Understanding public service provision using digital technologies during COVID-19 lockdowns in New Zealand through a complexity theory lens

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Abstract
Complexity theory is used to explore an exemplar of how digital government services evolved under conditions of uncertainty and rapid change created by COVID-19 in 2020. Based on a qualitative, constructivist research design, informed by interviews with key senior public servants and document analysis, the complexity lens helps us to understand how provisions of digital public services were quickly adapted and evolved to meet new and emerging needs experienced because of the pandemic. Means for making collective sense of the unknown from which to plan first steps, learning from doing, agility, co-construction and adaptive leadership are in evidence.

Keywords Digital public services · COVID-19 · Complexity theory

1 Introduction
On the 30th of January 2020, the Director General of the World Health Organization (WHO) declared the novel coronavirus outbreak that we now know as COVID-19 a public health emergency of international concern (WHO’s highest level of alarm). The first COVID-19 case was detected in New Zealand on 28 February 2020. Just days later, forewarned by how quickly the virus had spread in communities elsewhere, the NZ government reacted with a response aimed at protecting the health of New Zealanders by preventing spread of the virus in the community and avoiding overload on the health system. Part of this response was a regime of lockdown levels requiring individuals to isolate in household ‘bubbles’ and restrictions on movement, for an initial period of four to six weeks. Thus, at very short notice, people had to stay home and most public services...
could only be delivered contactlessly. Government agencies, businesses and citizens needed to adapt quickly for work and service delivery to continue. Many in the public and private sectors and in the community were ill-prepared and yet we saw a rapid rise in service delivery via the online environment, adaptation of service delivery models and some new digital public services quickly introduced to support the continuance of public services delivery in key areas, such as health, welfare and education.

In this contribution, we empirically investigate this digital public service response by the New Zealand Government to manage COVID-19, including challenges that were encountered. In the sections to follow, we describe our research question, methodology and design.

The paper adds to our theoretical understanding of adaptive and agile public management practices that assist public officials tasked with maintaining public service delivery under conditions of change and uncertainty through the analysis facilitated by the complexity theoretical lens. It narrates the example how a national government, New Zealand, responded with modified and new public service provision in uncertain and rapidly evolving times produced by the COVID-19 pandemic. Internationally, the New Zealand Government’s response to pandemic has been considered as relatively successful, with low numbers of COVID-19-related deaths compared to the rest of the world. The significance of this paper is its contribution to the existing literature on the role and impact of digital technologies on public service provision in periods of disruption and high uncertainty such as the pandemic presented. The rapid shift towards digital public service provision, which occurred during lockdown in early 2020 involved many actors, who through their interdependent reflexive interactions with each other, the circumstances of the times and the users of services, recalibrated existing services to avoid the need for physical contact and designed and deployed new services required to manage the virus’ spread.

2 Research question, methodology and research design

We chose a constructivist methodology to explore the research question of how do public management and digital government evolve under the pressures of novel conditions and unknowns to facilitate the changing public services required of it? Data were collected through a dedicated workshop on digital service provision in 2020 with twenty senior public officials and academics. All the government departments involved in the response were asked to participate and present a response to our research question. Document review and follow-up qualitative interviews with deeply involved public servants in the health and education sectors allowed us to drill deeper into how these two sectors responded.

To analyse our data, we chose a complexity theory informed lens described in the next section. Drafts of our data analysis were reviewed by our participants and their further input incorporated before finalising a narrative account of the
evolution of digital government that occurred under lockdown and our complexity informed analysis of the micro-processes that enabled it.

3 A theoretical framework based on complexity theory

Digital government is a way of doing governance and delivering public services in the digital era (Lips, 2020). We offer a theoretical framework based on complexity theory for understanding how digital government evolves under the contextual forces that affect public administration in times of heightened uncertainty and change. Raadschelders (2011) identified four broad ontological and epistemological theoretical traditions in use in public administration. He labelled them as:

1) The scientific tradition, with its origins in the organisational and management sciences and formulating hypotheses that can be tested for addition to theory using positivist method
2) The practical experience tradition, which uses a variety of methods to understand the effects of an intervention and change in the real world
3) Practical wisdom that works at the level of providing insights into the relationships that exist between citizens and government, how these are operating and how they might be changed
4) Relativist theories that provide interpretations of the interactions between the individual actors, institutions and processes—‘hermeneutics, phenomenology, critical theory and postmodernism’ and the like.

Which of these traditions researchers choose to use is influenced by the researcher’s understanding of the phenomenon they are seeking to know and understand. Lips (2020 p. 44–62) named nine lenses or perspectives that have been and could be used to examine digital government:

1) Technology
2) Data and information
3) A change perspective—revolutionary vs evolutionary
4) Business/private sector
5) Transformative
6) Institutional
7) Network governance
8) Surveillance state
9) Good governance

Lips noted that each of these lenses offers only a partial view and that a complexity theory-informed perspective offers a more holistic lens for understanding digital government changes. Eppel and colleagues (Eppel, 2017; Eppel & Rhodes, 2017; Eppel, Rhodes, & Gerrits, 2021) argued that complexity theory lens either alone or in combination with extant theories (Raadschelders, 2011;
Eppel, 2017) offers alternative perspectives, institutions, methods and practices for better understanding and managing public sector policy and change. In brief, the system of individuals and organisations providing public services are interdependent, constantly changed by and changing in response to each other in nonlinear ways. It can be theorised and understood as part of a complex adaptive system (CAS) made up of many interdependent parts in constant nonlinear interaction with each other. This micro-view of how change in public services occurs sits comfortably with the more macro-view of Osborne and colleagues (2015) of an ecosystem generating public services through interaction amongst different parts of the ecosystem.

Essentially a complexity informed view rejects that change is led by a small number of rational actors and implemented in a controlled, predictable and linear fashion (see for example, Holland, 1995; Mitleton-Kelly, 2003). Instead in a complex system, there are many interdependent actors influencing each other in a nonlinear, reflexive pattern. In such a system, no one agent has full understanding of all of the parts nor control over how those parts behave. Co-evolution occurs during the interactions amongst multiple interdependent actors in interaction with (in the example investigated) the evolution of the virus and technologies used to continue digital service delivery (e.g. Gerrits, 2011; Eppel, 2012; Eppel & Lips, 2016).

In a CAS, each actor uses their bounded knowledge to decide how best to act and cannot know in advance how the other agents in the system will behave in response. The pattern of reflexive action and reaction can be one that generates positive feedback or reinforcement of a direction of change or it might be negative feedback that undermines the change made by others and locks the system into its initial state. Over time, the micro-dynamics of the feedback loops are likely to produce new emergent patterns such as new social structures or patterns of interaction that have not existed previously (Eppel, 2012; Kiel, 1994; Meadows, 2008; Mitleton-Kelly, 2003).

What follows from these complexity theory-based propositions is a view of governance as a dynamic process involving the interaction between multiple actors to produce a resulting change (Eppel, Rhodes, Gerrits, 2021). In keeping with that view, our research used a theoretical framework based on complexity theory to understand the digital public service response to managing COVID-19 in New Zealand, including challenges to continuing service delivery that were encountered as the pandemic evolved and new public services were needed.

Using this complexity view, public service provision results from the interaction of many individuals working in public sector organisations responding to historical and contemporary signals from elected officials in the form of policies, practices built over time in organisations in the design and delivery of services, and also feedback from users to shape the services they deliver (Osborne et al., 2015). Thus, services and service delivery are explained through the complexity lens as products of interactions amongst interdependent actors from both within government and amongst the community actors, constituting a public services ecosystem. Further, these signals are constantly undergoing change in response to the interactions and other events requiring agile behaviour by public servants (Mergel et al., 2021), and these changes can lead to new emergent services not previously known.
A complexity framing fits comfortably with the demand for agility and adaptation because it can focus on different levels: the individual, the organisation and the overall pattern that emerges from iterative ongoing adaptation to actions and feedback (Morcol, 2012; Room, 2011).

Drawing on Lips (2020) summary, the features of this complexity view of digital government are summarised so:

1) The system needs to be viewed as a whole and cannot be reduced to its parts because the sum of the parts is not equal to the whole. The whole has characteristics not present in the parts.
2) There is more than one system. Some systems are nested as part of a more complex whole. These systems interact with each other to produce nonlinear effects — sometimes no change — and sometimes change out of all proportion to the initial stimulus because of positive reinforcement of the initial change.
3) Nested human and non-human assemblages of actors in a variety of institutions make up a digital government system.
4) The boundaries of this complex digital government system and the parts that make it up are constructed by the interactions amongst the parts.
5) The digital government system is open to new people, ideas and resources.
6) The structure and institutions of the digital government system and the patterns of relationships between the parts of the system are held in place by interaction between the parts and positive and negative feedback amongst them.
7) Over time, the parts of the system adapt and coevolve with each other causing the digital government system to also evolve and create new institutions, rules, hierarchies and structures. Such changes are self-organising, requiring no external intervention and no one has control over the patterns that emerge.
8) Some emergent patterns might change the interactions and patterns of the system in ways that are helpful to achieving desired outcome and could be encouraged; others might be deleterious or unhelpful to a desired outcome and need to be disrupted.
9) All of the above dynamics are occurring all of the time. Sometimes change from these interactions is visible because positive feedback loops reinforce a pattern of change; and sometimes the system can appear stable and unchanging because negative feedback loops negate changes and holding the system in check. Any attempt to influence a CAS needs to take into account that the starting point is not zero; there are pre-existing dynamics and the patterns produced by previous changes continue to affect the system.

Learning in this type of dynamic system is key to ongoing feedback and adaptation. Learning can occur in such a system by taking into account that the parts act interdependently. Because each change stimulates an unpredictable response, the whole is constantly undergoing change and is more than the sum of its parts. A consequence is that no one person has full knowledge of all the interactions that make up the whole. Learning occurs through ongoing sense-making from multiple perspectives (Weick, 1995; Weick & Sutcliffe, 2007). Sense-making
pays attention to small changes and the dynamics (feedback loops) creating them. Some small changes will be reinforcing a desired direction of change whilst others might be undermining it. Organisational agents in the CAS are capable of influencing desirable change through the application of single, double and triple loop learning (de Waard et al., 2021; Fomme & van Witteloostuijn, 1999). ‘Single loop learning refers to making simple adaptations and taking corrective actions, whereas double-loop learning involves reframing, that is, learning to see things in totally new ways. Finally, triple loop learning entails agents developing new processes or methodologies for arriving at such re-framings’ (Fomme & van Witteloostuijn, 1999, p. 1).

Uhl-Bien and colleagues (Uhl-Bien et al., 2007) refer to the alignment required between leadership and complexity theory to enable change in a CAS as adaptive leadership. Adaptive and enabling leaders work behind the scenes to encourage entrepreneurial activity and find adaptive spaces for leaders to create new productive linkages between individuals, their organisation and various networks (Uhl-Bien & Arena, 2018). Mergel and colleagues refer to an agile way of governing in which there is ongoing feedback between actions of public officials, organisations, their processes of interaction and their changing context (Mergel et al., 2021).

The complexity theory-informed lens described here is used in the next section to examine the processes of interaction that created the digital public service response of New Zealand’s public management system to the COVID-19 pandemic in 2020–21 and the effect these processes had on the evolution of digital government services in the country.

4 A digital public service response to the COVID-19 pandemic in New Zealand

4.1 Addressing information deficits

The first response we saw was an increase in activities aimed at gathering information and making sense of what were previously unknown events being seen internationally. The appearance of COVID-19 begged a public management response of global and national institutions. The New Zealand government began to develop its public management response when the news of the virus and its likely spread into a global pandemic was first detected. A standing committee of senior officials with a risk assessment focus began paying attention to the appearance of the virus in early January 2020. Over the ensuing months, these officials initiated an all-of-government collaborative leadership process to plan New Zealand’s response (McLachlan, 2020).

At that stage, there were many unknowns including knowledge of the virus, its virulence, how it would spread. Various agencies contributed the best of their sector knowledge and professional expertise gained from domestic and international sources to inform the response. The process was a sense-making one with fragments of partial knowledge from different perspectives, including the early experiences of other nations as the virus spread. Individual domestic agencies were connected
to global networks and collectively anticipated the effects of the virus’ spread on their sector: Ministry of Health (MoH) with their public health focus and connections domestically and internationally with other health agencies and WHO; Ministry of Business, Innovation and Employment (MBIE) with the knowledge of businesses, trade and national infrastructure to support the essential functioning and logistics of New Zealand’s economy; Civil Defence, and Police (McLachlan, 2020). This network of senior public servants used imperfect and fragmentary knowledge of an unknown, seen from multiple perspectives in an iterative way to plan actions needed. As time went on, the membership and roles of actors in this group continued to evolve to bring new perspectives and resources into play.

When the first community-spread cases of COVID-19 were detected within New Zealand in March 2020, collaborative planning was well underway and included information sharing and co-ordination, particularly with Australia, New Zealand’s closest neighbour, both sharing the advantage of no land-based borders. Each agency and sector thought primarily about their own area of responsibility, but the emerging public management and health challenges were better understood when these partial pictures were combined and in some cases resulted in resources being shared across agencies.

Government reasoned that a public health response would best serve New Zealand’s social and economic interests and enacted a number of measures to slow the arrival of the virus from outside and prevent the spread internally. Government’s initial goal was to protect New Zealand from an out-of-control rampage of the virus through its communities and help New Zealand cope with the scale of the wide-reaching social and economic effects anticipated by closing its borders to the rest of the world. On 21 March 2020, the Prime Minister told the populace that the government had decided to act early and hard. A State of National Emergency was issued on 25 March 2020 and the country entered Alert Level 4 lockdown: people were told to stay at home, and work from home unless they had exemption as essential service providers. Compared with other jurisdictions, essential services were narrowly defined. Public Health orders enforced this ‘stay at home’ policy and imposed penalties for breaches.

In some sectors, such as in Health, Education, Social Services and Taxation, we observed a rapid expansion of digital public services to accommodate limited face-to-face contact and overloaded call centres. Call centres became an important lifeline for some, especially the most vulnerable and digitally excluded. However, call centre technology and logistics were tested to the maximum: inter-organisational co-operation and collaboration on these shared and prioritised capability and resources. Some organisations paused existing work, reassessed what they were doing and redirected resources to supporting new contactless and virtual ways of working and delivering essential services. For example, the Accident Compensation Corporation (ACC) redirected their digital product development resources to ‘standing up’ products that until then were only on the drawing board, such as a tele-health interface to assist health service providers to continue meeting clients’ needs. ACC were able to do this because of their experience with using agile methods for the management of new digital developments (Eppel & Lips, 2021). ACC’s prior investment in their call centre technology and capability
also made them well placed to support other agencies such as the Ministry of Social Development (MSD) who deal with older and socially and economically vulnerable clients. Under lockdown, information sharing amongst government agencies was thought desirable for facilitating continuance of government services under more joined up arrangements such as that provided by whole-of-government call centres to provide consistent responses and redirection to the most appropriate services. Combining resources and capability in this way made it easier for government agencies to adapt to changing needs and concentrate resources where they were most needed without regard for organisational boundaries. As a further adaptive response, a special privacy code of practice was agreed, similar to one used after the Christchurch earthquakes in 2011, to make it easier for government agencies to share information.

Also, given the rapidly changing circumstances surrounding the pandemic, information sharing with the public was prioritised and increased. Throughout Alert Level 4, the Prime Minister and the Director General of Health, kept the public updated about the evolving status of the virus in the country and explained the government’s responses. They held daily televised press conferences which were also live-streamed: these two people became the faces of the New Zealand response to COVID-19. Their messages signalled that government alone could not defeat the pandemic and emphasised the important part individuals needed to play as part of the ‘team of five million’ in stopping the virus’ spread. New legislation, the COVID-19 Public Health Response Act, administered by the Ministry of Health (MoH), came into force on May 13, 2020, surpassing the Public Health Orders that had underpinned the government’s response to that point. The Act was built from the experience of the first few weeks and anticipated the need for responses wider than Public Health Orders allowed for.

4.2 An all-of-government approach to adapting to working and delivering services online

Towards the end of February 2020, when it seemed likely an all-of-government response might be needed, the Digital Public Service (DPS) branch of the Department of Internal Affairs (DIA) was told by the Minister for Government Digital Services that COVID-19 was the ‘only aeroplane on the runway’: all Business as Usual (BAU) for the branch needed to be stopped and all efforts needed to go into COVID response. DPS joined the all-of-government Operations Command Centre and led a digital infrastructure workstream as part of the all-of-government response. This workstream involved four areas that would become significant if borders were closed and people isolated at home:

1. Support government agencies as they moved to remote working
2. Act as a broker between government agencies and the vendor community in relation to getting Information & Communication Technology (ICT) equipment to the places where it was needed most
3. Provide support for the government’s communication efforts through providing digital channels
4. Lead prototyping for a potential COVID card and provide technology and assurance advice and support for MoH’s [COVID-19] contact tracing app.

During the ‘go early, go hard’ Alert Levels 4, 3 and 2 response periods, which lasted in various forms and levels from March 2020, throughout 2021 and into 2022, people, businesses and government agencies were reliant on digital public services. Where possible, people packed up their digital technology from work and took their work home. Government agencies were observed to vary in their levels of digital maturity regarding remote working. Some, such as Inland Revenue Department (IRD) and Land Information New Zealand (LINZ), were able to continue their key digital development work with only minor delays from the disruption assisted by their use of agile methodologies for their digital development (Eppel & Lips, 2022). Home internet connectivity for government staff was also an issue: a Department of Internal Affairs (DIA) support team focussed particularly on supporting those government agencies that provided critical services.

As global supply chains became increasingly disrupted, it became apparent that the ICT equipment in the country was insufficient for the demand that government agencies faced. Therefore, DIA also worked with its sister agency MBIE to develop a prioritisation framework for ICT equipment, connecting demand for Internet devices and the vendor community.

As previously mentioned, information sharing with the public about what was known about the virus and New Zealand’s response was prioritised. There was a lot of new information, relating to many public service sectors and this was changing and requiring updating as the virus and the responses coevolved. A new web-based source of trusted information using the branding ‘Unite against COVID-19’ and website (https://covid19.govt.nz) was created by the all-of-government COVID-19 response group. Sourced from many agencies across government the website was designed as a one-stop shop to inform, educate and support, and enable New Zealand’s ‘team of five million’ to play their part in defeating the virus. In the initial haste to launch this site, the first version of the website did not use the common Web platform usually used for government websites and crashed—a rare failure to adequately integrate existing knowledge. Once the website was quickly migrated to the much more tested and robust common Web platform to create stability, it performed very well and has done so ever since. Lesson learned:—older but tested can be better than new and untested.

The Unite against COVID-19 website was symbolic of the all-of-government collaborative approach begun in January and user-centric. It provided an authoritative, trusted information channel covering all public services dedicated to the Government’s response: personal health and wellbeing; travel; business, work and money; community; and updates and resources. Information was clustered in a user-friendly, way irrespective of which department of government was behind the scenes and in doing so mitigated against siloed, partial, wrong and misleading information. Key messages from the website were also disseminated via other common platforms: Facebook, Twitter, Instagram, LinkedIn and Whatsapp. The updates and resources
section included important free government helplines for individuals and links to the latest information about COVID-19-related scams and phishing attempts which flourished in the new environment. In the early months, to further inform and educate New Zealanders about COVID-19, the Prime Minister also conducted a series of Facebook Live sessions ‘Conversations through COVID-19’ in which she interviewed experts and practitioners from various backgrounds and reinforced public health messages (Wilson et al., 2020).

At the same time that MoH’s data gathering was focussing on the health effects of COVID-19, the New Zealand Treasury was focussing on the economic impacts on individuals and businesses. New income support packages to keep businesses going were applied for and delivered online. Regularly updated information, resources, public services and advice related to COVID-19 were also made accessible via the websites and social media channels of individual government agencies. The MoH website for instance provided a daily update on COVID case numbers and locations and regular updates on other coronavirus issues, such as testing availability, advice for health professionals, advice for higher-risk people, the provision of Personal Protective Equipment (PPE), the latest studies about the virus, contact tracing and border control measures (Wilson et al., 2020). In 2021, this was extended to information about COVID vaccines and their availability.

4.3 Health’s digital government response

New Zealand’s COVID-19 response was a public health-led one. MoH was supported by an advisory group of epidemiologists and health scientific experts. Prior to the pandemic, the Digital Health Strategic Framework had re-orientated MoH towards the use of agile management approaches and development methods for digital solutions. MoH commented that, compared to three years prior, developing and beginning to implement the Digital Health Strategy had put the organisation in a position to be more agile and deploy parts of their digital infrastructure in new ways to meet the COVID response needs.

In general, MoH’s digital strategy aimed to embrace the growing opportunity of ‘digital’ working. It differed from their traditional data capture systems and informed how MoH and the health sector focussed on new digital technologies and approaches in their COVID-19 response. Under their Digital Health Strategy, MOH had created cloud platforms, a data layer and adopted new ways of working like continuous delivery and working in an agile way. This meant that MoH could release a “Minimum Viable Product” (MVP) to start with and then improve upon it with user feedback. Another key element was the development of a secure data and analytics platform to support in particular MoH’s efforts to track the progress of the virus in the community, and the production of national-level data for the health system, government and the public. This platform enabled some institutional information barriers between MoH and twenty-odd regional health-delivery agencies (the District Health Boards) to be overcome. It also allowed national reporting and analytics. The developments have established a base for extension in the longer term to other
communicable diseases, a future vaccination register and an early warning and surveillance response system for policy purposes.

On the funding side, this new way of developing digital solutions was facilitated by discussions with the New Zealand Treasury, as the funding gate-keeper, to change approval processes. These discussions satisfied Treasury that the agile methodologies being used by MoH offered sufficient checks and balances to protect the investment being made in small incremental steps. So rather than Treasury requiring a fully fleshed out design and business case for each new development before work could begin, a minimally specified new solution to an emerging problem could be in place in a matter of weeks and later incrementally improved with the help of user feedback. The traditional multi-year waterfall approach towards new digitally supported service development in which the new products only emerge for use at the end of the project, was replaced by agile and adaptive stepwise improvements to the existing capability. This approach was well suited to the high level of unknowns, including ongoing changes in what the digital service needed to do and lack of knowledge about users and their behaviour.

A good example of MoH building an MVP and improving it along the way as business process requirements became clearer, was the National Contact Tracing System (NCTS). This system used a cloud platform and records the interactions between individuals identified as cases, close contacts or casual contacts and Public Health Units (PHUs) or MoH. The initial version was built and released in only one week in March 2020. Subsequently, there were more than 21 releases of this system to enhance it. MoH extended the NCTS to include testing of people working at the border and in Managed Isolation and Quarantine (MIQ) facilities with the Border Management and Workforce Testing Register (BMWTR) to register those who arrive back in New Zealand from overseas and enter MIQ facilities, and those belonging to the border workforce required to have regular COVID-19 tests. The BMWTR was linked to NCTS to allow MoH to trace people out of MIQ back into the community, and reused data models and concepts from NCTS. MoH noted that collaboration between multiple agencies at the border would have been much easier with a national digital identity for each individual that could be used cross-government because individuals often had more than one employer or were in more than one category.

MoH also led development of a NZ COVID Tracer app jointly with MBIE, which people were asked to download to their phone to enable faster and more accurate contact tracing. People registered and entered their contact details with the MoH. The app worked in conjunction with the use of a QR code for every location in New Zealand. Individuals were required to scan a QR code on a poster at places and services they visited. The app kept track of where someone has scanned so their phone recorded where they had been. The QR codes reused the government standard (the Global Location Number) that makes every NZ business uniquely identifiable and is used to enable e-Invoicing. It is another example of innovation through applying existing solutions in new ways.

Later, an optional Bluetooth functionality was added to the app to collect data on who people had been in contact with. People could sign up for contact alerts so that the NZ COVID Tracer let them know if they had checked into a location at the same
time as a known infected person and might need to get tested for the virus. Infected individuals were also asked to share their digital diary with MoH if needed to aid contact tracing procedures to contain new COVID cases in the community.

Particular attention was paid to privacy concerns and the Office of the New Zealand Privacy Commissioner (OPC) was consulted in the tracer app’s development and conducted a Privacy Impact Assessment on the privacy friendliness of the app. People’s personal information and contact details they choose to register through the app are provided to MoH so contact tracers can quickly get in touch if people are identified as a close contact of someone who has COVID-19; these personal details are not shared with other government agencies except where the agency is directly involved in the public health response and sharing the information is necessary for public health purposes. Other information recorded through the app, such as scanned QR codes, manual diary entries or contacts, is stored securely on people’s mobile phones, with digital diary entries automatically being deleted after 60 days. No information is transmitted from people’s phones and if they are identified as a confirmed or probable case of COVID-19 people can choose whether to share their digital diary with MoH.

Early uptake of the NZ COVID Tracer app was limited: businesses often failed to display readable QR codes and there was no co-ordination at the government systems level for collecting contact tracing information. As a result, private sector entrepreneurs jumped in and offered alternative contact tracer apps. Rather than government nominating one App, several went into operation and the OPC began rating these apps for privacy protection and minimal data collection. In response to these ratings, developers quickly adjusted their apps in line with privacy principles. People without the app or a mobile phone, were encouraged to keep a physical diary and businesses a physical register of visitors who couldn’t scan a QR code.

Lack of co-ordination across the public sector created some initial conflicts in standards: besides the development and use of different apps, different workplace and hospitality registers and different QR codes came into use. This issue was managed by making it mandatory for businesses and workplaces to display an official NZ COVID Tracer QR code for each location. An extensive communications campaign was needed to educate about the purpose and use of the App. The reality of further COVID community outbreaks in Auckland in August 2020 and February 2021 respectively, after a period of months of no COVID cases in the community helped increase uptake of the NZ COVID Tracer app to more than 2 million people by September 2020 and over 2.7 million users, and 51 per cent of users having enabled Bluetooth tracing in March 2021.

Another system developed by MoH was an MIQ Patient Management System. This addressed information about the other health needs of people coming back to New Zealand through MIQ. As a new clinical records system, it allowed health professionals on MIQ sites to undertake health assessments, document health interventions and then send this information on to the person’s registered General Practitioner once they left MIQ.

MoH also developed a new digitised COVID-19 Immunisation Register to record every COVID-19 vaccination in New Zealand. This later enabled individuals to
access a record of their vaccination status on their mobile phone. MoH planned so that this system could eventually become the National Immunisation Solution recording all childhood and adult vaccinations. A related developed tool is the digital consumer channel that allows users to book and manage the vaccination process, see their vaccination history and, should this be needed, create a vaccination appointment.

In general, reliance on science, facts, evidence, and data modelling, was prominent in the New Zealand government’s COVID-19 response. Using the newly developed secure data and analytics platform, MoH collected and published daily-updated data about individual cases of COVID-19, including data on any confirmed or probable cases of COVID-19, the number of people recovered, how many people are and have been in hospital, and case numbers by district, age and gender. Also, MoH provided data about significant geographic clusters, and the number of tests completed each day and over the previous seven days. Furthermore, MoH commissioned modelling reports to help understand the health outcomes and impacts on New Zealand of COVID-19 and to inform the response strategy. Real-time data about case numbers and demographics, genomics of the virus and transmission rates were accessible to all via the NZ COVID-19 Dashboard (https://ncoviddashboard.esr.cri.nz) provided by the Environmental Science and Research Institute (ESR). This Dashboard also provided international comparisons based on data reported to WHO.

4.4 Education’s digital government response

The education sector’s particular challenge under lockdown was to continue children’s schooling and create a very rapid shift to distance learning. From the start of school Term 2, 15 April 2020, 800,000 students in 2500 schools across New Zealand needed to continue learning from home whilst the community was in lockdown.

Prior to the pandemic, the Ministry of Education (MoE) was working on assisting students to learn at home using digital devices and the internet but did not know how many households with school students did not have adequate internet and/or access to devices. Solving the problem of supporting student learning with digital devices required an exercise in discovery and iterative, collaborative problem-solving using information and resources from many sources. Each solution, requiring new collaborations, opened the door to a new gap and the next problem to be solved. In the end, the Ministry of Education came up with a multi-channel home-schooling package that had to cope with the reality that 55,000 households did not have internet access at all or only via a mobile phone. For older students, the package included online learning resources, laptops and modems where needed, delivered directly to homes to support parents in helping children learn. Two television channels (English and Māori medium), a radio channel (mainly for Pasifika students) and a hardcopy workstream, supported younger students and those without internet thus relieving teachers of some of the load associated with learning how to teach remotely for the first time (Wilson et al., 2020). Not only did MoE distribute laptops and modems to families excluded from the internet, MSD also provided mobile phones where needed to their clients.
Results were achieved with the help of schools and teachers and an MoU with telecom providers (Local Fibre Companies (LFC) and Internet Service Providers (ISP)). ISPs and LFCs helped MoE identify approximately 115,000 students living in 55,000 households across New Zealand, who had no internet. In general, households are not a universal customer grouping for government interventions across the public service; the focus is generally on individuals. First, MoE needed to identify which students lived in which households, and secondly, they needed data about the connectivity status of those households and their access to suitable devices for learning. In some cases, devices available belonged to other family members, were unsuitable for learning. Schools address data for their students is not information collected system-wide or stored and accessible in any common format. Where it existed, it required work with individual schools and teachers to access it and update it for the actual location under COVID lockdown.

The quality of the student address data also turned out to be a challenging issue: not only did MoE need to figure out where a student actually lived in real-time during lockdown, which could be a different address from usual, but also ISPs did not all use the same physical address standard, even though one was available. Privacy constraints were addressed in MoUs developed with ISPs and fibre infrastructure providers early in the process. Student location data were matched against every ISP’s existing active internet connections. The resulting delta list identifying approximately 55,000 households without connections remains an evolving picture.

Further, some students had internet access but with poor speed and/or data caps, which was another challenge because education use requires more bandwidth to be effective. This was especially the case in rural and remote areas. A partial solution was provided by the major telecom providers lifting data caps, but this did not always extend to wireless technologies in rural New Zealand: in some places, data caps were only lifted during the night which was not useful for continuing education use during the day. MoE also collaborated with Crown Infrastructure Partners (CIP) and MBIE on an infrastructure programme on overcoming capacity and coverage constraints, but some connectivity infrastructure issues, especially in rural and remote areas, persisted.

To find an internet solution for each physical address, MoE targeted households individually, cross-referencing school-held and ISP information and looked for a solution supporting zero contact delivery of devices relocated from schools or elsewhere to meet lockdown requirements. In total, approximately 115,000 devices were needed. Schools themselves had approximately 16,000 devices, which were still on school grounds during lockdown: MoE arranged for collection, cleaning and reconfiguration of these devices and redistributed them to student homes. This led to a balance of approximately 98,000 devices needed across all year levels. MoE supplied Internet modems and devices directly to approximately 25,000 student homes under Alert Level 4 conditions where zero contact delivery was possible: the device was left on the doorstep. Zero contact delivery was challenging, as devices needed to be preconfigured to work out of the box: a dedicated 0800 service helpline was set up to offer support. The limited supply resulted in a mix of Chromebooks, Windows laptops and iPads. A further 11,500 devices were distributed during the August 2020
virus outbreak, 4000 of these in Auckland. Ownership of the devices after distribution transferred to the student’s school.

Disruption of international air freight meant a limited supply of new devices in New Zealand. This had not initially foreseen as a clear priority for the government and availability became a first-come, first-served approach to the dissemination of internet modems and devices across all sectors. MoE rapidly identified that it could not provide support to all students in need and were therefore constrained to identify a priority group of senior secondary school students (those studying towards end of schooling qualifications in years 11, 12 and 13) for online learning and developed a multi-channel delivery approach for other learners.

However, having Internet access is not enough for individuals to be digitally included: cybersecurity, in particular phishing scams, turned out to be a significant risk, especially for first time internet users. To mitigate this risk, MoE worked with the Network for Learning (N4L) to operationalise a public DNS-based safety filter and MoE put a filter on all the devices they distributed. Parents suddenly thrown into the role of substitute teachers needed assistance as did other adults needing to pursue their businesses online.

Although New Zealand government agencies were heavily reliant on digital channels during the COVID-pandemic, they were conscious that 20 per cent of New Zealanders do not or cannot engage via digital channels. International research has shown that in order for people to be digitally included, four dimensions need to be met: digital access, skills, motivation to want to use the devices, and trust to engage with government digitally. This implies that internet access alone is not enough for people to be digitally included. As an amelioration to this problem, the coordinating government department for digital inclusion, DIA, initiated a collaboration with Maniakalaani, a community-based trust supporting digital skills development in schools in a low socio-economic part of Auckland. Maniakalaani developed a programme for digital skills support targeting 30,000 individuals and families. They also collaborated with MBIE to develop a skills training programme for small businesses, because it had become more apparent during lockdown that many small businesses didn’t have an online presence and lacked know-how to change this situation. Many small businesses struggled during Alert Level 2, 3 and 4 to do business online or if face-to-face, then socially distanced, because they could not receive contactless payments through a website.

5 Contribution of the complexity lens

The global COVID-19 pandemic created increased conditions of uncertainty and unknowns for governments, institutions and people. Established patterns of public administration and public service delivery in the New Zealand public management system were severely disrupted and there was no guidebook. At each phase, in the evolution of the pandemic, the New Zealand government and its agencies used information gathering from multiple sources to make sense of it for the New Zealand context. Weick and Sutcliffe, (2007) advise that the best response to uncertainty...
and weak signals is taking steps to gather and process information from multiple
sources and angles to better understand the dynamics creating an emerging situation.

In the preceding narrative presentation we reveal the dynamics of the system
interactions taking place in response to COVID-19 and the novel patterns of inter-
organisational working that emerged across the public sector and specifically in
health and education through our use of our complexity theory analytical lens.

In the period before the virus reached New Zealand, health, education, economic
development, infrastructure, public safety agencies actively used their international
networks to gather intelligence and pool their collective knowledge in an all-of-gov-
ernment forum to inform New Zealand’s approach towards the COVID-19 pandemic,
based on the best information available. They acknowledged a lot of unknowns and
recognised the likelihood more surprises would emerge (Stacey, 1992; Taleb, 1997;
Eppel, 2012; Termeer & van den Brink, 2013). Initially, unknowns were if/when the
virus would get to New Zealand, how contagious and life-threatening it could be,
and could the health system cope? New Zealand had an advantage of being an island
at a distance from the initial transmission wave around the world and therefore could
learn from the experiences of others. New Zealand’s first step, border restrictions,
limiting entry and quarantining new arrivals, aimed to slow the virus getting into the
community, created a time window for learning to occur.

When the virus was eventually detected in the community, government shifted its
strategy, quickly, establishing the ‘stay at home and isolate in you bubble’ regime.
As a precautionary and learning approach, epidemiologists and health advisors rec-
ommended steps to limit the virus’ spread in the community and give the health
system more time to prepare and learn about the virus. The government’s order for
people to stay at home and isolate was intended to achieve those things but it also
opened up new layers of unknowns: will the health system cope? Are there enough
ventilators and enough personal protective equipment (PPE) to protect health profes-
sional from infection?

The public service needed to consider how services could continue if everyone
except essential workers stayed at home: how could individuals, the society and the
economy be supported to continue functioning? In the lead up to the isolate at home
decision, individually and collectively government agencies turned their attention
to how they could continue to function in a physically distributed, technologically
enabled way. Tried and true solutions suited to the times came to the fore. Hence
emphasis went into information provision and public service delivery online which
in turn helped individuals and organisations to cope. The branding ‘Unite against
COVID-19’, as a single authoritative source of information across all-of-govern-
ment and joining up call centres acted as a single point of entry through which peo-
ple could be referred to the right information or agency helped to reduce uncertainty
and maintain access to public services. It also enabled sharing of expertise and
capability across agencies and, with that, processes of single-loop and double-loop
learning were active and encouraged. This strategy also allowed for reinforcement of
what was working, quick identification of gaps and the development of information
or new services to fill them using agile processes.

Government agencies were also encouraged to solve the many new problems
arising, in new ways, often using and building on their existing digital platforms.
Pre-COVID investments in the future digital capability development proved valuable and were leveraged to previously unplanned-for ends in the new circumstances. The government’s Strategy for a Digital Public Service published in 2019 (GCDO, 2019) served as a useful coherent fabric to underpin digital innovation in individual agencies because it reinforced a common set of principles and enablers of digital transformation of public services, and increased the likelihood of positive feedback cycles and further innovation.

Agencies worked alone and with others on these innovations. For example, the introduction of the QR code to assist with COVID contact tracing was enabled by a register of unique business addresses previously developed by MBIE for other purposes. Agile approaches to digital projects allowed resources to be moved to new priorities quickly, draw on user feedback and enabled quick release of minimally functioning applications which could be enhanced through experience and user feedback whilst they were in use. Positive feedback loops and capacity for organisational learning helped to overcome information deficits such as how users would respond and created opportunities for further adaptation and innovation as needed (for example, the multiple uses of the contact tracing App). It also enabled user-co-construction of what a service needed to become, and brought applications into use in minimum time so that the benefits of their use were quickly available.

Government’s response also needed to evolve with the virus and its progress through the community. Hence the MoH initially focussed on applications to detect, trace and slow the virus’ path through the community through contact tracing and the QR codes. These too were developed quickly and fine-tuned through use when more was known about user behaviour and their effectiveness for intended purpose. They were built on common platforms that enabled quick adaptation to new uses as new needs became apparent, for instance in the MIQ testing regime. Another example of adaptation and co-evolution was the support offered by MoE to 55,000 households to make it possible for the children in them to participate in online learning activities. Internet access and/or devices were provided to a substantial number of households: ongoing incremental learning through doing, and working with new partners such as the ISPs overcame obstacles. We saw triple loop learning where obstacles were avoided by taking a fresh approach, such as the broadcast education lessons for situations where internet access could not be quickly solved.

6 Conclusion

The use of the complexity lens helps us to see the processes of interaction amongst individuals and organisations that created New Zealand’s response to COVID-19. A public services ecosystem consisting, as it does of many government, and non-government, agents is a complex adaptive system (CAS). Each organisation has evolved a pattern of working internally and with others to make it effective. COVID-19 presented a sudden and not immediately well-understood disturbance to that ecosystem and its ability to continue public service delivery.

The complexity lens helps us to see how the ongoing interactions amongst individual system agents allowed adaptation of existing services to work under new,
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partially unknown and less certain circumstances. Sense-making, drawing on a diverse range of perspectives and information sharing increased the holism of the picture seen and enabled a shared understanding of these novel circumstances and the priorities to be addressed. The CAS lens allows us to see individual organisations taking action in parts of the system, without losing sight of the whole. As well as the use of agile digital development methodologies, leadership and management in the public sector needed to be flexible and agile also. The all-of-government strategic group adapted it focus and membership as the virus evolved and played a facilitative leadership role to ensure that the resources of government worked together and responded as needs changed.

Changes to the dynamics of the system brought about by the virus led to new processes of interaction from which novel patterns could emerge. Hence, MoE and MoH were enabled to act both alone for their sectors with new collaborators for their sectors as well as feeding into the collective sense-making and digital strategy of government agencies. Forced to work from home during lockdown, both MoH and MoE had to rethink and redesign aspects of their service delivery. MoH sped up their use of their new digital tools, such as Cloud-based systems and platforms, and repurposed existing capability for novel situations. They designed in ways that supported their longer-term digital service aspirations, for example, the Vaccine register acting as the template for a future more comprehensive register. MoE, on the other hand, had to rethink its relationship with students and households in ways that circumvented its mediation through schools. Doing so opened MoE to thinking differently about future ways of supporting digital learning. The steps MoE took to get school students connected illustrated the focus on an outcome to be achieved, and a great deal of interactive learning and collaborations with other agents to bring in new information and resources to solve multiple gradually emerging aspects of the problem.

The rapidly co-evolving environment between the COVID-19 threat and digital government created the conditions for a rapid shift towards digital public service provision. We are able to see a complex management problem involving many interdependent actors, who through their interactions with each other and the users of services were able to design and recalibrate existing services for the physical contact-free environment and designed and deployed new services required to manage the virus’ spread. Openness to double-loop learning, redistributed resources, and sharing of resources and capabilities across departments helped.

Elimination of community transmission of the virus within New Zealand was initially achieved by information sharing and planning across government and going hard and early into Alert Levels 4, 3 and 2 during April 2020. Maintaining no community transmission of the virus under Alert Level 1 remained a challenge because of continuing traffic at a low level through the border, gaps in MIQ and detection and the emergence of new virus variants. Community COVID-19 outbreaks in August 2020, and again in February 2021 demonstrated; retaining the public health gains whilst rebuilding the economy and avoiding going sharply backwards as other countries did, relied on community support for the restrictions imposed, effectively managed barriers to entry and community monitoring through testing, and where needed speedy tracing of contacts. The arrival of vaccines in the middle of 2021,
and yet another more transmissible but less-virulent variant, changed the game yet again in late 2021 and required a new round of learning and adaptation, which is outside the timeframe of the case we report here. It is too early to tell if the newfound agility and adaptiveness of digital services endures.

**Declarations**

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

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