaccine management and procurement to PHARMAC and DHBs in 2012, and national surveillance and intelligence to ESR in 2002. Healthline had no formal role in the response but had an emergent important national function. Healthline became involved in outbreak management identifying gaps and leveraging their strengths that included national overview of communications, intelligence, upsurge through communication, and help with contact tracing communicated through the media (25-29). Organisations with important devolved roles (Healthline, ESR and PHARMAC) were not part of the official outbreak plan.

Frequent restructuring within the Ministry over the previous decade(s) created high turnover of staff and teams that were not at full capacity. Capable teams were in place in 2019 but lacked experience and training in outbreak management. Many initially did not know about Emergency Plans and had not been trained in outbreak management. In the Auckland region, ARPHS and the three DHBs had large financial deficits. ARPHS was understaffed.

Health system response to the measles outbreaks in March 2019 and onwards

A measles outbreak occurred in Canterbury from February to May 2019, with a total of 39 cases. On 12 March, the Canterbury DHB made an announcement to media that 100,000 to 125,000 people would need to be vaccinated. Community Public Health (PHU Canterbury) worked with primary care services to deliver a vaccination programme, with 22,000 MMR vaccinations delivered during the outbreak period after which the outbreak subsided.

In metro Auckland, the PHU (ARPHS) established an Incident Management Team (IMT) on 14 March. Later ARPHS established a formal regional Technical Advisory Group (TAG) function. In April, the TAG recommended that an extra MMR0 vaccine be given to infants in the Auckland region, however this was not implemented due to concerns about primary care capacity and vaccine stock. The IMT progressively engaged the three DHBs according to where the outbreak was identified (focusing first on ADHB and WDHB), and upscaled in different modified ways. However, at no stage was it upscaled to the official regional Northern Region Health Coordination Centre (NRHCC) as described in the Ministry's outbreak plans, which constitutes the 4 DHBs and 2 PHUs in the Northern region.

In the Auckland region, the first (solitary) case was reported in CMDHB on 27 February. The second case, which was the first with secondary spread, was reported on 12 March in the ADHB region, and the outbreak then moved to the WDHB region with further cases reported in the CMDHB region on 1 May, where eventually the majority of cases would be reported.

By 15 May, when 53 cases were reported, ARPHS had experienced high workloads for many weeks and decided to move to Phase 2, and subsequently to Phase 3 on 19 June, when 113 cases had been reported. At that point, ARPHS indicated to the review that they had run out of resources to trace and follow up all contacts. Because the DHBs, are responsible for vaccination coverage, the shift to Phase 3 also required a shift in responsibility and leadership from ARPHS to the DHBs and ADHB installed an incident management team.

In the CMDHB district, on 19 June when Phase 3 started, the first 40 cases had been reported(1). CMDHB would become the epicentre of the outbreak with 1152 cases that predominantly affected the Pacific community in South Auckland.

Because of the March Canterbury outbreak, there had been fears that there were insufficient measles vaccines in the country to use in the Auckland outbreak. At the end of May, the Ministry and PHARMAC approved a re-allocation of 40,000 additional vaccines that had been earmarked for Canterbury to the Auckland outbreak.

In June and July, local Auckland vaccination campaigns in response to the outbreak were developed, with drop-in clinics held in Counties Manukau and Waitematā DHB regions. This regional campaign was ad hoc and lacked time for good preparation.

By mid-July, only 9,000 doses of the 40,000 allocated vaccines had been distributed in Auckland.

On 30 August, when 719 cases of measles had been reported, the Ministry's National Health Coordination Centre (NHCC) was activated. A week later this was followed by the physical set up of

the NRHCC (prior to this it was a virtual team). The NRHCC adopted a modified form of the Northern Region response required by the National Health Emergency Plan - the Northland DHB and PHU were not involved.

The activation of the NHCC received a great deal of media attention. In the same week, the Ministry and both the responsible Associate Minister of Health and the Prime Minister, encouraged all unvaccinated people under 50 years old to get vaccinated.

The response to these national announcements was dramatic, with 54,000 vaccines being ordered and distributed in 5 days. In the first week of September, several providers ran out of stock, and this led to increased media attention.

On 16 September 52,000 new doses of vaccine arrived in the country.

Most of September and October was used for vaccine stock management. Frequent changes were made to the priority groups that were targeted for vaccination in response to the limited remaining vaccine stock. The eligibility changes confused vaccinators and the public and this was reflected in the media.

Throughout, the system lacked uniformity in public communication and upscaling procedures. Outbreak plans made in the preparedness phase were not followed. This hampered the smooth transition of outbreak management from leadership by individual DHBs, to regional leadership and then to leadership of the national response. Communication lines between organisations were often unclear to those involved. The mandate for action and responsibility for upscaling at different stages of the outbreak were not able to be identified during this review.

Until 30 August, communication initiatives to the public and health sector were undertaken at all levels of the health system and on many websites. There were no standardised national key messages. There was no clear nationally coordinated public information about the measles outbreak posted online.

All interviewees, regionally and nationally, reported the upscaling should have occurred much earlier in the outbreak. Before the NHCC and NRHCC were activated, *'everybody and nobody was responsible for the overall control of the outbreak'*. There were misunderstandings about the roles and responsibilities in an outbreak situation. Several key Ministry staff believed that outbreak control was devolved to DHBs as a regional task and that the Ministry's role was predominantly one of stewardship, in support of DHB action.

The outbreak response (at all levels) followed the outbreak rather than getting ahead of it. The first national TAG/EAG meeting on 3 September, held at the height of the outbreak with 719 reported cases, advised DHBs to ensure that outbreak response plans were up-to-date. Suggested triggers for the escalation of the response were made. These included sustained spread in other regions of NZ, sustained spread of cases in early child care centres in a region, an increase in hospitalisation rates, or a fatality. These are tasks that belong in 'preparedness', and not in the response phase of an outbreak.

The Ministry's TAG/EAG also recommended MMR0 be given in the Auckland region, and this was implemented. In their second meeting, on 10 September, the TAG/EAG recommended that a national catch up campaign should commence as soon as possible when vaccine supply was secured. It further recommended strong, clear and consistent messages were needed for health professionals and the public. These messages needed to consider who should seek immunisation, where

vaccination was available, and who should not actively seek immunisation. These actions were deemed necessary to maintain confidence in the vaccination programme.

Equity considerations

Early in the outbreak, inequities in the disease burden became clear. Pacific and Māori populations experienced the highest rates of measles and hospitalisations. The steep increase in the number of Pacific cases occurred in June, by which time there was significant community transmission. This coincided with the move to outbreak management phase 3, and meant that Auckland's Pacific communities did not access the level of contact tracing provided to other (earlier affected) communities, and were left awaiting the implementation of large scale vaccination (outreach) campaigns. In the rest of New Zealand, with fewer measles cases, public health units were still actively tracing, vaccinating and quarantining contacts.

The effective implementation of MMRO was required to protect the high number of at-risk infants in the younger Māori and Pacific cohorts, that were reflected in the high case numbers and hospitalisations for these groups.

Targeted vaccination prioritised groups that were most impacted by the outbreak, including children aged under 4 years, Pacific and Māori and young people aged 15-29 years. In practice, however it was problematic to turn away people outside these risk groups.

There were difficulties maintaining the period of quarantine for many contacts of measles cases. As two thirds of the measles cases were from deprivation decile 9 and 10, for many people on a weekly wage it was not practicable to comply with quarantine measures. Work and Income New Zealand (WINZ) requires a minimum of 2 weeks stand down to give approval of an emergency grant. For measles, 2 weeks is the maximum time people are required to be in quarantine.

Translated information about measles that were made available for the public were delayed. Translators with the ability to communicate in the preferred languages of measles cases and their families and contacts, were not always available to support public health staff. There was a clear difference in access to health information for Pacific and Maori groups compared with the total population.

The populations that were disproportionately affected by the measles outbreak had limited input or involvement in providing strategic advice, outreach services and communication strategies.

Recommendations (summarised)

1. Measles immunisation rates must urgently improve to prevent outbreaks and the emergence of new immunity gaps in adults in the future. The declining coverage in the childhood vaccination programme is a concern.
2. Consider combining outreach vaccination for at risk Pacific and Maori children with 'catch-up' vaccination of adults to close the immunity gap and improve childhood vaccination coverage.
3. Ensure registration of vaccinations occurs during reactive large-scale immunisation campaigns. Reactive ad hoc vaccination on a large scale in outbreak situations, which has happened frequently over decades, carries the risk of inaccurate immunisation registration. Consider the development of a new comprehensive national vaccination register for vaccinations given in all different settings.

4. Stronger national and regional leadership and coordination of communicable disease control across the system is urgently needed. The Ministry needs to consider how to achieve a clearer/stronger national chain of command and coordination of infectious disease control and outbreak management at a national level.
5. Consider clarification of command and leadership functions for infectious disease control and outbreak management in regions where one PHU works with more than one DHB.
6. Develop a generic outbreak management plan. Many processes in outbreak management are similar. Describe the roles, responsibilities, accountabilities, communication and command lines of and between all stakeholders on a national and a regional level. The same uniform phases of outbreak management and terminology and abbreviations should be used throughout the system to enhance communication in case upscaling is needed. Additional disease specific protocols and guidelines can be developed, e.g. for measles and influenza pandemics that should be used by all districts.
7. Clarify and/or officially mandate the roles and responsibilities of organisations such as ESR, PHARMAC, IMAC and Healthline that have been devolved significant functions in outbreak management on a regional as well as a national response level.
8. Centralise and standardise functions and information (standard communication materials, framework for outbreak management, social media communication). This is more efficient and will lead to greater uniformity and facilitate smooth upscaling.
9. Consider the role of Maori and Pacific leaders and providers that are already working effectively with communities at risk of infectious disease outbreaks. A culturally appropriate response is needed in infectious disease control to achieve equitable service outcomes. This requires involvement health care workers with the appropriate cultural and linguistic competencies.
10. Consider for every outbreak threat, convening one initial entire outbreak management team meeting at an early stage, to ensure all possible expertise is represented and informed. Decide together how to continue.
11. Consider shared and coordinated decision making by the responsible authorities to determine whether, which, and how many vaccines are kept in stock for emergencies, and how to deal with unexpected situations. This should occur in the preparedness phase and not during an outbreak situation.
12. Make optimal use of digital solutions at all levels of the health system. Develop integrated national databases. Develop generic uniform applications that are flexible and easy to adapt to changes and upscaling possibilities (contact tracing). Digitalise outbreak management plans. Uniform systems and uniform input facilitate uniform output.
13. Prioritise equity considerations with a focus on Maori and Pacific populations who continue to bear the heaviest burden of infectious disease outbreaks in New Zealand. The Ministry's statement that '*... Equity recognises different people with different levels of advantage require different approaches and resources to get equitable health outcomes...*' needs to be reflected in the implementation of the measles immunisation programme and emergency outbreak response management.

1. Introduction

Background

In 2019, New Zealand experienced the largest measles outbreak since 1997. A total of 2,185 cases were reported, the majority in Auckland, specifically in the Counties Manukau and Waitemata district health board areas. There were significant disparities by ethnicity, with high incidences in Māori and Pacific populations. The highest number of cases occurred in Pacific peoples.

New Zealand has been classified by the WHO as 'measles free' since 2017. Internationally however there has been a resurgence of measles, with outbreaks in many countries around the world, leading to importations. All domestic measles cases in New Zealand since 2012 have been traced to overseas importation.

The 2019 outbreak has now ended and a formal evaluation is yet to be completed. The Ministry of Health commissioned this report to the Director General, to make an informed assessment of New Zealand's preparedness and response to the 2019 outbreak.

Purpose of the review

The terms of reference state that the purpose of the review was to:

- (i) 'reflect on how the system responded and continues to respond to the outbreak; and to identify opportunities to strengthen the future responses, and
- (ii) identify what went well and what could be improved to help manage future disease outbreaks.'

Scope of the review

With regard to national outbreaks of measles, with a focus on the greater Auckland region, in the calendar year 2019, an assessment of:

1. The preparations in place prior to March 2019 to respond to possible measles outbreaks given the context of rising numbers of measles cases worldwide.
2. How well the health system responded to measles outbreaks in March 2019 and onward.
3. The effectiveness of monitoring activity.
4. The activation of an incident management response by the Ministry of Health on 30 August 2019 with regard to:
 - i. timeliness of establishment
 - ii. delivery of the incident management response
 - iii. effectiveness of communication and information flow, including information provided to decision-makers
 - iv. resourcing of the incident management team.

5. Supply and distribution of measles vaccines.
6. Equity considerations including the extent to which at-risk groups and individuals were targeted and reached.

The Reviewers

Dr. Gerard Sonder is a Public Health Physician and infectious disease Epidemiologist from the Netherlands. He worked at the Public Health Service, Department of Infectious Disease Control Amsterdam from 2000 to 2018 in different roles, heading the department from 2013, in which he was responsible for infectious disease control and outbreak management for the Amsterdam region. He has been associated with the Academic Medical Center (AMC) and the University of Amsterdam since 2009 for the purpose of research and publication. His research focuses on the epidemiology and control of infectious diseases and the evaluation of public health guidelines for Infectious Disease control including Travel Medicine. He holds a master's degree in Biology as well as a PhD in the evaluation of Public Health Programs for Infectious Diseases. Gerard relocated to Wellington New Zealand in October 2019 and holds a part-time position with the University of Otago as a senior lecturer for the postgraduate Travel Medicine qualifications, and works as consultant in the response to COVID-19 for Pacific populations and the development of national New Zealand vaccination guidelines for travellers.

Dr Debbie Ryan is the principal of Pacific Perspectives, a policy and research consultancy specialising in Pacific health. Debbie has extensive experience in the health sector as a general practitioner, manager, senior public servant and researcher. Her research interests have focused on equity and health system and health services responses to minority groups. Recent sector roles include leadership of the Ministry of Health's COVID19 Pacific response team, the *Tofa Saili* report on Pacific health for the Health and Disability System Review and HRC funded research in to Pacific peoples experiences of health services. She is a registered medical practitioner with qualifications in medicine, public management and company direction. Debbie was awarded MNZM (Member of the New Zealand Order of Merit) in 2018 for services to the Pacific community and health.

Review approach

This report is based on a desk review of documentation obtained from the Ministry of Health and the contributing organisations (Appendix 1), peer reviewed articles and reports published by official bodies (Appendix 3) and interviews and information and material provided by key people.

A large amount of material was collected and analysed using the Terms of Reference questions as a framework. Assessments made by the reviewers were evaluated against both national and international protocols and guidelines, official lines of communication and hierarchies as described in various emergency and outbreak plans, scientific publications and our professional experience both in New Zealand and overseas with infectious disease control, outbreak management, public policy, health system management and service evaluation and how to improve equity for disadvantaged groups. The content of this report is based on the review carried out in the time allocated by the Ministry. The review commenced on 14 February. This coincided with the run-up to the COVID-19 epidemic and the report of the first COVID-19 case in New Zealand on 28 February. Data collection was mostly completed on 24 March, a day before the lockdown.

Initial findings were presented to the Ministry of Health on 7 May 2020.

Acknowledgements

The Reviewers would like to thank all interviewees and contributors for their professionalism and cooperation with the review. We acknowledge their contribution occurred when most were frontline in the lead up to the COVID-19 preparedness and response.

2. Measles Epidemiology and Vaccination

This section provides an introduction to measles and vaccination, the history and epidemiology of measles in New Zealand and the global context for action to prevent measles outbreaks.

Context

Measles is one of the most contagious diseases that affects humans. Complications of measles include pneumonia, diarrhoea and encephalitis. Case fatality ratios vary from 0.1% in the developed world to 15% in the less developed world. The more contagious the disease, the higher the population immunity needed to stop transmission and to prevent outbreaks. Population immunity of around 95% that is evenly distributed throughout the population, is considered necessary to interrupt measles transmission after any introduction of the measles virus. Due to its highly infectious nature, measles effectively seeks out unvaccinated individuals and is considered to be the 'indicator disease' able to identify individuals and subpopulations who have not been reached by immunisation programmes.

Measles vaccination coverage serves as an indicator of the quality of immunisation programmes, while the epidemiology of measles cases highlights populations or areas in which immunisation services require further strengthening.

Before the introduction of vaccination, measles was a childhood disease. Because it is so contagious, almost every child got the disease and, if cured, was immune for life. The introduction of measles vaccine has tremendously reduced circulation, complications and death from the measles virus. However, introduction of vaccination in countries with suboptimal coverage has allowed unimmunised individuals to remain susceptible to measles into adulthood. This has resulted in a much wider age distribution of measles cases than had historically been the case (2).

Vaccination history and epidemiology of measles in New Zealand

The measles vaccine was introduced in New Zealand in 1969 for 10 months to five-year-old children and at-risk children up to 10 years old. Although the coverage until 1980 is not known, coverage was always too low to alter the 2-3-year epidemic cycle (3).

In 1974, immunisation at 12 months old was recommended and in 1978 a five-year measles elimination programme was implemented (coverage not known), before a single dose of the combined measles-mumps-rubella vaccine (MMR1) was introduced in 1990. A second MMR dose (MMR2) was introduced in 1992 for 11-year olds, in response to a measles outbreak in 1991. In an effort to improve coverage, MMR1 was shifted from 12 months to 15 months in 1996, to allow immunisation to be given alongside other childhood vaccines. This change was planned prior to, and then implemented during the large 1997 outbreak (4).

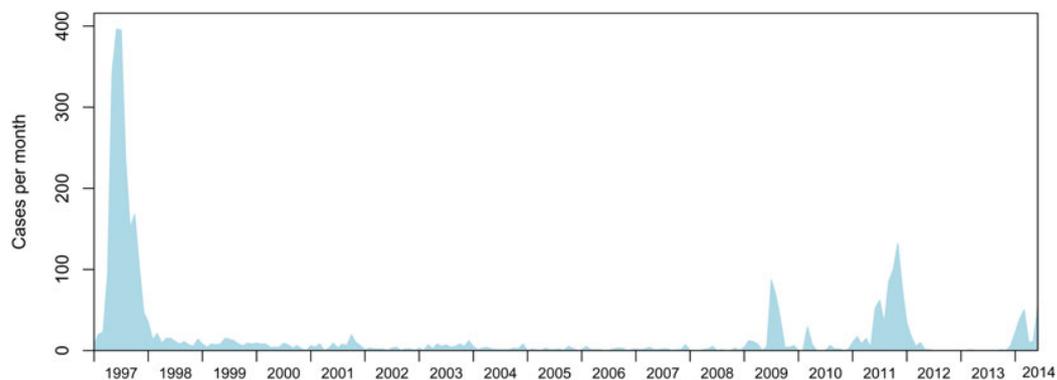
In the 1990s, vaccination coverage has been only just above 80% for MMR1 (95% is required to prevent measles outbreaks); the coverage for MMR2 in the 1990s is not known.

A mathematical model for the measles dynamics in NZ was developed in 1996 (3), that was used to successfully predict the epidemic of 1997. This epidemic was curtailed by a mass immunisation campaign targeted at children under 10 years old.

Following the introduction of the National Immunisation Register (NIR) in 2005, vaccination coverage has improved, but remains sub-optimal with rates of between 87% and 93% for MMR1. For MMR2 the coverage is between 83% and 88%. Coverage rates have been close to, but have never reached the national target of 95%. Furthermore, equity gaps based on ethnicity, socioeconomic status and region have persisted (5).

Since the last large measles outbreak in 1997 and until 2018, there have been regular outbreaks in New Zealand after several measles virus introductions from overseas. Significant outbreaks have occurred in 2009, 2011-2012 and in 2013-2014 (6) and in 2016 (7) with incidences of 54, 120, 58 and 21 per million population per year.

Figure 1: Measles notifications (confirmed and probable cases) in NZ from 1997 to 2014 (Source Hayman et al. *Ep Inf* 2017).



Hayman et al (6) analysed all 1137 reported measles cases involved in the outbreaks between 2007 and June 2014. The vast majority of cases were seen in very young age groups; those children who had yet to receive their first MMR vaccination. Since 2007, an age shift is reported; although the majority of cases were still in very young children, a greater number was reported in teen aged children/young adults, which reflects under-vaccination in these age groups. Analysis by ethnicity and deprivation index, shows that the majority of cases were among European New Zealanders, especially wealthier Europeans aged 5-17 years. These are likely groups that refuse vaccination. Looking at incidence (cases per capita) the highest incidence was reported in the youngest, most economically disadvantaged, Pacific population.

Immunity and immunity gap

Before the National Immunisation Registry (NIR) database was established in 2006, there was no central/national registration of MMR vaccination. Mass vaccinations were carried out every few years. They were ad hoc and in response to outbreaks.

An estimate of the immunity of the NZ population has been made using historical vaccination data in reports to WHO (2001-2005) and data taken from the NIR 2006-2012, combined with serosurvey data on measles immunity in blood samples collected in 2004-2005 (4). These results were confirmed in a more recent serosurvey (blood samples collected 2014-2015), that found only 77% (87% if unequivocal test results were also considered immune) of adults aged 15-44 years had immunity to measles. Analysis by age, found that measles immunity was lowest in those 15-34 years (birth cohorts 1980-2000) (73% and 84% respectively if equivocal results were also considered

immune). Analysis by ethnic group, found the lowest immunity was in Asian (77% and 84%, respectively) and Pacific people (70% and 82%, respectively) (8).

Despite a higher vaccination coverage in recent birth cohorts (from 2005), overall immunity against measles remains ca. 90%, and is lower in people born between 1982 and 2005 - the cohort identified as the 'immunity gap'. Furthermore, immunity is not evenly distributed throughout the country, which makes New Zealand prone to measles outbreaks following any introduction of the virus (4).

World Health Organisation Global Vaccine Action Plan

The Global Vaccine Action Plan (GVAP), endorsed by the 194 Member States of the World Health Assembly in May 2012, is a framework to prevent millions of deaths by 2020 through more equitable access to existing vaccines for people in all communities (9).

Under the Global Vaccine Action Plan, measles and rubella are targeted for elimination in five of the six WHO Regions by 2020.

The World Health Organisation (WHO) defines measles elimination as '... the absence of endemic measles virus transmission in a defined geographical area (e.g. region or country) for at least 12 months in the presence of a surveillance system that has been verified to be performing well.'

As a member of the WHO Western Pacific Region, NZ committed to measles elimination in the WHO Western Pacific Region.

Overall, the world has made tremendous progress in the control of measles. By 2019, 43% (89 of the total 194 countries) have achieved elimination status. Deaths from measles have decreased by 80% from 2000 to 2017 as a result of vaccination. This has averted an estimated 21 million deaths since 2000.

Despite this progress, vaccination coverage has levelled off in the past eight years and since 2017 there has been a resurgence of measles with outbreaks in many parts of the world with resultant importations to many countries. The reasons for these outbreaks include increased conflict and migration, climate change, increasing inequities in wealth, health and security, alongside increasing circulation of misinformation leading to distrust and reduced vaccination uptake (5).

In 2016, New Zealand's Ministry of Health established the New Zealand National Verification Committee (NVC). The NVC was tasked with annual reporting of the progression towards measles and rubella elimination to the WHO Regional Verification Committee (RVC) for measles and rubella elimination in the Western Pacific. Following the annual meetings of the RVC, recommendations are made to all state parties.

The RVC officially granted New Zealand 'measles and rubella elimination status' in 2017 (10). The RVC report cautioned that, despite having interrupted transmission of endemic measles, significant immunity gaps remained in New Zealand among demographic and geographic risk groups, in particular older adolescents and young adults, and the Māori population. The RVC further expressed concern that unless urgent action was taken to fill these immunity gaps, New Zealand would continue to be at risk of measles outbreaks from importation.

'...RVC also acknowledges the programmatic challenges of achieving high coverage of immunisation directed at young adults, but notes that the significant population of measles and rubella-susceptible older adolescents attending high school could still be reached and protected by vaccination.'

3. The 2019 measles outbreak

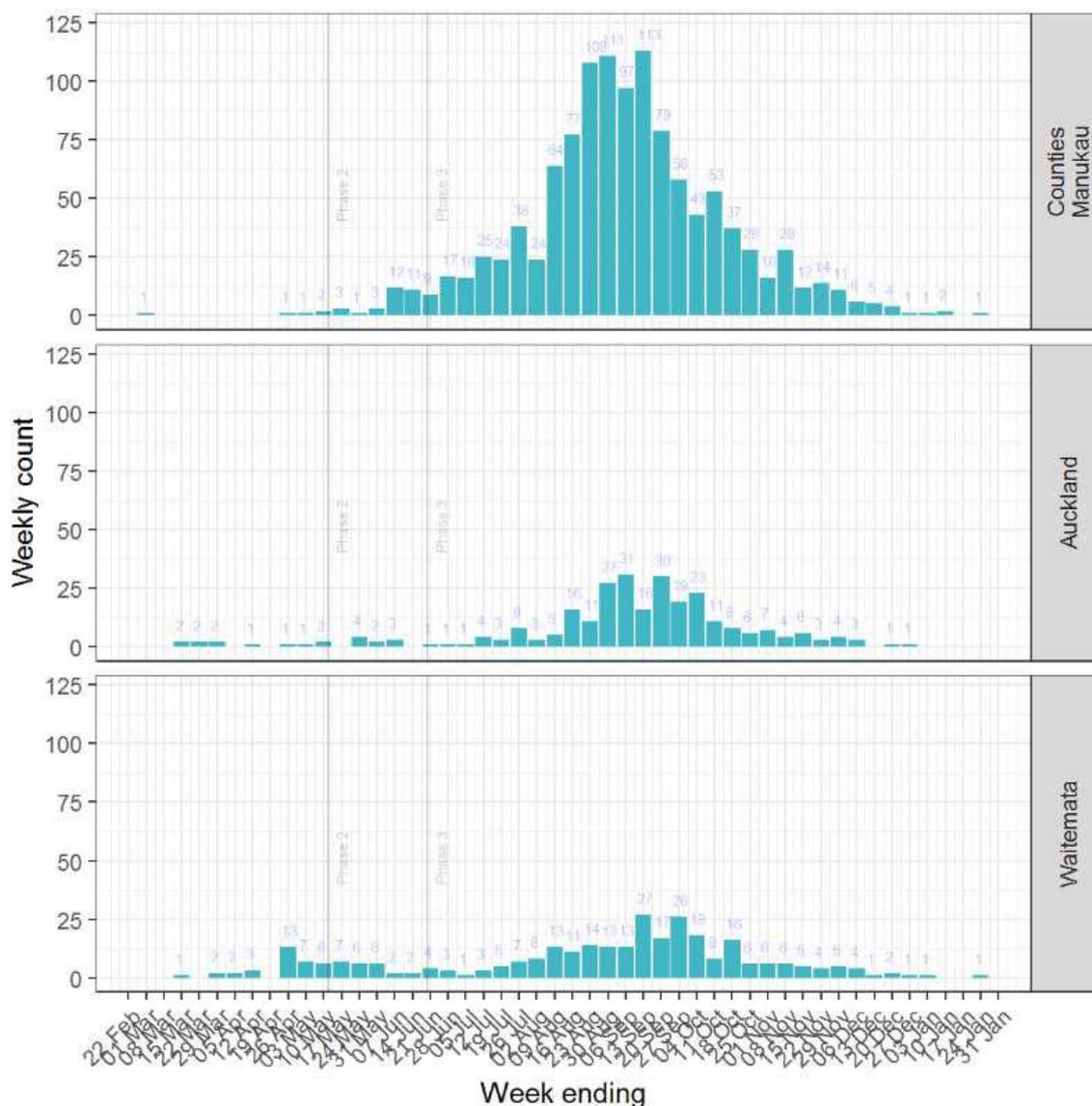
This chapter begins with a brief summary of the epidemiology of the 2019 measles outbreak. The Terms of Reference Question 1 is addressed through a description of the preparations in place to respond to a measles outbreak, including prevention of a measles outbreak, actions after a measles case is notified, actions in the case of an outbreak and Health Emergency Planning.

Epidemiology of the 2019 measles outbreak

The largest measles outbreak for more than two decades occurred in New Zealand in 2019. In January, 14 measles cases were notified, 12 in Waikato and 2 in Bay of Plenty district, with no further cases notified in these districts for a few months after.

The first case in the Canterbury district was notified on February 12, leading to an outbreak of 39 cases that was declared officially over on 16 May 2019. On 14 March, the first cases of measles with secondary spread were notified in the Waitemata and Auckland district health board areas. This eventually led to a large outbreak in the Metro Auckland region, with most cases reported in the Counties Manukau district.

Figure 2: Weekly numbers of measles cases reported to Auckland Regional Public Health Service (ARPHS), by District Health Board Region, 2019. (Source: NDCSM Daily Surge Report 1 January 2020 ARPHS).



A total of 2,185 confirmed cases were reported in New Zealand in 2019. Of these, the majority (85%) were from the 4 northern DHB regions: Counties Manukau, Waitemata, Auckland and Northland. In 2019, 17 of the 20 DHBs reported one or more cases of measles. The peak of the outbreak occurred in mid-September, when the majority of cases were notified.

Seven hundred and sixty-eight (35%) patients were hospitalised, 520 (24%) were under 2 years old. The majority (68%) of the cases were between 10 and 50 years old. The high number of cases (69%) that had never been vaccinated, reflects the group referred to as the ‘immunity gap’ in the New Zealand population. This is the cohort of people born between 1982 and 2005, at a time when vaccination coverage rates were low. They were under- or unimmunised and many had unknown immunisation records. Māori and Pacific were likely over represented in this group.

The analysis of the cases by ethnicity (using prioritised ethnic group), shows in absolute numbers, the majority of cases were among Pacific peoples (41%); European or other (26%); Māori (24%); MELAA (Middle Eastern/Latin American/African) or unknown (2%) (11).

Although the data for the 2019 measles outbreak has not yet been formally analysed, our review suggests that the measles cases were older when compared to previous outbreaks.

In 2019, the combination of many introductions into an under-vaccinated population led to significant spread of disease with an incidence of 444 cases per million. The Pacific population was most affected with an estimated incidence of 2,340 per million, followed by the Māori population (674 per million), the European NZ population (171 per million) and the 'other' populations (67 per million).

Typing the measles viruses with genetic sequence techniques provides information on the clustering of viruses. As measles viruses genetically change very slowly when transmitted, all viruses in an outbreak that belong to the same genetic type belong to the same cluster. Analysis of the types of the measles viruses completed up to August 2019, reveals that 18 different measles viruses were introduced, 13 of which have led to further spread and separate outbreaks (personal communication, ESR). For the purposes of this review we have considered that this constituted one (or two) large outbreaks.

TOR Question 1: Preparedness in place prior to March 2019 to respond to measles outbreaks

Prevention of measles outbreaks

In a highly immunised country without endemic transmission, there are essentially two possible ways to prevent measles outbreaks: the first is to prevent measles virus importation into the country. The second is to stop the virus from spreading and causing outbreaks following a virus introduction.

Prevention of virus importation

The risk of importation of measles into New Zealand depends on the incidence of measles and the success of elimination programmes in the source countries of travellers into New Zealand. Although the world has made tremendous progress towards the elimination of measles, for different reasons, vaccination coverage has levelled off in the past decade. There has been a surge in measles cases worldwide, with 140,000 measles deaths in 2018 (12).

Preliminary data shows that reported cases in the first quarter of 2019 rose by 300% compared to the same period in 2018 (13).

WHO recommends that a 95% coverage with two doses of measles vaccine is required in each country and in all communities to prevent disease.

The risk of measles import to New Zealand has increased over the past years due to a combination of factors:

- Measles has not been eliminated in the world and there has been a recent upsurge of cases.
- Steadily increasing numbers (4% annually) of travellers worldwide, and a steep increase in international arrivals in New Zealand (from 3.1 million in 2000 to 7 million in 2018).
- Measles is contagious before the typical (rash) symptoms appear. As such it is impossible to screen and stop travellers who may be infected at the border.

This is confirmed by the many introductions of measles to New Zealand by travellers. In 2018, 30 cases of measles were reported after 8 separate introductions by travellers; in 2019, until August, there were at least 18 virus introductions.

The only way to prevent outbreaks in the future is to increase the immunity of children and to close the immunity gaps in the NZ population.

Improving immunisation coverage in New Zealand

The National Immunisation Registry (NIR) was implemented by the Ministry in 2005, with the aim of improving childhood vaccination coverage. The NIR was intended to provide greater insight of vaccination coverage in new birth cohorts and support the Ministry to closely monitor childhood vaccination coverage. Since 2005, all children are entered in the NIR at birth, as are all the National Immunisation Programme (NIP) vaccinations.

Initiatives that have led to improved vaccination coverage in New Zealand include regular reporting of coverage in different regions, national childhood immunisation targets set as part of health system performance measures, and incentive payments to general practices.

The responsibility for immunisation and vaccination management in New Zealand changed in 2012 as part of health system reforms. On 1 July 2012, the Ministry of Health, PHARMAC and the District Health Boards signed a Memorandum (MoU) of Understanding related to vaccine funding arrangements. In this MoU, the roles and responsibilities of the organisations were clarified, with financing of vaccines devolved from the Ministry to the DHBs, and the procurement of vaccines on the National Immunisation Schedule transferred from the Ministry to PHARMAC. DHBs are responsible for vaccination coverage in their region and also for closing the equity gaps between population groups.

Immunisation gaps

Vaccination coverage has improved significantly since 2006, with a closing of equity gaps in immunisation rates for Māori and Pacific children compared with non-Māori non-Pacific children. However, vaccination coverage has remained under 95%. It plateaued at around 93.3% for MMR1 in 2014, after which it slowly declined, especially in Pacific and Māori children (5). There are several probable causes for this decline, including the international trend of increasing numbers of people who reject vaccination; increasing general practice work load; and 'vaccination fatigue' after 10 years of heightened health system alert.

The existence of the immunity gap in the older age groups and other risk groups in New Zealand has been known for many years and reported in international peer reviewed publications (4). A cost-benefit analysis of supplementary vaccinations to close the gap was published in 2017. Hayman et al. (2017) estimated that 435,742 people in New Zealand, were susceptible for measles (4). Based on several assumptions, for example, that the susceptible population was homogeneously distributed around the country, Hayman et al (2017) calculated that 104,357 measles vaccines needed to be given to reduce population susceptibility to a level where the basic reproduction rate R_0 would be < 1 if a virus were to be imported, and therefore further spread would be prevented (4). In preparation for the National measles vaccination campaign in 2020 however, based on more detailed information and different assumptions, Metro Auckland estimated that for their region alone, 152,000 – 186,000 vaccines would be needed to close the gap. (14)

The immunity gap was recognised by the NVC and reported to the RVC from 2018. The RVC, in their 7th annual meeting in 2018, endorsed the NVC recommendation to urgently fill the immunity gap by focussing on the specific under-served and under-immunised ethnic groups and age groups.

District Health Boards have written formally to the Ministry on a number of occasions to request a national campaign that they believed could create the momentum to mobilise as many unvaccinated people as possible to get vaccinated in order to close the gap and prevent outbreaks.

Whilst, the Ministry had begun plans for a national immunisation catch-up campaign to fill the gaps, this had not happened by early 2019.

Findings:

- *New Zealand has a well-known 'immunisation gap' that has led to several measles outbreaks over the years.*
- *The immunity gap remains a threat for measles control. Outbreaks have been predicted, and closing the gap has been signalled in policy, plans and research.*
- *In response to the recommendations of the National Verification Committee 2017, the Ministry initiated a SWOT analysis on different strategies to close the immunity gap on 17 September 2017. This document was shared with the sector at the Ministry's Measles and Rubella symposium on 6 October 2017 in Wellington. To date, only some of the actions in the SWOT have been started, such as funding an incentive payment to general practice for measles vaccination administered to those considered to be the target populations. These actions however were not timely enough or sufficient to close the immunity gap and prevent the 2019 outbreak.*
- *Registration of vaccinations started with NIR in 2005. Prior to the NIR, there was no central/national registration, making identification and targeting of unvaccinated individuals difficult.*
- *Implementing the NIR in 2005 was a big step forward for registration and monitoring the vaccination coverage in the younger birth cohorts. Since 2006, the vaccination coverage in children has increased significantly. It has however always been below the desired 95%.*
- *The vaccination coverage in children has gradually declined since 2015, as it has in many other countries. Besides the immunity gap, vaccination coverage in younger birth cohorts needs urgent attention.*
- *In 2019, the NVC reported that an error in NIR data coverage in previous years was found and corrected. This resulted in some records being dropped from the previous annual reports and a decrease in the percentage coverage for all cohorts compared to those reported in previous years. This decrease has been on average 2.2% per year for MMR dose 1 over 10 years and 4.7% per year for MMR dose 2 over 7 years.*
- *The worldwide decline in vaccination coverage has led to an increased measles incidence in many countries. The steady increase in incoming travellers into New Zealand led to an increase in measles import in the country.*
- *The epidemiology of the 2019 measles outbreak has not yet been epidemiologically analysed. Analysis of the cases should also focus on the imported measles cases in order to estimate whether it could be effective to require proof of vaccination to certain immigrants, such as students or seasonal workers.*
- *Reactive vaccination on a large scale in outbreak situations, which has happened in NZ frequently over recent decades, carries the risk of inaccurate vaccine registration. Registration of vaccinations does not immediately influence the outbreak, and is readily postponed by busy staff. Reactive large-scale vaccination does contribute to increased*

vaccination coverage; however, incomplete registration will continue to make it difficult to trace unvaccinated people and close immunity gaps.

- Responsibility for the childhood immunisation programme in NZ is complex. PHARMAC is responsible for the vaccine schedule and purchase of vaccines, DHBs are responsible for vaccine coverage and local programmes, and PHOs/primary care are responsible for delivery of the immunisation schedule. The Ministry is responsible for implementation of the National Immunisation Schedule and associated changes. In Auckland, there is an added challenge for the role of the public health unit ARPHS in vaccination during outbreak management because ARPHS has to work with three DHBs. We note that ARPHS is not the only PHU that works with up to 3 DHBs, but the population that ARPHS serves is certainly the largest and most diverse in the country.
- ARPHS does not have access to population level NIR data, that would have helped with identifying where there were areas of low immunisation in the community (13). Population level NIR access is enabled through the DHBs and immunisation coordinators and is provided via the metro Auckland IMT response (and prior to this via DHB Planning & Funding staff).
- Just over a year prior to the outbreak, on 25 October 2017, ARPHS, on behalf of the 3 Metro Auckland DHBs, requested that the Ministry implement a national MMR catch up campaign because of the large mumps outbreak that occurred in the Auckland region in 2017. The Ministry responded that as most cases were localised to the Auckland region, a prioritised local catch-up programme was appropriate and contributed \$100,000 per DHB in support.
- In the absence of national support, the local catch-up campaigns in response to the mumps outbreak in 2017, were very resource intensive and challenging. Local campaigns in the ADHB and WDHB regions vaccinated more than 5,000 high school age children (in 15 low decile schools that had high numbers of Pacific and Māori youth). Some interviewees suggested that this may have contributed to the lower numbers of measles cases in the ADHB and WDHB regions compared with CMDHB, during the measles outbreak of 2019. The extent to which these campaigns contributed to an increase in the vaccine coverage in the different age groups is not known.

Actions after a measles case is notified

Measles is a notifiable disease under the Health Act (1956). Each case of measles has to be reported by a medical practitioner to the district Medical Officer of Health who is part of the regional Public Health Unit (PHU) (16). In addition, a formal notification role for laboratories was introduced as part of the Epidemic Preparedness Act (2006). This was designed to help improve the ability to respond to future epidemics and the timeliness and completeness of notifications (17).

Following the notification of a case to a Public Health Unit, the case is entered for surveillance purposes in EpiSurv, the national surveillance database managed by ESR (18).

Public Health Units are responsible for source and contact tracing and for all other actions to prevent further spread of the disease. After a case is notified, within one working day, the PHU is required to start source and contact tracing. The PHU collects all relevant clinical and demographic data, including a history of vaccination, immune deficiency, contact with another measles patients and a history of travel. The PHU ensures that the patient is isolated in order to prevent further spread. Active case-finding also starts with the PHU communicating to doctors and laboratories in the areas that the patient may have acquired the infection, and requesting them to notify suspected cases immediately to the PHU. This enables the PHU to administer early prophylaxis to cases in order to reduce the symptoms and prevent further spread of disease (18).

PHUs identify all persons that the patient has been in contact with during the contagious period. Contacts born before 1969, and contacts born after 1969 with evidence of 2 measles vaccinations are considered immune. All other contacts are given MMR vaccine, as there is some evidence that post exposure vaccination given within 72 hours post contact with a measles patient may reduce the risk of disease. Susceptible contacts are advised to avoid contact with other susceptible people, if they have received MMR within 72 hours, since protection cannot be guaranteed during this period.

Contacts are advised by PHUs to stay in quarantine for 14 days after the last contact with a measles patient. If a contact develops symptoms of measles, the contact is tested. If a measles diagnosis is confirmed, the contact is considered a case, and contact tracing starts around the new patient.

Findings

- *Our assessment based on the scope of this review and the information we were able to review, is that ARPHS was well prepared/equipped for their infectious disease control and outbreak management function and works according to standing protocols and guidelines.*
- *Due to the short incubation period for measles, it is very rare for a contact to be traced and spoken with within 72 hours of contact with the index case. For this reason, few measles post-exposure vaccinations are able to be given for post-exposure prophylaxis indications. Whilst ARPHS continued to identify and prioritise MMR vaccination for these situations, ARPHS did not have the resources to vaccinate all contacts who had not had 2 MMR vaccinations, regardless of their time since exposure. In low-immunity communities, ring vaccination is probably effective at targeting under vaccinated contacts, and could therefore have a beneficial effect on stopping tertiary cases and therefore outbreak control.*
- *ARPHS is the largest PHU in New Zealand, serving a very diverse and mobile population. In response to the unique needs of its population, ARPHS have developed a data management system that can produce detailed information about cases and contacts. This allows the generation of detailed information that is available for guidance of the management of outbreak response.*

Actions in case of an outbreak - Health Emergency Plans

In common with many countries, the SARS epidemic in 2002 was for New Zealand an important reason to develop and implement structured health emergency and outbreak plans. In New Zealand, the **National Health Emergency Plan: Infectious diseases**, was published in 2004 (19). The plan describes the responsibilities for initiating and coordinating any health sector emergency response, and the role of DHBs in the event of a local outbreak in their region.

Under their Crown Funding Agreement (CFA), DHBs are required to develop Regional Incidence Coordination plans that need to outline appropriate actions and responses from all devolved health services in the event of a major incident or emergency in their regions.

Coordinated Incident Management System (CIMS) is the primary reference for incident management in New Zealand. The purpose of CIMS is to achieve effective coordinated incident management across responding agencies for all emergencies regardless of size, hazard or complexity. All emergency services use a CIMS structure to staff their Emergency Operations Centres (EOCs).

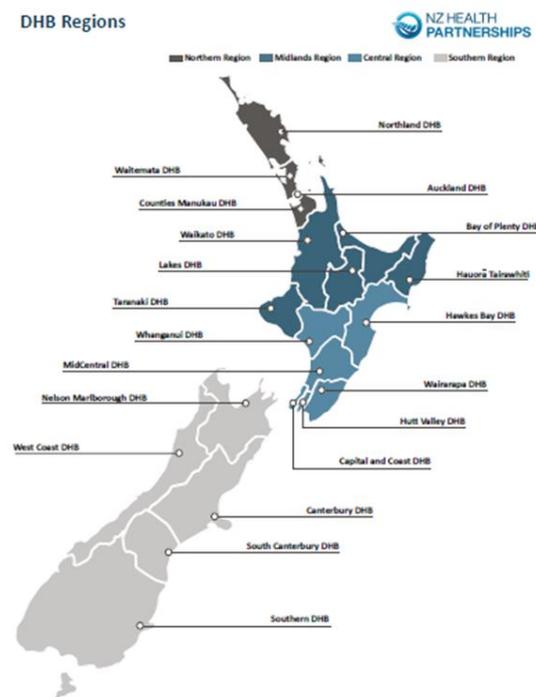
CIMS is consistent at all operational levels, and is intended to provide a structure allowing the multiple agencies or units involved in an emergency to work together as a team. In the case of a

national emergency, the CIMS structure facilitates communication between the Ministry's National Health Coordination Centre (NHCC) and DHBs.

The National Health Coordination Centre (NHCC) is a structure through which the Ministry can nationally coordinate and manage the health responses to and recovery from emergencies. The centre is kept in a constant state of readiness for activation for a response to any emergency.

The National Health Emergency Plan: Infectious diseases (2004), requires that all DHBs should have a single point of communication to ensure the Ministry can communicate directly with DHBs at all times. In addition, each DHB is responsible for the preparation of a regional incident co-ordination plan in order to set out the proposed regional response in case of a regional outbreak. These plans are intended to provide a consistent approach to coordination, cooperation and communication within each region. The regional plan is pre-defined and divides the country into four regions: Northern, Midlands, Central and Southern region, each with their own CIMS structure. In the case of a national health emergency, the Ministry communication line is through these 4 regions.

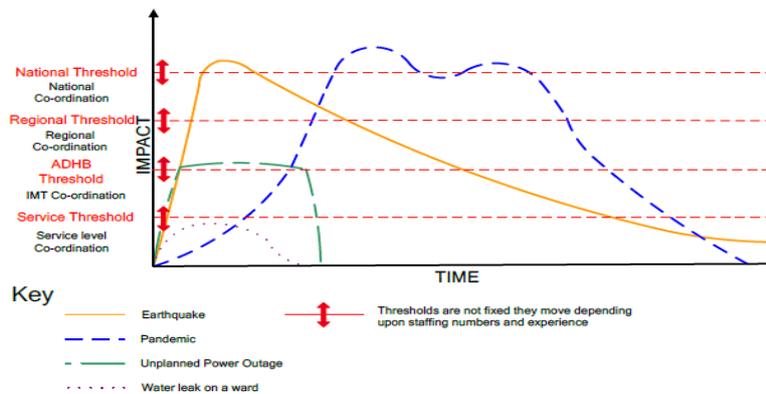
Figure 3: The four DHB Regions as described in the National Health Emergency Plan 2004 (Source: NZ Health Partnership).



Ongoing exercises and training programmes are meant to be held in order to maintain a pool of appropriately trained people with CIMS roles competencies.

The Incident Management Team (IMT) uses the CIMS structure to manage an emergency response. Activation of the IMT is fluid and depends on different factors.

Figure 4: Examples of activation thresholds for local, regional or national response to emergencies. (Source: Auckland District Health Board Health Emergency Plan 2014-2017)



The National Health Emergency Plan (NHEP) is activated when the Ministry of Health learns, or is advised of, a potential national health-related emergency. The Ministry, on the basis of overseas and domestic information, intelligence and technical advice, will instigate subsequent phases of activation and/or stand-down.

The NHEP describes that the Ministry will advise DHBs of plan activation using a standard code structure using colours for activation; white, yellow, red and green.

The **New Zealand Influenza Pandemic Action Plan** (20) has been in existence since 2002, but has undergone substantial revision since then due to the evolving threat from H5N1 influenza, the influenza A (H1N1) 2009 pandemic and the subsequent all-of-government programme of pandemic planning and exercises that have been implemented.

In 2006/2007, the Ministry planned and coordinated a pandemic exercise programme consisting of two major exercises, Exercise MAKGILL and Exercise CRUICKSHANK. The exercise programme aimed to assess New Zealand’s plans for responding to an influenza pandemic.

In the decade since 2007, the New Zealand Influenza Pandemic Action Plan (NZIPAP) has been revised twice, in 2010 and 2017. The 2010 revision incorporated lessons from the 2009 H1N1 ‘Swine Flu’ pandemic response. The publication of the NZIPAP, 2nd Edition in August 2017 reflected changes in terminology, legislation, agencies names, population-based calculations and references to publications and websites.

The NZIPAP New Zealand pandemic planning is based around a six-phase strategy:

1. Plan For It (planning and preparedness);
2. Keep It Out (border management);
3. Stamp It Out (cluster control);
4. Manage It (pandemic management);
5. Manage It: Post-Peak; and
6. Recover From It (recovery).

Exercise POMARE was conducted as a part of the National Exercise Programme (NEP) for 2017/2018. Exercise POMARE was designed to enhance all-of-government pandemic readiness in light of the revisions to the NZIPAP 2nd Edition (2017) as part of the Pandemic Readiness Work Programme.

The Exercise POMARE Post Exercise Report of 20 September 2018 (21), made a number of important recommendations, including suggestions for revisions of the NZIPAP 2nd edition:

- A number of agencies needed to update their business continuity plans to cater for an influenza pandemic.
- Given the likely duration of an influenza pandemic, agencies also needed to consider their ability to respond concurrently to other national security events (earthquake, flood event, bio-security event).
- The NZIPAP 2nd Edition (2017) needed to be updated to better reflect the current structures, roles and responsibilities, and critical functions of central government agencies.
- There were also sections of the NZIPAP that needed to be expanded to provide more in-depth guidance.
- Ongoing education and training were required in order to maintain a base level of corporate knowledge across all levels within central government agencies to ensure an effective all-of-government response to an influenza pandemic.
- Given the significant threat that a severe influenza pandemic poses to both the international community and New Zealand, it was strongly recommended that an influenza pandemic activity be conducted every four years as part of the National Exercise Programme; exercise participants identified that their agency's business continuity and response plans would benefit from strategic guidance that clearly articulated the government's priorities for the delivery of critical functions and services.

Findings:

National level:

- *The Health Emergency Plan for Infectious Diseases, 2004, was out of date, but still published on the Ministry website.*
- *For the 2019 measles outbreak, the New Zealand Influenza Pandemic Action Plan (NZIPAP) 2017 was used (in a modified way, because it wasn't a pandemic). There was no communication about this internally (within the Ministry) or externally (DHBs and the rest of the sector).*
- *In 2019, the NZIPAP 2017 was out of date. Recommendations had been made but were yet to be implemented.*
- *Many interviewees had not heard of Health Emergency Plans and/or had never been trained in Emergency Management.*
- *Most interviewees were not aware which plan was used for the upscaled situation and why.*
- *The CIMS structure was used in modified ways throughout the outbreak.*
- *Most of the shortcomings described in the Exercise POMARE report that have not yet been addressed are also the findings of this measles outbreak review.*
- *Frequent restructuring within the Ministry over the previous decade(s), has left relevant departments understaffed.*
- *There has been a (very) high turnover of Ministry staff, leading to teams with capable but often inexperienced staff.*

- *Due to a series of emergencies (Christchurch Mosque attacks, Kaikoura earthquake, White Island eruption) the Ministry of Health Emergency Response team has been in response mode for more than a year; this has left little time for business as usual activities.*

Regional level:

- *All DHB's have relatively recent emergency plans published on their websites.*
- *The ADHB Health Emergency Plan 2014-2017 (22) was out of date and refers to the National Health Emergency Plan and to the NZIPAP and used four colours for activation; white, yellow, red and green.*
- *Frequent and recent outbreak exercises, and consequent adaptations of emergency plans, have been published on the DHB websites.*
- *Most of the interviewees in metro Auckland were aware of and had participated in exercises in outbreak management.*
- *We were not able to compare the outbreak preparedness between the Canterbury and Metro Auckland regions as planned, because Canterbury did not respond to several interview requests.*

4. Health System Response

This chapter discusses the Health System Response to the 2019 measles outbreak, with a brief discussion about the measles outbreak in Canterbury early in 2019, followed by a description of how the outbreak progressed in the Auckland region.

TOR Q 2: How well did the health system respond to the measles outbreaks in March 2019 and onwards?

Canterbury Outbreak

A measles outbreak occurred in Canterbury from February to May 2019, with a total of 39 cases. While the outbreak was officially declared over on 16 May 2019, a further case was later reported linked to the Auckland outbreak. Community Public Health (PHU Canterbury) worked with primary care services to deliver a vaccination programme, with 22,000 MMR vaccinations delivered during the outbreak period (24). The Canterbury outbreak subsequently subsided with no further outbreak-related cases reported, despite all the other events and gatherings (linked to the terrorist shootings in March 2019) that occurred in Christchurch city at that time (23).

Auckland Outbreak

The New Zealand Influenza Pandemic Action Plan 2017 (NZIPAP) used by the Ministry for the Measles Response, describes 6 phases in outbreak management. ARPHS adapted the national plan and developed a tailored 'Measles, Mumps and Rubella' Protocol for measles mumps and rubella outbreaks in the Auckland region, that involved 2 overlapping phases. ARPHS made the decision to further adapt their MMR protocol in the early phases of the 2019 measles outbreak response (15). This version of the ARPHS MMR protocol was developed as part of a Co-ordinated Regional Response Plan, that was approved by the three Metro Auckland DHBs, and signed off with the agreement of the Ministry on 10 April 2019. The adapted plan used by ARPHS had 3 phases, derived from the 6 phases in the NZIPAP:

- Phase 1 Case and Cluster Control. '*Stamp it Out*'. The objective of this phase is elimination of the disease and prevention of transmission.
- Phase 2 Focused Control. '*Manage it*'. This Phase occurs when there is widespread community transmission of measles and involves prioritisation of public health action to protect high risk groups, including high risk contacts of measles cases.
- Phase 3 '*Outbreak and Epidemic Management*'. This Phase guides action when a rapid increase in cases is seen where focused control activities are unlikely to contribute to epidemic management.

We describe the events that occurred in the Auckland region from February to 9 September 2019 in this section.

The ARPHS MMR Protocol and TAG recommendations

27 February Phase 1 *Stamp It Out*, Case and Cluster Control started with 1 measles case.

The first case in the Auckland region was reported on 27 February with no secondary cases. This was followed by a second case in a child without an obvious source was reported on 12 March, and two further introductions of measles from China and the Philippines on 13 and 15 March, with secondary cases.

Historical records show that all previous measles importations in New Zealand also occurred in March/April.

14 March 2019, ARPHS established an Incident Management Team (IMT), just after the first cases of measles had been reported in the ADHB and WDHB regions, using the CIMS structure to ensure coordination. At week 4 of the IMT, a Technical Advisory Group (TAG) function was formally established. The IMT initially involved the Auckland and Waitemata DHBs, with Counties Manukau Health DHB and Northland absent as no measles cases had been reported in these districts.

19 March 2019, the ARPHS/ADHB/WDHB 'TAG' Strategy and Vaccine meeting was held. In April 2019, the TAG recommended that MMR0 be given to infants, however this was not implemented because of concerns about primary care capacity. General practitioners were in the middle of the annual influenza vaccination campaign. MMR0 is not a regular vaccine in the National Immunisation Programme, so to action this would have required a change in the GP claiming systems, which was problematic. There were also concerns in the Auckland region about the availability of measles vaccines due to the Canterbury outbreak.

The information provided to the review showed that from the start of the ARPHS IMT, the Ministry was provided with daily information in order to support international communication with WHO and communication with government.

25 April, there was a discussion between ARPHS and the Ministry about the use of the term 'outbreak' and the Ministry advised that alternatives for example 'clusters of cases', or 'household clusters' were preferred terms for use in communications. This was attributed in the ARPHS report to concerns about managing high demand for vaccines. An outbreak of measles was 'officially' declared from 29 April.

1 May, CMDHB reported the first case of measles in the district. From this point, the nature of the measles outbreak would shift from cases being predominantly NZ European (West Auckland WDHB/ADHB earlier phase of the outbreak) to a high burden of cases and hospitalisations for Pacific families in the Counties Manukau district.

Early May, measles was spreading in the community in the Auckland region, and on 14 May, 53 cases were reported. At this stage, ARPHS staff had experienced high workloads for many weeks.

Sustained Transmission of Measles in the Community in the Auckland Metro Region

8 May, ARPHS discussed with the Ministry, the move from Phase 1 'Stamp It Out' to Phase 2 'Manage It'. The Ministry responded that a delay of 2 weeks was required to allow for communication with the Minister of Health. The delay in moving to Phase 2 put further pressure on ARPHS as this meant two more weeks of 24/7 work.

ARPHS made the suggestion to move to the next phase based on their assessment that:

- the measles virus was likely to be widespread in the Auckland region; and
- the workload on their staff due to contact tracing was no longer sustainable.

The move to Phase 2 meant that ARPHS focus became those considered at highest risk from measles (household members of confirmed measles cases identified as 'high risk' and vulnerable groups, such as unvaccinated children in early childhood centres). The move to Phase 2 also meant that contact tracing of lower risk contacts and communication activities was devolved to GPs to manage (23).

15 May Phase 2 *Manage It* started. There were 55 measles cases in the Auckland region.

ARPHS action during this period of sustained community transmission of measles involved providing indirect information on contact management (through primary health care providers and mass communications) and DHB action to improve immunisation coverage.

ARPHS provided the leadership for the Auckland region response to the measles outbreak during the initial Keep It out and Stamp It Out phases. During this time, ARPHS involved the sector via meetings with the three Metro Auckland DHB Hospital, Planning and Funding and Primary Care teams, with community input as required.

As it became clear that the response would move to the Manage It phase, a metro Auckland Incident Management Team (IMT)¹ was established. ARPHS remained an integral component of the DHB established IMT.

29 May, the Ministry of Health and PHARMAC agreed additional vaccine supply to bring MMR1 forward from 15 to 12 months in the Auckland region.

End May, Pharmac reallocated 40,000 vaccines from Canterbury to the Auckland region in response to ARPHS advice that 30,000 additional vaccines were required.

30 May, in a Funding and Planning measles teleconference, all three metro Auckland DHBs report that they had no capacity to do a mass vaccination campaign in their region. If such a campaign was needed, the Ministry would have to drive it.

6 June 2019, ARPHS, on behalf of the 3 DHBs, again wrote to the Ministry to request a national MMR campaign. The letter stated that by 27 May there were 71 confirmed measles cases generating 3,700 contacts that had required follow-up. ARPHS also stated that the 3 DHBs had decided to move the 15 months MMR immunisation forward to 12 months, using active recall by general practices. The Ministry replied on 2 July that a national campaign was being considered, and advised that consideration was also being made to move both MMR vaccinations in the NIP forward to the second year of life in 2020.

6 June, ADHB expressed concern to the IMT about the number of cases in the Counties Manukau region and the pressures experienced by ARPHS staff. ARPHS also warned that it was likely that Emergency Department and inpatient services in the Counties Manukau district would be overwhelmed.

11 June, the MMR1 vaccination that was given to children aged 15 months as part of the immunisation schedule was moved forward to 12 months for children in the Auckland region.

18 June, ARPHS released a 'Whanau Pack' with written information about measles that was a resource for health care providers, and included information that could be given to measles patients and people who were contacts of measles cases. The development of this resource was partly driven by the scale of the outbreak and in preparation for the shift to phase 3, which meant that public health staff would no longer be making individual contact with patients with measles and most of their contacts.

19 June Phase 3 Outbreak and Epidemic Management started when there were 116 measles cases in the Auckland region.

26 July, the Northern Region Health Coordination Centre (NRHCC) was activated, with the 3 metro Auckland DHBs. This was initially a virtual team, and then as a sustained response was developed, a team was established at the Emergency Operations Centre (EOC) located at Auckland City Hospital. This was later called the Northern Region Health Coordination Centre (NRHCC). Northland DHB (the fourth DHB in the Northern Region grouping) was excluded as there were few cases in Northland district, however there was close and regular communication with Northland DHB to share material, communications and planning.

June and July, local vaccination activities were developed and prepared, with 'drop-in clinics' held in Counties Manukau and Waitemata DHB districts. In the Auckland region measles vaccine was also made available through pharmacists late in the outbreak. This required central changes, including claiming mechanisms and updating individual pharmacy contracts (DHBs hold contracts with pharmacies for influenza vaccine). Preparatory work was undertaken on pharmacist readiness for MMR, infrastructure (more vaccine fridges etc) and training in anticipation of the announcement. Approximately 120 pharmacies (out of approx. 300 in metro Auckland) decided to offer this service. The service was announced by the Associate Minister on 30 October 2019 and began vaccinating in December 2019 when the height of the outbreak was passed. We did not receive information about how many people were reached through all these vaccination efforts, however PHARMAC reports that only 9,000 additional vaccines (of the 40,000 reallocated to Auckland at the end of May) had been used by mid-July.

8 August: CMDHB presented a proposal to the Ministry of Health to improve the immunity to measles of their population. This proposal included funding an additional five vaccinator nurses to deliver outreach services and opportunistic vaccination in Middlemore hospital. The Ministry agreed to fund these nurses, a total of \$285,000.

23 August, the Ministry of Health released a National Health Advisory Updated Advice for Measles Vaccination: *'There have been over 600 cases to date. People travelling to Auckland, particularly South Auckland, should be immunised against measles before they travel. Babies who are travelling to Auckland or living in Auckland should have their first measles vaccine earlier at 12 months of age. Vaccination should be done at least two weeks before travelling to allow their immunity to develop. If you are aged under 50 years and have never had at least one dose of a measles vaccine get vaccinated now.'*

30 August, the activation of the Ministry of Health's National Health Coordination Centre (NHCC) for the Measles Response was announced by Hon Julie Ann Genter, Associate Minister of Health with delegated responsibility for Public Health (Refer Chapter 5).

31 August, the Virtual Metro Auckland IMT (ARPHS and 3 DHBs) focused on MMR vaccine delivery and stock, as many general practices reported vaccine shortages.

1 September, ARPHS briefed the 3 Auckland Metro DHBs on the objectives of the IMT (prior to the transfer of responsibility to the NRHCC). Recognising that the outbreak was likely to continue for months, the strategy was now to limit the extent and shorten the duration of the measles outbreak by increasing vaccination uptake. This was a change from the approach that the ARPHS operated IMT had initially taken, that involved oversight of a public health response, but excluded delivery of measles mass vaccination. The Ministry had provided additional funding to support vaccination outreach in South Auckland.

It was agreed that a funding proposal for MMR catch up across the metro Auckland region would be made to the Ministry. ARPHS developed a regional proposal on behalf of the DHBs to the Ministry. The proposal provided for the collection and utilisation of consistent data, delivery of a regionally consistent MMR vaccination strategy, unified reporting from the region and delivery of coordinated public information messaging.

3 September, the first Ministry national TAG meeting was held. TAG recommended

- MMR0 should be offered to infants aged 6-11 months old in Auckland. The reason for this recommendation was that the disease burden in this age group accounted for 10% of cases and 67% of hospitalisations.
- PHARMAC advised that stock volumes should be estimated and a coordinated response developed before implementation of vaccination programmes.
- Unvaccinated children under 14 years (In NIR) could be recalled subject to vaccine supply.

3 September, daily regional and ARPHS IMT meetings commenced.

6 September, the NRHCC physical co-location (IMT) was initiated and completed on 9 Sept.

9 September NRHCC held their IMT Planning – PHO Teleconference. This meeting was fully supported by DHB Emergency Management.

An internal evaluation report prepared by ARPHS and the Auckland region DHBs includes the following conclusions (Auckland Measles Outbreak Report 2019):

- There were deficiencies in the NIR to support outbreak activities in health and education settings; ARPHS staff were administering MMR1 vaccines to contacts of confirmed cases but without access to NIR were not able to check if vaccination had been provided by GPs who were also giving MMR1 vaccines.
- There were health and safety issues for staff; high workload requirements continued for extended periods of time. Temporary staff should have been hired earlier in the response, but ARPHS was dependent on external support from DHBs.
- The size and scale of the outbreak was **unprecedented** and the IMT (and the organisations comprised by the response) were under substantial and sustained pressure.

Findings:

- *We were not able to compare the outbreak response and its effects between the Canterbury and Auckland regions because we were not able to speak to Canterbury DHB and Public Health staff as part of this review. The information provided to the review did not include analysis of the Canterbury measles outbreak and we are not able to draw conclusions about the differences between the outbreak and approach to the response between the Canterbury and Auckland regions.*
- *Some interviewees commented that possible differences could be due to the different populations of the regions, with fewer people living in crowded homes in Canterbury, higher vaccination coverage in the Canterbury population, more rapid contact tracing by Canterbury Public Health Staff (followed by vaccination and isolation of contacts), and an earlier and more targeted local vaccination campaign.*
- *Some interviewees commented that in previous measles outbreaks, TAG groups had not been required for standard responses, such as in the response to measles outbreaks.*

- *The question of the availability of vaccines in the Auckland region during the early period of the outbreak was disputed by some interviewees.*
- *Some interviewees mentioned that the healthcare system in New Zealand is highly siloed, and this hampers collaboration and cooperation.*
- *The organisation of outbreak management in Auckland, where a single PHU serves three DHBs with distinct district responsibilities can be complex. Several interviewees observed that districts where a PHU is integrated within a DHB, means that information, databases and responsibilities are shared, and in these districts, they may be better equipped to respond to outbreaks.*
- *The Auckland/Northern region response involved the gradual progression of the ARPHS IMT into a modified regional NRHCC, that did not include Northland DHB. The leadership of the outbreak response started with ARPHS and needed to be transferred to the Auckland metro DHBs as the outbreak progressed as a result of devolved responsibilities for contact tracing (PHU) and improving vaccination coverage (DHB).*
- *The official NRHCC was set up in early September, only after the activation of the Ministry's NHCC, but in a modified way as the Northland DHB was not involved. In an officially upscaled outbreak situation, the 'Northern region' would comprise 2 public health services (ARPHS and the Northland PHU) and 4 DHBs (ADHB, WDHB, CMDHB and Northland DHB). This could be unnecessarily complicated. Interviewees stated that the establishment of the NHRCC did not always require a whole of region operational response. This modified upscaling needs to be clarified with the DHBs and or National Health Emergency Plan*
- *We were not provided with evidence of communication to the Ministry that the Northern Region upscaled situation was modified.*
- *ARPHS maintained their own CIMS structure, after the activation of the NRHCC by the DHBs that included ARPHS. This worked well, according to ARPHS/DHBs.*
- *The activation of the NRHCC in the Auckland region (and the NHCCC nationally) clarified responsibilities:*
 - *"... before [NRHCC] everyone and nobody was responsible for the overall control of the outbreak "*
- *All interviewees agreed that NRHCC should have been set up much earlier. We were not able to determine who had responsibility for activating the NRHCC or the reason for the delay.*
- *Communications between the Ministry and the Auckland region organisations sometimes confused the phase numbers of the response. We were not able to determine if this led to misunderstandings in the implementation of the response.*
- *ARPHS started the outbreak with a financial deficit of \$4.6 m. Almost half of that was subsequently compensated by the Ministry. The balance of the ARPHS deficit was the responsibility of the three Auckland metro DHBs, that were also operating deficits. In 2019, ARPHS had 12 unfilled vacancies. It is outside the scope of this review to determine the impact this may have had on delivery of the response.*
- *The metro Auckland DHBs and ARPHS had advocated for many years for a national measles vaccination campaign. SWOT analyses prepared by the Ministry in 2017, identified that a national campaign required careful planning. In 2019, in the course of the largest measles outbreak in New Zealand in 20 years, targeted contact tracing was no longer possible, and when the outbreak escalated, the only possible action was to attempt to increase the immunity in the population.*
- *Increasing population immunity and filling the immunity gap is the goal of a national measles campaign. During this measles outbreak, a regional vaccination campaign had to be*

set up. That campaign was ad hoc and lacked good preparation. In September, ARPHS proposed a plan to vaccinate in different phases in different DHB districts in order to manage staff issues and vaccine supply. However, the situation was no longer under control.

- *We observed that during the outbreak, many documents and outbreak plans were used in a 'modified' form, even before something unexpected had happened. These modifications, if necessary, should have been made in the preparedness phase, which would have allowed more focus on the management of the outbreak.*
- *We noted that several plans and documents were prepared by ARPHS during the outbreak.*

Examples included:

- *The 'Coordinated Regional Health Sector Response Plan for Measles Control, March 2019, that involved modification of the MMR protocol; and introduced the 3 phased approach.*
- *The 'Measles Focused Control Operational Plan, April 2019' that set out public health actions as a priority and provided comprehensive advice to health and other relevant sectors about action during the measles outbreak.*
- *The 'Whanau Pack, June 2019' that provided written information about measles for health care providers as well as information for measles patients and contacts. This information was translated in to different languages.*

Most of these documents could, and should have, been prepared in the preparedness phase, especially because it was not an unexpected outbreak.

5. Monitoring

TOR Q3: The effectiveness of monitoring activity

Measles is a notifiable disease that must be reported to the Medical Officer of Health. After a case is notified to a Public Health Unit, the case is entered for surveillance purposes into EpiSurv, an integral part of the national notifiable disease system, developed and operated by ESR. Data entered into EpiSurv and from other sources are analysed and interpreted by ESR (epidemiologists, public health physicians, bioinformaticians etc). This intelligence is then provided to the Ministry and the sector.

One of the conditions for a country to obtain measles elimination status, achieved by New Zealand in 2017, is a good and reliable surveillance system. The notification system has been evaluated by NVC for measles and rubella and works well; all laboratories notify positive test results automatically in EpiSurv and public health staff report clinical and demographic details. The Communicable Disease Control Manual provides information that 'genetic characterisation should be carried out in accordance with advice from the national measles laboratory'. These samples are sent to the reference lab (New Zealand Canterbury Health Laboratory) for sequencing in order to enhance source and contact tracing, when necessary.

Findings:

- *There are no indications that monitoring is inadequate or ineffective for measles or that it should be improved.*
- *ESR has knowledge, expertise and experience in outbreak management but ESR was not effectively utilised until the Ministry's NHCC was activated.*

6. Ministry of Health Response

The Ministry of Health is the Government’s principal agent in the New Zealand health system with overall responsibility for stewardship of the system, and is the main advisor to the Minister on public health policy. In an emergency response, the role of the Ministry of Health is to provide leadership for planning and responding to an event on a national scale (17).

TOR Q4: The activation of an incident management response by the Ministry of Health on 30 August 2019.

Four specific areas of the Ministry of Health’s response were identified and are addressed in this chapter.

- i. Timeliness of establishment.
- ii. Delivery of the incident management response.
- iii. Effectiveness of communication and information flow, including information provided to decision-makers.
- iv. Resourcing of the incident management team.

These specific areas reflect the Ministry’s key responsibilities in a national emergency. We address each of these issues separately in this chapter, beginning each subsection with a summary of the information we collected, followed by our findings.

i. Timeliness of Establishment

To address the question of the timeliness of the activation of the incident management response by the Ministry of Health, we have constructed a timeline of key events.

Table 1: Timeline of key events

Date	Event	Number of measles* cases national and Auckland region**
Early March	ESR alerted the Ministry to significant overseas outbreaks. Measles cases from these overseas countries were subsequently reported in New Zealand in late March.	Auckland: 1 National: 22
8-17 April	Ministry Incident Management Team (IMT) for Canterbury measles outbreak provides national reporting. IMT stood down 14 April.	Auckland: 17 National: 77 Hosp: 26
May-July	Frequent ad hoc contact continues between the Ministry staff and the Auckland Region DHBs and ARPHS.	Auckland: 80 National: 170 Hosp: 76
July 2019	Ministerial delegation for Public Health changed from Minister Clark to Associate Minister, Hon Julie Ann Genter as part of a planned Cabinet reshuffle.	Auckland: 312 National: 441 Hosp: 175

	Ministry prepared <i>Public Health Briefing to the Associate Minister of Health 29 July.</i>	
13 August	A Measles Project Team was established by the Ministry to respond to the Auckland outbreak. Informal daily meetings were mainly about meeting WHO focal point obligations and providing information to Associate Minister, Hon Julie Ann Genter. The team were also tasked with responding to the CMDHB request for resources.	Auckland 503 National 639 Hosp 237
21 August	The Measles Project Team begin producing daily Sitreps.	Auckland 629 National 773
23 August	The Ministry website is updated with a call to action: '... there is an outbreak, everybody under 50 who hasn't been vaccinated should get vaccinated today.'	Hosp 282
23 August	The Ministry responded to Associate Minister, Hon Julie Ann Genter 's request for a briefing (cc Minister Clark)	
30 August	The Ministry activates the NHCC and an announcement to the media is made by Associate Minister, Hon Julie Ann Genter.	Auckland 779 (Hosp Auckland 274 ¹) National 938 Hosp 328
9 September	A Regional Incident Management Team is established by the three Auckland metropolitan DHBs to coordinate the response across the region. This team is located at Auckland City Hospital. Daily teleconference meetings commence with the Ministry's NHCC.	Auckland 1062 (Hosp Auckland 381) National 1275 Hosp 441

* estimates based on ESR weekly cumulative reports

** ADHB, WDHB and CMDHB

NHCC

The activation of the NHCC provides a strong signal to the health sector about a national emergency response.

'The purpose of the NHCC is to coordinate the health and disability sector response to an emergency event. The NHCC is staffed by trained Ministry responders who work as part of an Incident Management Team operating under the Coordinated Incident Management System (CIMS)' Ministry of Health NHCC Sitrep 31 August.

Key documents show how events unfolded and we have summarised relevant extracts here.

21 August Ministry of Health Measles Project Team Sitrep

- 719 measles cases in NZ to date.
- The Counties Manukau region is hit hardest.
- The most affected groups are aged 0-4- and 15-29 year olds and people who are unvaccinated.
- Approximately 50% of measles cases have been hospitalised, this is higher than in previous outbreaks, there have been no deaths.

¹ This is the first time first time hospitalisations are reported per DHB.

- Vaccination is not typically the first response in a measles outbreak, because it takes 14 days to build up immunity and measles spreads faster than reactive vaccination campaigns can be set up.
- ARPHS is experiencing service pressure with 1426 notifications of potential measles cases. ARPHS are overwhelmed and are unable to perform intense contact tracing. They have moved into a 'Manage it' phase², improving vaccination coverage in order to minimise the effect of the outbreak.
- All Northern DHBs have internal structures in place to manage the outbreak. Isolation management procedures are in place in hospitals.
- The Ministry has created a Measles Project Team to respond to the outbreak.
- The Ministry received a request from Counties Manukau Health (CMDHB) on 8 August for funding for vaccination campaigns. CMDHB had identified a population of about 11,000 Māori and Pacific people to target for vaccination (out of the 120,000 non-immune people in the region).

Ministry of Health briefing to Associate Minister of Health, Hon Julie Ann Genter 23 August

- 719 measles cases with a major outbreak in the Auckland area.
- The groups that were most affected were children 0-4 years old, young adults 20-29 years old, and the Pacific population.

The Ministry approach was to:

- Increase immunity in the general population. In the Auckland region, this involved moving the first measles immunisation MMR1 for children from 18 months to 12 months.
- Provide funding for 5 additional vaccinators for the CMDHB region commencing 23 August.
- Plan to convene a Technical Expert Advisory Group meeting on 10 September, with the aim of developing a plan to improve immunisation rates.

Findings:

- *The NHCC was activated when there were 719 measles cases in the country, the majority in the Auckland region.*
- *We were not able to determine who was responsible for the escalation to activate an NHCC or who initiated the activation of the NHCC on 30 August. We did not receive information detailing the Ministry's decision making about moving from the regional management of the measles outbreak by DHBs and PHUs to a national response led by the Ministry. Information about the activation of the NHCC was not included in the briefing to Associate Minister of Health, Hon Julie Ann Genter on 23 August or referenced in the Sitreps before 30 August.*
- *All interviewees agreed that the NHCC should have been activated much earlier in the outbreak.*
- *We found that there was misunderstanding among many interviewees about the roles and responsibilities in an outbreak situation. Several Ministry staff believed that outbreak control was devolved to DHBs as a regional task and that the Ministry's role was predominantly stewardship in support of DHBs.*
- *The Northern Region DHBs and ARPHS had internal structures in place to manage the outbreak (21 August sitrep refers) and there had been ad hoc communication between ARPHS and the different metro Auckland DHBs and the Ministry. The activation of The*

² This statement is incorrect. Phase 2 was 'Manage it' and ARPHS had moved to Phase 3 'Outbreak and Epidemic Management' on 19 June.

Northern Regional Health Coordination Centre (NRHCC), that supported coordination across the Auckland metropolitan region, occurred 10 days AFTER the NHCC. All interviewees in the Auckland region believed that the communication improved after the NRHCC was activated.

ii. Delivery of the Incident Management Response

We have described in Chapter 3 the low level of health sector preparedness and awareness of the Health Emergency Plans. The delivery of the Ministry’s response to the measles outbreak was guided by the Pandemic Plan NZIPAP within the overarching Emergency Management Framework. The review was not provided with information about the communication to the sector of the use of the NZIPAP for this outbreak or how the plan was to be implemented.

The Ministry’s actions following the activation of the NHCC involved providing technical advice to the sector through the establishment of the Technical Advisory Group (TAG), also called the expert Advisory Group (EAG).

The Terms of Reference for the TAG/EAG show the purpose was to provide advice on additional activities that needed to be undertaken as part of the acute response to the outbreak in the Auckland area and the activities that needed to be undertaken at a national level to control the outbreak.

The first TAG/EAG meeting was held on 3 September when the outbreak was near its peak. This was a week earlier than reported to Associate Minister of Health, Hon Julie Ann Genter in the 23 August briefing. The group was convened by the Director of Public Health, with experts from PHARMAC, ESR and the Ministry. EAG recommendations were:

Table 2: TAG/EAG recommendations 3 September

For Auckland	Outside Auckland	General
<ol style="list-style-type: none"> 1. MMRO (6-12 months infants) should be implemented in the Auckland region. 2. GPs should actively recall unvaccinated children < 5 years old using NIR and practice management systems. 3. Provide specific support for Samoan populations to regain confidence (there had been anecdotal reports of a recent drop in vaccination coverage in children). 	<ol style="list-style-type: none"> 4. MMR1 should be brought forward from 15 to 12 months. 5. Importance of at least 1 MMR for people aged under 50 years, with 15-29 years a priority. 	<ol style="list-style-type: none"> 6. Advice to DHBs about ensuring outbreak response plans are up-to-date and their staff are vaccinated 7. Triggers for escalation of response were suggested including sustained spread in other regions of NZ, sustained spread of cases in early child care centres in a region, an increase in hospitalisation rates, or a fatality (noted was there are no international guidelines) 8. Consideration should be given to what a national outbreak response could be and any supplementary immunisation activities as a component of that (It was noted that vaccine supply was a critical component in any response).

A second TAG/EAG was convened on 10 September with a focus on how to improve measles immunity and advice was sought about a measles immunisation catch up campaign to address known immunity gaps.

Table 3: TAG/EAG recommendations 10 September

- | |
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| <ul style="list-style-type: none"> • Further work was urgently required to define when there is a high risk of community spread. Suggestions made included when there are two or more cases with no obvious link in place or persons within the same DHB. • Planning for a national catch up campaign should commence as soon as possible when vaccine supply was secured. • Strong, clear and consistent messages were needed for health professionals and the public about who should seek immunisation and where, along with who should not actively seek immunisation. <ul style="list-style-type: none"> • It was noted there had been inconsistency of messages. • Any communications campaign should include consideration of social media channels and engage influencers to reach the target audience of adolescents and young adults. • It was suggested that clear messaging was needed specifically to address vaccine hesitancy. • To maintain confidence in vaccines, it was suggested that consistent messaging outlining how measles can present in an immunised person would be helpful. |
|---|

Other actions that were taken by the Ministry were:

- 11 September assistance to ARPHS in response to a request for additional staff.
- DHB Planning and Funding Managers across New Zealand were contacted to assess vaccine requirements.
- 18 September in response to vaccine shortages, the Ministry directed Auckland providers that MMR vaccinations should be prioritised to the following groups: children due for MMR vaccinations at 12 months and 4 years according to the schedule to ensure on time delivery, targeted community outreach for 15-29-year olds, and Pacific Peoples.

Findings:

- *The approach to infectious disease control in New Zealand is highly devolved. DHBs have responsibility for vaccination coverage and PHUs have responsibility for managing infectious diseases and outbreak control in their regions. The Ministry has only a marginal role and the Ministry has no command over DHBs.*
- *The Pandemic Plan NZIPAP used by the Ministry of Health for this outbreak had not been updated with the recommendations of the POMARE exercise:

 - *“... the NZIPAP 2nd Edition (2017) needs to be updated to better reflect the current structures, roles and responsibilities, and critical functions of central government agencies...”(18).**
- *There was no uniformity in upscaling procedures, the outbreak plans that were in place were not followed. This hampered a smooth transition in outbreak management from an individual DHB response to a regional and then to national level action.*
- *We were not able to determine the mandate for action at the different stages of the outbreak.*
- *Government had devolved important functions to PHARMAC in 2012 (vaccine prioritisation and procurement) and ESR in 2002 (intelligence) but these organisations were not part of the official outbreak plan. Notwithstanding, some interviewees observed that ESR had played a*

major role in providing public health intelligence and outbreak response expertise in previous outbreaks, and that ESR's response role was not well understood or the ESRs expertise effectively utilised in the 2019 measles outbreak.

- *Healthline did not have a formal function in infectious disease control nor in outbreak management. Healthline took on an important role, identifying gaps and leveraging their strengths that included*
 - *national overview of communications;*
 - *intelligence and capacity to communicate, monitor and respond through social media;*
 - *upsurge capacity for communication; and*
 - *upsurge capacity to help contact tracing. Whereas the official responsibility for contact tracing lies with PHUs, this was ad hoc - and possibly unintentionally-partially outsourced to Healthline. During the 2019 measles outbreak, several newspaper articles were published with flight numbers of airplanes that had been identified as including passengers with measles onboard, and asking passengers who had been on the same flights (these are contacts of measles patients) who were unsure of their immune status, to contact either their PHU or Healthline (25-29).*
- *Because of the ad hoc delegations to Healthline, responsibilities between PHUs DHBs and Healthline were not clear. This led, for example, to the conclusion that Healthline should have access to NIR data to be able to check immunity of contacts. Whether Healthline should or should not have such a delegated contact tracing role, should be carefully assessed, taking privacy laws into account and whether Healthline can and should fulfil the full contact tracing role, including knowledge and training held by PHU staff, access to EpiSurv to register contacts etc. It should be very clear who is responsible and accountable for which contacts.*
- *Some interviewees commented that the use of media for contact tracing could lead to public distress and recommended that a different approach involving personal – contact was required in the future.*
- *The Ministry's communication department were not involved in NHCC until very late in the process.*
- *The national TAG/EAG provided useful practical recommendations in the two meetings that were held at the height of the outbreak on 3 and 10 September. It was remarkable that, at the peak of the outbreak, TAG/EAG flagged that DHBs should be advised to ensure their outbreak response plans were up-to-date and their staff were vaccinated, and that triggers for escalation of response were suggested including sustained spread in other regions of New Zealand, sustained spread of cases in early child care centres in a region, an increase in hospitalisation rates, or a fatality. It is not clear whether this is the TAG/EAGs responsibility, but it should have been done in the outbreak preparedness instead of the response phase.*

iii. Effectiveness of Communication and Information Flow, Including Information Provided to Decision-Makers

Communication to the public

The outbreak control continued to be managed by individual DHBs at a regional level until the outbreak had become significantly advanced.

In the Auckland region, the leadership of the outbreak response shifted from ARPHS to the DHBs with the transition from Phase 2 (*Manage it*) to Phase 3 (*Outbreak and Epidemic Management*).

Technically there were many different outbreaks as the cases were linked to individual importations, however these were all measles outbreaks and were perceived as a large national outbreak.

DHBs and PHUs had information about measles on each of their websites, but with some differences in content. An example being the population that was targeted for catch up vaccination varied due to different interpretations and prioritisation of the Ministry directives.

The national TAG/EAG meeting on 10 September noted that there had been inconsistency of messaging. TAG/EAG recommended that any communications should include consideration of social media channels and engaging influencers. Consistent messaging is important for vaccine confidence.

Once the NHCC was activated in August, national coordination was challenging as there were so many different websites and other media with measles information around the country and it became impossible to streamline all the information in order to respond to emerging issues.

Information provided to decision-makers

The New Zealand Emergency Management approach adopted the CIMS structure in order to ensure uniform upscaling processes, and facilitate communication between the national centre and the periphery, and between and within organisations and agencies. The NHEP requires all DHBs to establish a single point of contact for communication with the Ministry, when there is national upscaling in an emergency situation. All the DHBs are grouped in to 4 regional areas to further facilitate streamlined communication. The Ministry's lead role for communication is the National Coordinator, who is supported by the Regional Coordination Team in working with DHB Incident Controllers.

The briefing to the Associate Minister of Health of 29 July 2019, did not include information about a measles outbreak, although the outbreak response in Auckland had moved to phase 3 (*Outbreak and Epidemic Management*) a month earlier on 19 June and the number of cases was still rising. The Ministry briefing included information about meningococcal disease, and potential for an MMR catch-up campaign. The need to clarify the roles between PHARMAC, DHBs and the Ministry was highlighted.

Communication with the Associate Minister's office was an area of tension as the outbreak proceeded in September, with the need to respond rapidly to heightened media interest and Parliamentary questions. This put pressure on the small Ministry Response Team and impacted negatively on the efficiency of the response. This process was streamlined later in the outbreak.

Many interviewees commented that the shortage of vaccinations that occurred in early September was unexpected as PHARMAC had provided repeated reassurances about the availability of vaccines. The reassurance provided by PHARMAC about sufficient numbers of vaccines in New Zealand, was based on historical usage and the information PHARMAC received about the number of vaccines needed by ARPHS and CMDHB and this may have been passed on to Associate Minister of Health, Hon Julie Ann Genter. PHARMAC were able to immediately provide information about vaccine stock and advised the need to take stock to avoid shortages if MMRO were to be implemented, when they became involved in the in the NHCC on 30 August.

Findings

- *Because upscaling the response had happened in modified ways at every level, there were unclear communication lines and accountabilities between organisations.*

- *Healthline's help with professional communication was appreciated by interviewees, but Healthline had no official role in outbreak management. Mandates for decision making and information flows were not clear.*
- *Until 30 August, communication initiatives were maintained at all levels of the health system, there were no national key messages. After 30 August, recommendations for vaccination delivery changed frequently. This was related to vaccine supply.*
- *Experiments with social media were undertaken on several levels. The use of Facebook, for example, requires constant monitoring to correct misinformation, a process that is very resource intensive. In addition, the internet has no DHB borders and information posted online required good coordination, that was not evident during the measles outbreak.*
- *Clear processes for communication with the Ministry's offices are essential to enhance workflow and so that not 'everybody' is interrupted frequently. We observed that communication was often random and inefficient.*
- *The Ministry's Communications Department was not involved in NHCC from the beginning and this much needed resource was not available until later in the Response.*
- *With the activation of the NHCC on 30 August, the NHCC commenced communication directly to GPs, pharmacists and other stakeholders, while DHBs were also still communicating with these groups about the measles outbreak.*
- *The Northern Region did not upscale according to the emergency plans. The delay in activating the NRHCC (until the after the activation of the NHCC by the Ministry of Health) hampered regional communication and uniform communication to the Ministry.*
- *The Auckland region DHBs did not receive consistent messages in their communication with the Ministry, notably in relation to vaccine supply and availability.*
- *The Ministry did not always have up-to-date national data, such as MMR run rate, on hand. There was conflicting information provided to the sector by vaccine suppliers, PHARMAC and the Ministry. This made planning of vaccination campaigns difficult.*
- *We received information from some interviewees that limitations were sometimes placed on communication due to national sensitivities; for example, the delay in the use of the term 'outbreak' for the Auckland events, or the prioritisation, and changes to priority groups for targeting. This was a further barrier to clarity in sector communications.*
- *The feedback provided by Auckland region interviewees was that national communications and responsiveness to issues was often very delayed or late. Furthermore, the advice that was provided was often very lengthy, and lacked the level of specificity that was required by key audiences.*

i. Resourcing of the Incident Management Team

At the time the measles outbreak started, the NHCC had been activated at the Ministry multiple times for more than a year, responding to various emergencies around the country. The Communicable Diseases Team within the Ministry had been active in an Incidence Management Team responding to the meningococcal disease outbreak in Northland.

The national emergency plans do not provide for a specific point when national upscaling should have occurred. All interviewees agreed that this should have happened much earlier.

During the outbreak, the Ministry's teams struggled to combine the Incident Management Team with their business as usual responsibilities. The Ministry's process for staffing the NHCC was that staff were recruited from across the Ministry to work in shifts so that people could contribute to the emergency response without neglecting their usual work.

Findings:

- *The sequence of events that made it necessary to keep the NHCC activated for more than a year were unprecedented and interviewees stated this was the reason for the delay in updating emergency plans.*
- *There had been a series of restructures within the Ministry, that had led to the separation of the Immunisation Team from the Communicable Diseases Team and leadership of the teams by different Directors. A subsequent (recent) restructure then re-joined the teams. Cooperation between the teams had become no longer business as usual.*
- *The series of restructures had also led to a high turnover of staff. Many people were new to their positions and had not been trained in emergency plans and roles.*
- *As a result of restructuring, the Immunisation Team had multiple acting managers in the 18 months prior to the start of the outbreak, and the role was vacant between May and July 2019. The current manager had started in the role 2 months before the NHCC was activated . The Immunisation Team (now 8 staff) was down to 3 staff in July 2019 (the outbreak was led by the Communicable Disease team until September).*
- *There were few Ministry staff who were experienced in outbreak management, many of the staff involved in the outbreak response were inexperienced and were also required to maintain their BAU roles. These issues and the prolonged measles outbreak reportedly led to exhaustion and frustration felt by many interviewees.*
- *The attempt to keep BAU running by having staff work in NHCC in shifts did not help the continuity of the response to the outbreak, as noted by the region.*

7. Measles Vaccines

This chapter discusses the events relating to the supply and distribution of MMR vaccines during the period from March to November 2019. We have discussed in Chapters 2 and 3 the roles and responsibilities of the organisations that contribute to immunisation coverage and vaccine management.

TOR Q5: Supply and distribution of measles vaccines.

With the exception of outbreak situations, the number of MMR vaccines used in New Zealand has for many years remained relatively stable at about 12,000 doses per month. PHARMAC holds approximately 4 months of vaccines in stock. For the smaller measles outbreaks that have occurred in previous years, this has been sufficient to meet increased demand; and vaccine shortages have not occurred.

On 12 March, in response to the measles outbreak in Canterbury, the Canterbury DHB made an announcement to the press that 100,000-125,000 people would need to be vaccinated in the region (30) and that 100,000 measles vaccines would be handed out in Canterbury region in the next few weeks (31). On 13 March Canterbury put out a press release that 18,000 vaccines had arrived and 9,000 would follow (24). As it eventuated, 22,000 MMR doses were delivered in Canterbury, and the outbreak was declared over on 16 May.

In mid-April, the Auckland region local TAG recommended the introduction of an extra vaccination - MMR0 - for infants aged 6-11 months. ARPHS reported however that the PHOs they consulted, could not manage this change because they were in the middle of the annual influenza vaccination campaign. In addition, MMR0 is not a regular vaccine in the National Immunisation Programme, so to action this would have required a change in the GP claiming systems, which was problematic. At that time there was also a discussion with the Ministry about the use of the term 'outbreak' because there was concern about vaccine shortages (chapter 4). For these reasons, active recall for MMR0 was not implemented at this stage. MMR0 was administered throughout the outbreak on the basis of individual clinical judgement (as described in the Communicable Disease Manual (CDC). Only after the Ministry approved the change to the schedule in October, when enough stock was available, were children actively recalled for MMR0 from week 43 (fig 5). NRHCC had operational plans focused on ensuring Pacific and Maori infant access to MMR0 as a key element of delivery when the policy was approved.

At the end of May, ARPHS advised PHARMAC, that they wished to vaccinate an additional 30,000 people. The 40,000 doses purchased by PHARMAC and not used in Canterbury were reallocated to the Auckland outbreak.

29 May, the Ministry of Health and PHARMAC agreed additional vaccine supply to bring MMR1 forward from 15 to 12 months in the Auckland region.

11 June, MMR1 administration at 12 months commenced.

By mid-July, only 9,000 doses of the 40,000 allocated vaccines had been distributed in Auckland.

30 July CMDHB advised PHARMAC of proposed vaccination activities and PHARMAC confirmed it would be able to supply the 20,000 to 30,000 doses CMDHB required, as there were still approximately 25,000 doses remaining of the 40,000 doses reallocated to Auckland.

1 August, there were 104,000 doses of measles vaccine in national and regional stock.

5 August, there was a teleconference with PHARMAC/Ministry/ARPHS, where early outbreak response and possibility of bringing forward 4-year dose to 15 months was discussed. Estimated 15,000 to 20,000 MMR doses required.

8 August, CMDHB presented a proposal to the Ministry for additional resources (5 extra nurses) to target a population of about 11,000 Māori and Pacific people for vaccination.

13 August, there was a teleconference with PHARMAC/Ministry; the Ministry provided an update that Counties Manukau were no longer planning to bring forward 4-year dose.

23 August, the Ministry's briefing to the Associate Minister of Health, Hon Julie Ann Genter, reported that there were no concerns about vaccine supply, with 100,000 doses in the national store.

National communication about the need for vaccination was included in the Ministry's call to action, posted on their website on 23 August:

'... there is an outbreak, everybody under 50 who hasn't been vaccinated should get vaccinated today...'

30 August, there were 78,000 vaccines in national and regional stock.

30 August Activation of the NHCC, and an announcement made by the Associate Minister of Health Hon Julie Ann Genter to the media:

'People under the age of 50, especially children, who have not been vaccinated, should seek a free vaccination from their doctor as soon as possible.'

2 September, the Prime Minister discussed the measles outbreak at a media conference to launch the Cancer Action Plan, encouraging wide vaccination across the country for any person who had not had two doses of MMR vaccine and encouraging people to stay at home if they had symptoms.

MMR vaccine usage in Auckland significantly increased following the media statements by the Associate Minister of Health and the Prime Minister (see Figure 5 and Figure 6 Metro Auckland DHBs MMR doses given by week).

The response was dramatic, with 54,000 doses being ordered and distributed in five days. PHARMAC had not been consulted in advance about vaccine supply to support such a large-scale programme.

Simultaneously, on 3 September, the first meeting of the Ministry's national TAG/EAG was convened. This was also the first formal meeting that PHARMAC attended in regard to the measles outbreak. The TAG/EAG advised, as the ARPHS/ Auckland regional TAG had previously recommended in April, that an additional MMRO vaccine for infants aged 6 months old should be implemented in the Auckland region. At this meeting, PHARMAC cautioned that there was a need to first take stock of vaccine volumes before MMRO was introduced.

Outreach vaccination was occurring in the Metro Auckland districts at this time. This involved active recall by general practices of children under 5 years who may have missed or been delayed in receiving their MMR vaccines, recall for the change from 15 months to 12 months for MMR1 and later for MMRO implementation and subsequently for follow up events (MMR1+2). Several additional drop-in clinics were also opened in the Auckland region. PHARMAC encouraged vaccinators to be aware of the increased demand and to keep a close eye on their stock levels.

In the first week of September, several vaccine providers ran out of stock, and this led to increased media attention. The Ministry of Health and PHARMAC responded on Sunday 8 September, by placing a temporary pause on ordering of MMR vaccine. This was done in order to enable a stocktake of the distribution of vaccines in each region. Metro Auckland IMT responded with large scale outbreak vaccination planning and taking on the metro Auckland vaccine distribution process to PHOs as part of vaccine management in response to issue of supply. In Auckland, vaccine shortages were ongoing from early August and required regular updates to outbreak response plans, communications, stocktakes, prioritisation of stock and a fully managed distribution network

PHARMAC had arranged with the vaccine supplier to bring forward the next two expected orders of vaccine to assist with meeting the increased demand for vaccines. An order of 52,000 doses of MMR vaccine arrived in New Zealand on 16 September. This was followed by a Ministry announcement on 18 September, that subject to final regulatory approval, a further 100,000 vaccines had been procured for New Zealand.

Most of September and October was used for vaccine stock management and frequent changes were made to the priority groups that were targeted for vaccination with the limited remaining vaccine stock.

By mid-November, 85,000 doses of MMR vaccine had arrived in New Zealand and a further 70,000 doses were scheduled to arrive in January 2020.

The National Immunisation Register shows that 231,129 MMR vaccinations had been given in New Zealand in the year to 16 December 2019. This compared with 126,452 vaccinations for the same time period in 2018.

Findings

- *DHBs are required to seek approval from the Ministry and PHARMAC for vaccinations given outside NIP. For the Canterbury outbreak, the intention to undertake mass vaccination, and the number of vaccines that would be required was communicated to the media, before PHARMAC or the Ministry of Health were advised.*
- *Unlike other medications, vaccines supply has a lengthy production time, are often produced in only a few factories worldwide and have a short shelf life that is cold chain stable dependent. In the past decade, there have been many vaccine shortages and 'out of stock' situations worldwide. The demand for programmed vaccinations, as in the National Immunisation Programme, are mostly related to the size of the birth cohort, so this number is quite stable and therefore predictable. In the case of outbreaks, especially large and unexpected outbreaks, this may cause problems because the number of vaccines that may be required is usually less predictable and delivery times for vaccines from international suppliers of 6 months are not unusual.*
- *The local vaccination campaign in response to the outbreak in Auckland, unintentionally turned into the long anticipated national vaccination campaign because of the extensive media coverage and communication by the government, and because everybody in New Zealand under 50 who had not been vaccinated for measles is eligible for funded vaccination. However, this occurred without the necessary preparations to overcome the threats and challenges that were identified in the Ministry of Health SWOT analyses in 2017.*
- *An additional 104,677 vaccines were delivered to the New Zealand population in 2019, without the level of preparation that was required to support a national campaign.*

- *There are some uncertainties about the (completeness) of the registration of MMR vaccines in the NIR. We were provided with information that suggests a discrepancy of around 90,000 between NIR data and vaccine claims data at the end of 2019.*
- *Several health care professionals that we interviewed stated that many people that were vaccinated as part of the outbreak response were the ‘worried well’; people who likely had been vaccinated already but who were not sure, leaving fewer vaccines for the unvaccinated risk groups. The evidence to validate this assertion was not available to the review.*
- *Before PHARMAC had participated in the TAG meeting of 3 September, there had been limited awareness in the health sector about vaccine production timelines (> 6 months) and the vaccine supply chain. There are only 2 manufacturers worldwide for the international market and measles vaccines have a limited shelf life.*
- *In the MoU (2012) between the Ministry, PHARMAC and DHBs, the roles and responsibilities of the different stakeholders in case of vaccine preventable outbreaks are not entirely clear. The roles are described as:*
 - o *PTAC (Pharmacology and Therapeutics Advisory Committee): may be commissioned at cost to the Ministry to advise about outbreak and programme management (first meeting TAG 3 September).*
 - o *PHARMAC: discuss with Ministry and affected DHB proposed response to outbreaks.*
 - o *PHARMAC: liaise with regional vaccine store about stock management issues and advice the Ministry if necessary.*
 - o *Ministry: inform PHARMAC when there are public health changes.*
 - o *Ministry: accountable for coordinated response to outbreaks.*
 - o *DHBs: manage public health response to local outbreaks and fund vaccines.*
- *Vaccines are delivered to national storage, then on to regional storage. After that PHARMAC has no line of sight or influence over distribution.*
- *There is no provision for Regional storage providers to block orders. Prioritisation of vaccine to areas of need is not possible under current PHARMAC subcontracting arrangements. General Practices are able to order any number of vaccines.*
- *The impact of media attention on the vaccine uptake in the first week of September is demonstrated in the graphs in Figures 5 and 6, from information provided by the metro Auckland DHBs.*

The doses of MMRO delivered in Metro Auckland and recorded on the NIR are provided below in Figure 5:

Figure 5: Weekly number of MMR0 doses given to children under 12 months old in the Metro Auckland region. (Source National Immunisation Register, provided by ADHB).

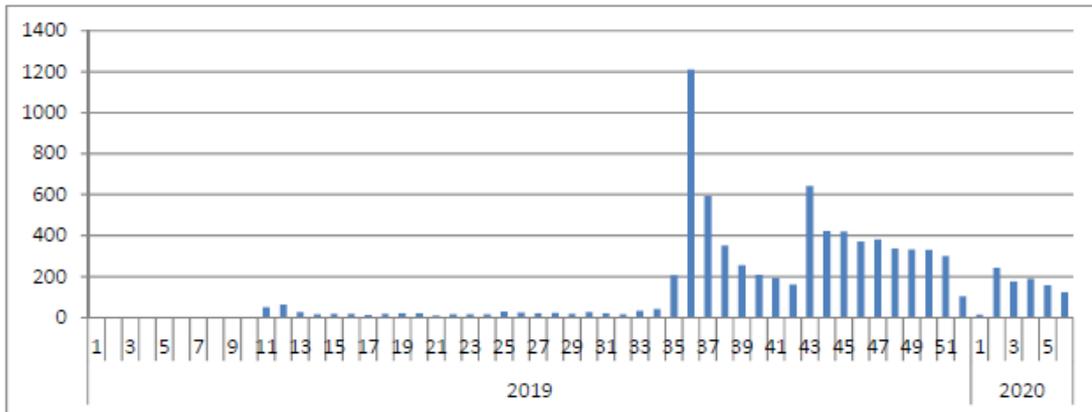
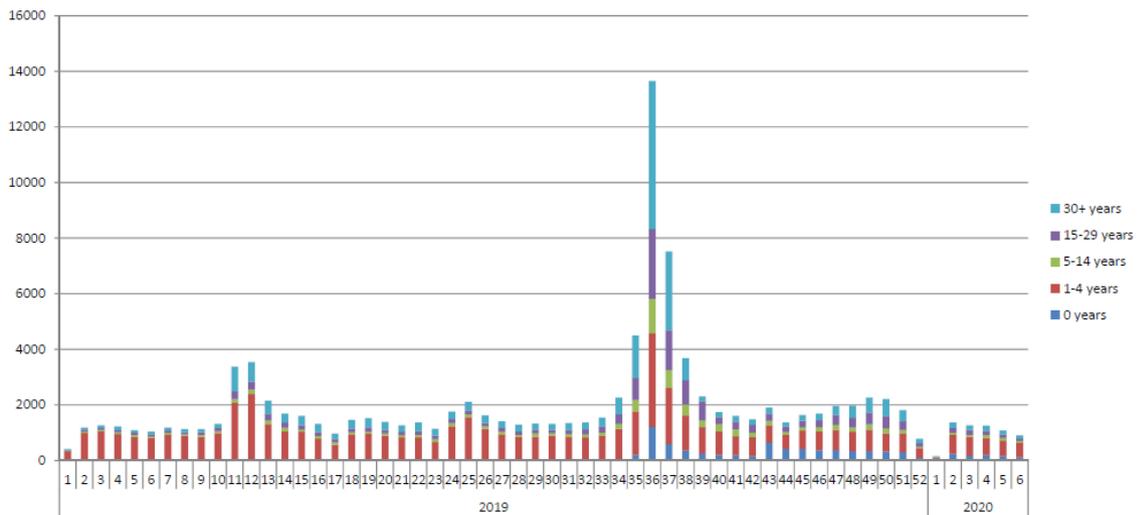


Figure 6: Weekly number of MMR doses given in the Metro Auckland region, by age. (Source National Immunisation Register, provided by ADHB).



8. Equity

The Ministry of Health has a strong commitment to equity, and an equity work programme was established in 2018 to address persistent disparities in health access and quality of services and outcomes for Māori and Pacific peoples and those in low socioeconomic groups.

'In Aotearoa New Zealand, people have differences in health that are not only avoidable but unfair and unjust. Equity recognises different people with different levels of advantage require different approaches and resources to get equitable health outcomes...' (32).

The Ministry cites the study by Schneider et al (2017) comparing health system performance between OECD countries that found for equity measures, New Zealand rated 8 out of 11 countries, in support of the need for action (32).

We have discussed in Chapters 2 and 3, that when New Zealand achieved 'measles and rubella elimination status' in 2017; the RVC cautioned that significant immunity gaps remained. The RVC recommended that urgent action was required to fill the immunity gap for underserved and under immunised ethnic groups and age groups. These immunity gaps were also reported in international and New Zealand academic publications and discussed in DHB and Ministry reports.

TOR Q6: Equity considerations including the extent to which at-risk groups and individuals were targeted and reached.

The 2019 measles outbreak has not yet been fully evaluated and analysed. With 2185 cases, the estimated incidence was 444.4 per million for the total New Zealand population. The Pacific population was most affected with 41% of all cases. The incidence in New Zealand by ethnicity is estimated in Table 4.

Table 4: Estimated Incidence of Measles in New Zealand by ethnicity

Population	Estimated incidence (per million population)
Pacific	2340
Māori	674
European	171
Others	67
Total NZ	444.4

After a solitary case in CMDH was notified on 27 February, the measles epidemic in the metro Auckland region started with a case with secondary spread notified on 12 March in the ADHB district, followed by cases in WDHB before the exponential increase in the large Pacific population in CMDHB.

The increase in the number of Pacific cases coincided with the move to Phase 3 in the management of the outbreak by ARPHS. During Phase 3, contact tracing had stopped because ARPHS had exhausted its resources after months of intensive contact tracing in the two other metro Auckland DHB districts.

In the rest of New Zealand, at this time, there were fewer measles cases, and PHUs were still actively tracing and quarantining contacts.

Although the numbers of measles by DHB region and ethnicity have not yet been reported over the entire period of the outbreak, an interim evaluation by ARPHS (Auckland Measles Outbreak Report 2019) reports that early in the outbreak, inequities in the disease burden became clear, with Pacific and Māori populations having the highest rates of measles in all age groups and the highest rates of hospitalisations. Two thirds of cases occurred in those living in areas NZDep 9 or 10.

Following the activation of the NHRCC, efforts to ensure vaccination equity in the Auckland metro region, included advice to primary care about the MMR0 policy, active recall activity and prioritisation of available vaccine to those groups most affected.

The interim report also reports on hospitalisations and complications using data from the start of the outbreak to 17 September. It found that of the 1064 measles cases in the Auckland region, 380 had been hospitalised. The highest hospitalisation rates were in children aged 0 to 4 years (52%) and hospitalisation rates were higher for Māori (41%) and Pacific (37%). The report suggests that hospitalisation and complication rates (encephalitis and pneumonia) were higher than in previous outbreaks but detailed analysis is not yet available to confirm this.

Senior clinicians from Emergency Departments (ED) and Paediatrics Departments, reported that very sick children were presenting to hospitals in June/July, prompting them to raise their concerns with the Ministry about the progress of the outbreak. The CMDHB Hospital ED and inpatient paediatric services were overwhelmed and unable to maintain preferred standards of isolation for infection control.

Findings:

- *An important early step in the management of the outbreak was the recommendation by the April Auckland regional TAG to introduce MMR0 for the Auckland region. Importantly, this recommendation was not actioned. The reasons that were provided to this Review were a lack of resources in primary care and the perception of pressure on vaccine supplies due to the outbreak that had been declared in Canterbury. MMR0 in the metro Auckland region was not implemented until September, following the recommendation by the Ministry's national TAG. We were unable to interview primary care personnel as part of this review, due to the timing and the emergence of COVID-19.*
- *The effective implementation of MMR0 was required to protect the high number of at-risk infants in the younger Māori and Pacific cohorts, that were reflected in the high case numbers and hospitalisations for these groups.*
- *Targeted vaccination in late October prioritised groups that were most impacted by the outbreak including children aged under 4 years, Pacific and Māori, and young people aged 15-29 years. In practice, however it was problematic to turn people outside these risk groups away.*
- *Measles is considered the 'indicator' disease that effectively seeks out unvaccinated individuals and subpopulations who remain unreached by immunisation programmes. The most recent measles serosurvey 2014/2015, found the lowest measles immunity in the age group 15-44 years was in the Pacific population, especially in women. The NIR data for birth cohort 2016 (who are eligible for MMR1 in 2018) showed that the lowest coverage of MMR1 was in Māori and Pacific children. Some interviewees suggested that, although the reported vaccination coverage for Pacific children in the Auckland region was high very recently, the MMR vaccination coverage in Pacific children may have fallen after the July 2018 tragedy where 2 children died after admission of incorrectly prepared MMR vaccination in Samoa.*

- *Interviewees suggested other reasons for the disproportionate impact of this outbreak on the Pacific community related to the well-known impact of the socioeconomic determinants of health, especially on the health of children. A 2019 report on Pacific health for the Health and Disability Review found that compared with all other ethnic groups, Pacific people are more likely to live in neighbourhoods of 'high deprivation', have the lowest median incomes, higher unemployment rates, the lowest rate of home ownership and the highest rates of household crowding (33). These factors have likely contributed to the rapid spread and worse outcome of disease for, in this case, the Pacific people.*
- *A problem identified by public health staff was the difficulty of maintaining the period of quarantine for a number of exposed contacts. As two thirds of cases were from decile 9 and 10, for many people on a weekly wage it was not possible to comply. Current criteria for approval of an emergency grant (Work and Income New Zealand WINZ) requires a minimum 2 weeks stand down period. Two weeks is the maximum time required for quarantine for measles.*
- *Translated information in preferred languages of the public, about measles was made available. Translations were however delayed and translators able to communicate in the preferred languages of measles cases and their families and contacts were not always available to support public health staff. There was a clear difference in access to health information for Pacific and Māori groups.*
- *Pacific people are characterised as 'transnational populations' with frequent movement within the Pacific region and close family and community linkages with New Zealand's Pacific population. There is therefore no surprise in the links reported between the New Zealand Samoan population 'immunity gap' and perceptions about immunisation and the events in Samoa.*
- *The commitment to equity in health policy and strategy documents was not adequately reflected in operationalising the measles outbreak response for Māori and Pacific populations. The populations that were disproportionately affected by the measles outbreak had limited involvement in providing strategic advice, outreach services and communication strategies.*

9. Conclusions

Vaccination coverage

For measles, at least 95% vaccine coverage that is equally distributed across the country, is required in order to prevent outbreaks after introduction of a virus. Since the introduction of the measles vaccine in 1969, the coverage in New Zealand has been too low to prevent outbreaks.

New Zealand has a history of frequent ad hoc measles vaccination campaigns and changes in vaccination schedules in response to measles outbreaks which has not been well documented or evaluated.

There is still a well understood immunity gap in the New Zealand population in the birth cohorts 1982-2005, caused by historical sub-optimal vaccination coverage, as confirmed by recent seroprevalence studies.

National registration of vaccinations started in 2005 and NIR commenced collection of immunisation information for children born from 2005 onwards. Since 2006, coverage has improved significantly but has never reached 95%, and is recently declining. Before 2005, there was no national registration which made it difficult to identify and target the susceptible population.

Historically, there have been multiple issues associated with recording information on the NIR for those outside the birth cohort.

An error in the reported coverage based on NIR data was corrected in 2019. It revealed that the coverage had been overestimated by on average 2.2% per year for MMR1 over the preceding 10 years and 4.7% for MMR2 over the preceding 7 years.

During the 2019 outbreak, it became apparent that measles vaccination coverage had recently declined more in Pacific children than in other ethnic groups of children. The decline was so recent that it had yet to be registered by the monitoring system.

In 2017, a cost-benefit analysis was published (Hayman et al. Vaccine 2017) estimating that 435,742 individuals in New Zealand were susceptible to measles and 104,357 needed to be vaccinated (assuming that immunity is equally divided throughout the country and unvaccinated individuals could be targeted, which is not the case), in order to reach sufficient herd immunity to prevent future outbreaks.

Based on these estimates, it is not clear why, as only one of the 19 DHB regions, Canterbury estimated the need for 100,000-125,000 vaccines in order to control the outbreak, as communicated by Canterbury DHB to the media. Hayman et al. estimated that Canterbury has 48,190 susceptible individuals, of whom 10,520 needed to be vaccinated to obtain herd immunity (under ideal circumstances). In the event, in the Canterbury outbreak, 39 measles cases were reported and 22,000 vaccines were administered.

In 2019, significant costs, and significant efforts by many health personnel throughout the country, were made in the effort to try to control the largest measles outbreak in decades in New Zealand. The outbreak lasted the entire 2019 year. At the end of that year, an additional 104,677 vaccines had been delivered to New Zealanders. This is about the same number of vaccines as estimated by Hayman et al (2017) as needed to close the immunity gap (under ideal circumstances).

There was inadequate registration of the administered vaccines in NIR. At the end of 2019 there was an estimated 90,000 discrepancy between vaccinations registered in the claims data and vaccinations recorded in the NIR data. It is therefore not possible to judge in how far the 2019 vaccination campaign has contributed to closing the immunity gap at a population level.

Infectious disease control and outbreak management

Although there are no international or consistent guidelines on (triggers for) response in relation to outbreaks of measles, it would likely have made quite a difference in outcome if the introduction of MMR0 had been implemented in the Auckland region in April 2019, as recommended by the regional TAG, rather than in September following the national TAG/EAG recommendation.

It is unclear how the recommendations of a regional TAG related to recommendations of the national TAG/EAG, and what is done should there be discrepancies in the recommendations of these bodies.

In the past decades, many functions have been devolved from the Ministry of Health to other organisations, such as ESR and PHARMAC, IMAC and DHBs. New organisations such as Healthline have begun to play an important role in outbreak management but without an officially mandated function and specified responsibility in outbreak management. The knowledge and experience that is present in these organisations was not optimally used in the response to the measles outbreak.

Devolution of infectious disease control to districts can work well. The strength of this approach in New Zealand lies with DHB and PHU in-depth knowledge of their district populations, including vulnerable groups and local context, stakeholders and networks in their districts.

Local outbreaks can be very well controlled within the districts. However, when an outbreak becomes trans-district or regional (as with Auckland Metro), centralised national coordination is essential.

The regional organisation of outbreak management in the greater Auckland region is complex, because one PHU works with three independent DHBs. The separation of responsibilities -DHBs for vaccination coverage, access to NIR data, knowledge of vulnerable populations in their own districts; PHU for the response to outbreaks and vaccination of contacts of measles cases - was problematic and led to the Auckland leadership response changing from ARPHS to Auckland Metro DHBs with the shift to Phase 3. Moreover, differences in the nature of the outbreak within each of the 3 metro Auckland DHBs required specific tailored responses, which added to the complexity of the response that was required.

In the Auckland region, potential weaknesses emerged and this was further exacerbated by resource constraints. In the 2019 outbreak, the outbreak epicentre moved across the metro Auckland regions and when it arrived in South Auckland, the district with the most disadvantaged and highest at-risk population groups, ARPHS had already run out of resources which had been expended in the earlier WDHB and ADHB responses. National coordination and oversight to ensure equity was essential as underlying system disparities (and the 'inverse care law') can be exacerbated in emergency situations.

Although the measles outbreaks in 2019 was caused by at least 18 separate virus introductions in different regions, the response required national coordination for several reasons:

- The outbreak widely perceived as one outbreak affecting most of the country.
- Eventually, 17 of the 19 DHBs reported measles cases in outbreaks which varied in size.

- All DHBs were reliant on and ‘competing for’ the same national vaccine stock.
- During the outbreak, the prioritised targeted vaccination groups frequently changed based on region and the availability of vaccine.
- The variety of measles communication on many different websites from many health organisations and social media, may have negated consistent messaging, that is important for vaccine confidence.

The entire outbreak management sector seemed to have been overwhelmed before the outbreak began. On every level, staff were motivated and worked hard but were unable to keep up with their ‘business as usual’ activity as well as the many emergency response situations they had to be part of during the previous year.

In the preceding decade, frequent restructuring at the Ministry of Health had resulted in understaffed departments and capability gaps, and a high turnover of staff meant many had not been trained in outbreak management.

At the district level, budgets had been constrained for many years while expenses and tasks were increasing. This has led to vacancies that could not be filled.

On all levels, tasks that belonged in the preparedness phase of outbreak control had been neglected. (National) outbreak plans and guidelines were out of date, recommended frequent exercises had not taken place, recommended adaptations had not been implemented. Many Ministry staff had not been trained in outbreak management.

In an outbreak situation, fast actions and decisions are important. Preparedness is essential. In the course of the measles outbreak, many tasks that belonged in the preparedness phase had to be undertaken in the response phase, which ultimately delayed the response.

New Zealand officially adopted the CIMS structure as the basis of operational response. CIMS should be consistent at all operational levels to provide a structure allowing units involved in an emergency to work together as a team. In the case of a national emergency, the CIMS structure facilitates communication between the Ministry’s National Health Coordination Centre (NHCC) and DHBs. During the 2019 measles outbreak, most, if not all, plans and upscaled structures were used in modified ways, which led to unclear situations with command, communication and responsibilities.

In a national upscaled situation, the upscaling and command structures are not clear. It was noteworthy that, in early September at the peak of the outbreak, the national TAG/EAG flagged that DHBs should be advised to ensure their outbreak response plans were up-to-date and that triggers for escalation of response were suggested.

Vaccines

Because of the long production times, the often limited production capacity worldwide, and short shelf lives, vaccines can usually not be bought and delivered instantly in large quantities in unexpected situations. This is further complicated when international outbreaks compete for the same limited resource.

Equity

Measles is considered the ‘indicator’ disease that effectively seeks out unvaccinated individuals and subpopulations who remain unreached by immunisation programmes. The immunisation gaps in underserved and under immunised ethnic groups and age groups in New Zealand were reported in the WHO RVC recommendations in 2017 and in international and New Zealand academic

publications. The Ministry's statement that '*... Equity recognises different people with different levels of advantage require different approaches and resources to get equitable health outcomes...*' needs to be reflected in the implementation of the measles immunisation programme and emergency outbreak response management.

10. Recommendations

1. Measles immunisation rates must urgently improve to prevent outbreaks and the emergence of new immunity gaps in adults in the future. The declining coverage in the childhood vaccination programme is a concern.

Investigate whether there are (additional) effective ways to more efficiently and effectively deliver (NIP) vaccinations.

Investigate whether it would be effective to seek proof of measles vaccination for certain immigrant groups (e.g. students, temporary workers) who apply for a visa.

2. Consider combining outreach vaccination for at risk Pacific and Maori children, with 'catch-up' vaccination of adults to close the immunity gap and improve childhood vaccination coverage. Remarkably, the influenza coverage among Pacific and Māori people over 65 years old is relatively high, showing there is vaccination awareness in these populations and the potential for whanau focused approaches.

3. Ensure registration of vaccinations occurs during reactive large-scale immunisation campaigns. Reactive ad hoc vaccination on a large scale in outbreak situations, which has happened frequently over decades, carries the risk of inaccurate immunisation registration.

Consider the development of a new comprehensive national vaccination register. The register should be made fit for purpose to enter for all vaccinations given in different settings (travel medicine vaccines, commercially administered vaccines) because they can overlap. Consideration should be given to use this system for registering pandemic vaccinations (influenza and COVID19 vaccinations) as well

Consider the development of patient access to the Register through an App, with options 'evidence of vaccination' 'history of vaccination, no evidence' and 'not vaccinated'. This could gradually be developed, with the potential for use to target unvaccinated people in future catch-up campaigns and outbreaks.

Evaluate the measles vaccination campaign 2019, that occurred in response to the outbreak. The evaluation should analyse the over 100,000 vaccinations administered, and discrepancies registered in the NIR and the claims data. If possible, complete NIR data and estimate how big and where the largest remaining immunity gaps are, and focus on how to reach the most at-risk groups.

4. Stronger national and regional leadership and coordination of communicable disease control across the system is urgently needed. The Ministry needs to consider how to achieve a clearer/stronger national chain of command and coordination of infectious disease control and outbreak management at a national level.
5. Consider clarification of command and leadership functions for infectious disease control and outbreak management in regions where one PHU works with more than one DHB.
6. Develop a generic outbreak management plan. Many processes in outbreak management are very similar, such as source- and contact tracing, sampling and lab testing,

communication, triggers for escalation on a regional level, triggers for escalation to a national level, mass vaccination and vaccine distribution (for vaccine preventable diseases), upsurge and distribution of lab tests. Different phases of outbreak management should be described and the same phases should be used in every outbreak plan. Terminology should be uniform to enhance communication in case upscaling is needed. Responsibilities and accountabilities should be clearly described.

For diseases that are most likely to cause superregional or national outbreaks, disease specific outbreak plans and guidelines should be developed in addition to the generic outbreak management plan. For measles for example, a well-known disease, each region should use the same outbreak plans, guidelines, with uniform information to the public. Only then is it possible, if an outbreak starts locally and emerges to a larger scale, to uniformly scale up to a super-regional and national level, and change the command and communication lines accordingly.

Evaluating/reviewing every outbreak in a standardised manner on every level, and updating response plans after each outbreak with the evaluation findings, is an efficient and (cost) effective way to keep plans up-to-date. If there are more outbreaks in the future, fewer exercises will have to be organised.

The generic outbreak plan can also be used as a template for outbreaks of new viruses such as COVID-19, that are likely to become more common in the future.

7. Clarify the roles, mandates and responsibilities of the various national stakeholder organisations (ESR, Healthline, IMAC, PHARMAC) in regional and national outbreak management plans. Clarify the command lines and roles of other key stakeholders (PHOs, GPs) in outbreaks at a regional level and at a national level. Command lines, internal and external communication lines and leadership functions should be clearly described, in addition to the changes that are required when a regional situation becomes a super-regional or a national situation. Implementation of the outbreak plans with the regional stakeholders should occur at a regional level, and can differ per region.
8. Centralise and standardise functions and information (standard communication materials, framework for outbreak management, social media communication). This is more efficient and will lead to greater uniformity, facilitate smooth upscaling and lead to improved national coordination. The current situation where all regions develop their own information, is a barrier to upscaling uniformly at a national level, when required. Many DHBs and PHUs concurrently developing their own versions of the same materials and tools and website publications is inefficient and costly to the system as a whole. Innovations should be shared with other districts.
9. Consider the role in outbreak management of Maori and Pacific leaders and providers that are already working effectively with communities at risk of infectious disease outbreaks. A culturally appropriate response is needed in infectious disease control to achieve equitable service outcomes. This requires involvement health care workers with the appropriate cultural and linguistic competencies.
10. Consider for every outbreak threat, convening one initial entire outbreak management team meeting at an early stage, to ensure all possible expertise is represented and informed. Key decisions for consideration at the initial outbreak meeting should include which sub-group will continue as the outbreak response team, and under which circumstances the entire

outbreak management team should become engaged. The objective of this initial meeting should be to facilitate swift upscaling and efficient implementation.

11. Because of the short shelf life of measles vaccine, it is not possible to keep large quantities of vaccine in stock for unanticipated outbreaks. Consider shared and coordinated decision making by the responsible authorities (Ministry and PHARMAC informed by ESR and regional distributors) to determine whether, which, and how many vaccines are kept in stock for emergencies, and how to deal with unexpected situations. This should occur in the preparedness phase and not during an outbreak situation.

12. Make optimal use of digital solutions at all levels. Develop integrated national databases. Develop generic uniform applications that are flexible and easy to adapt to changes and with upscaling possibilities (contact tracing). Digitalise outbreak management plans. Uniform systems and uniform input facilitate uniform output

Integrated national databases (EpiSurv, NIR, GP systems, personal health apps) that enable interoperability and allow functionality for key planners and implementers in the health system are essential for efficiency in future outbreak management. Linking these databases to a uniform national vaccination App or general health app, would make it possible to collect data through this app with the collaboration of citizens.

Ensure all PHUs use the same application for their source and contact tracing. This will result in greater efficiency, support a national overview and assessment of the need for upscaling in the future.

13. The burden of disease is inappropriately borne by Maori and Pacific peoples. Prioritise equity considerations with a focus on Maori and Pacific populations who continue to bear the heaviest burden of infectious disease outbreaks in New Zealand. The Ministry's statement that '... Equity recognises different people with different levels of advantage require different approaches and resources to get equitable health outcomes...' needs to be reflected in the implementation of the measles immunisation programme and emergency outbreak response management.

Consider a recommendation to the Ministry of Social Development to remove the Work and Income New Zealand minimum 2-week stand-down period for emergency grants for all notifiable infectious diseases, if quarantine is necessary to facilitate outbreak control.

Finally

New Zealand is unique because it is surrounded by the sea and not densely populated. This gives opportunities for strong oversight and control to keep infections out of the country than in more densely populated countries, and to stop infections from spreading once imported. Risk groups are limited in absolute numbers so are easier to target. This provides significant opportunities for a tailored well-functioning and targeted public health system. Intelligence to inform this lies within and outside the public health system. For at risk groups such as Pacific peoples there may be better analytical and intelligence functionality outside public health system structures.

Appendices

Appendix 1: Interviewees

During the review individuals from the following groups were interviewed

- The Ministry of Health
- District Health Boards (Auckland, Counties Manukau and Waitematā)
- Auckland Regional Public Health Service (ARPHS)
- Institute of Environment Science and Research (ESR)
- PHARMAC
- Ministers' offices
- Technical Advisory Group (TAG)
- Immunisation Advisory Centre (IMAC)

Appendix 2: List of abbreviations

ADHB	Auckland District Health Board
ARPHS	Auckland Regional Public Health Service
CDHB	Canterbury District Health Board
CIMs	Coordinated Incident Management Structure
DHB	District Health Board
ED	Emergency Department
ESR	Institute of Environmental and Science Research
GPs	General Practices
GVAP	Global Vaccine Action Plan
Hosp	Hospitalisations
IMAC	Immunisation Advisory Centre
IMT	Incident Management Team
MMR	Measles Mumps Rubella
MMR0	Measles Mumps Rubella vaccine dose given at 6 months of age
MMR1	Measles Mumps Rubella vaccine dose given at 15 months of age in the New Zealand immunisation programme
NHEP	National Health Emergency Plan
NHCC	National Health Coordination Centre
NIR	National Immunisation Register
NRHCC	Northern Regional Health Coordination Centre
NVC	National Verification Committee
NZIPAP	New Zealand Influenza Pandemic Action Plan
RVC	Regional verification Committee
WDHB	Waitemata District Health Board
PHU	Public Health Unit
PTAC	Pharmacy and Therapeutic Advisory Committee
Stirep	Situation Report
SWOT	Strengths, Weaknesses, Opportunities, Analysis
TAG/EAG	Technical Advisory Group – also called the Expert Advisory Group
WHO	World Health Organisation

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