

LITERATURE REVIEW

Comparing COVID-19 pandemic health responses in two high-income island nations: Iceland and New Zealand

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Abstract

Aims: We aimed to compare COVID-19 control measures, epidemiological characteristics and economic performance measures in two high-income island nations with small populations, favorable border control options, and relatively good outcomes: Iceland and New Zealand (NZ). **Methods:** We examined peer-reviewed journal articles, official websites, reports, media releases and press articles for data on pandemic preparedness and COVID-19 public health responses from 1 January 2020 to 1 June 2022 in Iceland and NZ. We calculated epidemiological characteristics of the COVID-19 pandemic, as well as measures of economic performance. **Results:** Both nations had the lowest excess mortality in the OECD from the start of the pandemic up to June 2022. Iceland pursued a mitigation strategy, never used lockdowns or officially closed its border to foreign nationals, and instead relied on extensive testing and contact tracing early in the pandemic. Meanwhile, NZ pursued an elimination strategy, used a strict national lockdown to stop transmission, and closed its international border to everyone except citizens and permanent residents going through quarantine and testing. Iceland experienced a larger decrease in gross domestic product in 2020 (relative to 2019) than NZ (−8.27% vs. −1.22%, respectively). In late 2021, NZ announced a shift to a suppression strategy and in 2022 began to reopen its border in stages, while Iceland ended all public restrictions on 25 February 2022. **Conclusions:** Many of Iceland's and NZ's pandemic control measures appeared successful and features of the responses in both countries could potentially be adopted by other jurisdictions to address future disease outbreaks and pandemic threats.

Keywords: SARS-CoV-2, COVID-19, pandemic, policy, Iceland, New Zealand

Introduction

A number of viral respiratory disease outbreaks in recent decades have become or have threatened to become global pandemics, including several influenza pandemics (e.g. the 2009 H1N1 'swine flu' pandemic), Severe Acute Respiratory Syndrome (SARS-CoV-1) in 2003, Middle East Respiratory Syndrome (MERS-CoV) in 2012, and the current COVID-19 (SARS-CoV-2) pandemic.

The World Health Organization (WHO) first became aware of an outbreak of 'viral pneumonia' in Wuhan, China on 31 December 2019 [1]. The rapidly rising number of cases beyond the epicenter in

China led the WHO Director-General to declare COVID-19 a public health emergency of international concern on 30 January 2020 and characterize it as a pandemic on 11 March 2020 [1]. By the end of May 2022, over 500 million confirmed cases of COVID-19 and over six million deaths had been reported to the WHO [2], although a vast number of cases and deaths have likely gone unreported [3–5].

Early in the pandemic, it became clear that some countries and territories had markedly higher burdens of COVID-19 morbidity and mortality than others [6,7]. The impacts have varied considerably, even among high-income jurisdictions. For example, Iceland and New Zealand (NZ) have reported some

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of the lowest mortality rates in the Organisation for Economic Cooperation and Development (OECD); as of 1 June 2022, Iceland had 41 COVID-19 deaths per 100,000 population [8,9] and NZ had 23 COVID-19 deaths per 100,000 population [10,11], while Hungary and the Czech Republic have reported some of the highest COVID-19 mortality rates (484 and 375 per 100,000 population, respectively [12]).

As both Iceland and NZ have had relatively low COVID-19 mortality burdens among high-income nations (second and first in the OECD for lowest excess mortality as of June 2022, respectively [13]), we examined the response employed by Iceland and contrasted it to NZ. Both are island nations with potential for tight border controls, although Iceland is smaller in population and land mass. Iceland and NZ are also similar in that both nations are highly reliant on their tourism industries (8.0% [14] and 5.5% [15] of gross domestic product (GDP) in 2019, respectively). Specifically, we aimed to identify public health interventions used in Iceland and NZ up to June 2022, examine whether the different approaches used in these countries produced different results in terms of public health and economic performance, and consider whether the public health interventions used may be relevant to pandemic responses in other high-income countries, especially other island nations. There is evidence, based on the increasing rate at which novel pathogens have emerged in human populations in recent decades, that the probability of experiencing large pandemics is growing [16,17]. This threat highlights the urgent need to improve preparedness for future pandemics.

Methods

Literature search strategy and selection criteria

PubMed was searched for the period 1 January 2020 to 1 June 2020, using the search terms: ‘COVID-19’ or ‘SARS-CoV-2’ or ‘coronavirus’ and ‘Iceland’ or ‘New Zealand’ in the title and/or abstract of the article. A total of 666 articles were identified, of which 629 were excluded as either duplicates or irrelevant (e.g. modelling studies, clinical trials, or those articles that did not specifically mention COVID-19 responses at a public health level or describe pre-COVID-19 public health preparations). Additional articles were identified through forward and backward citation searching. We included a total of 37 journal articles in the study. In addition, relevant websites of Government Agencies in Iceland (e.g. the Directorate of Health) and NZ (e.g. the Ministry of Health – Manatū Hauora, the Institute of Environmental Science and Research) and media

articles were also searched. Authors also drew on their direct involvement with the pandemic response in their respective countries.

Results

Summary of the COVID-19 status in Iceland and NZ up to 1 June 2022

First wave. The first case of COVID-19 in Iceland was detected on 28 February 2020 [18]. The first case was a person who had travelled from northern Italy before that region was designated as high risk (i.e. before travelers from that area were required to quarantine for 14 days upon arrival) [18]. By 31 March 2020, there were over 1300 confirmed cases in Iceland [18], and at the peak of the first wave in Iceland the weekly case rate peaked at 1.31 cases per 1000 population (Figures 1 and 2) [8,9,11,19].

The first case of COVID-19 in NZ was also reported on 28 February 2020 and was in a person who had returned from Iran via Bali, Indonesia [20,21]. NZ experienced its first wave of COVID-19 from late February to May 2020, during which time there were 16 clusters with 10 or more cases of COVID-19 detected in the country [20]. Many of these clusters were linked to aged-care facilities or private social gatherings (e.g. weddings), while others were associated with overseas travel, a school and a cruise ship visit [20]. At the peak of its first wave, NZ reached a weekly case rate of 0.10 cases per 1000 population (Figures 1 and 2) [11,19]

Initial elimination. Despite the initial surge in cases, both Iceland and NZ achieved elimination of community transmission of COVID-19 by May 2020 [22]. However, their strategies differed substantially, with Iceland’s strategy focused on testing, contact tracing and isolation of cases without the use of a lockdown [23–25] while NZ used a stringent lockdown to eliminate community transmission [26].

Subsequent waves. In Iceland, after elimination in May 2020, the 14-day quarantine policy was replaced by a new border screening program on 15 June 2020, which required test on arrival and self-quarantine while waiting for results [22,27,28]. This change led to a slight increase in community transmission and several clusters from travelers who had tested negative on arrival (i.e. tested positive after finishing self-quarantine) [22]. Following this, Iceland saw a small second wave in August 2020, and a larger third wave of infections in late September through to early November 2020 [29–31]. A fourth wave of COVID-19 cases then hit Iceland in mid-July 2021

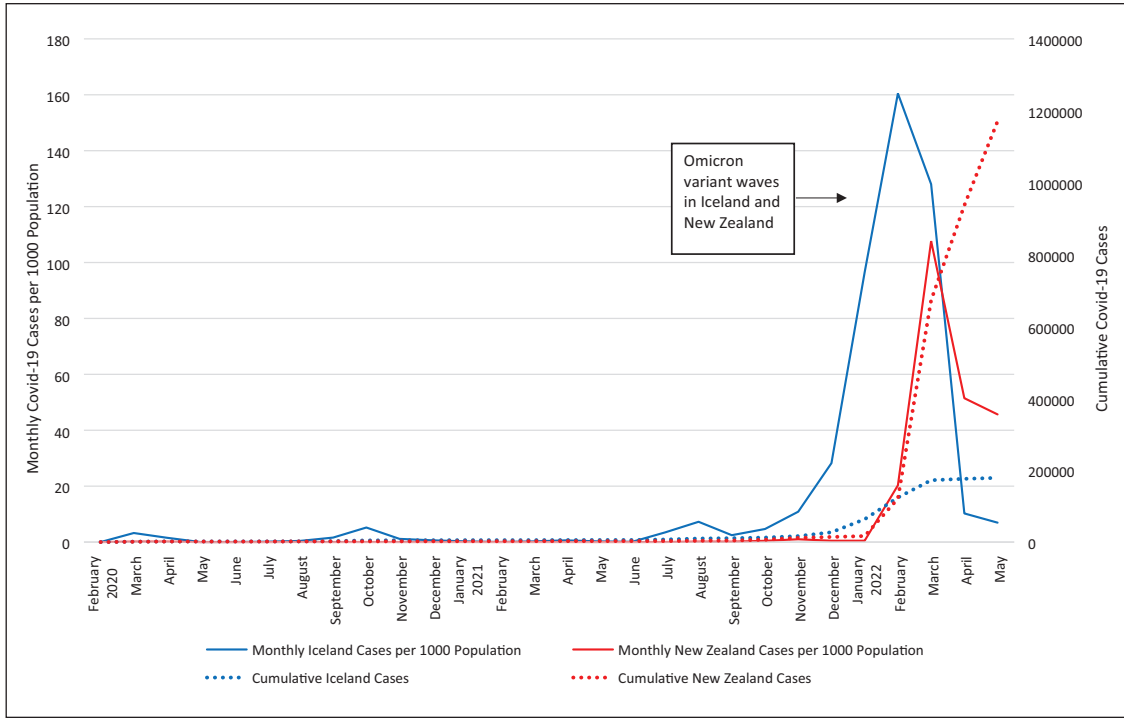


Figure 1. Epidemic curves of monthly newly notified confirmed cases and cumulative total confirmed cases in Iceland [8,9] and New Zealand [11,19] up to 1 June 2022 (includes cases identified at the border in both nations).

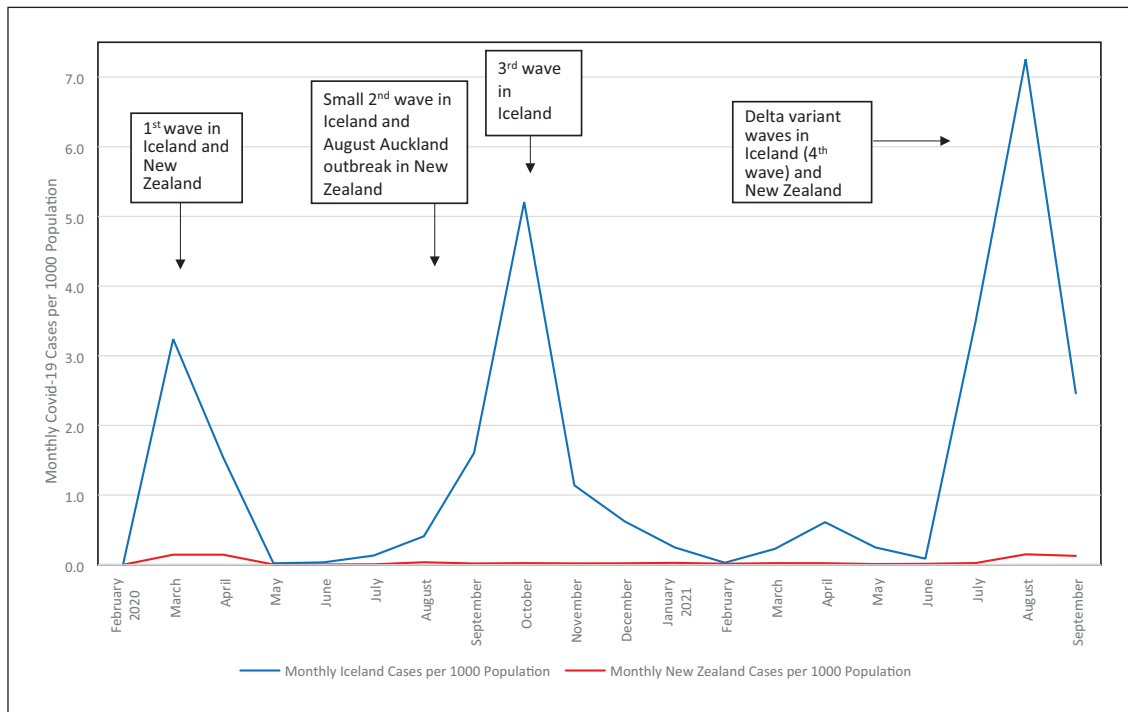


Figure 2. Pre-Omicron variant epidemic curves of monthly newly notified confirmed cases in Iceland [8,9] and New Zealand [11,19] up to 1 October 2021 (includes cases identified at the border in both nations).

dominated by Delta variant infections [32]. New restrictions were then introduced in November and

December 2021 in response to the fifth wave caused by the rapidly spreading Omicron variant [32].

In NZ, the initial period of successful elimination of community transmission of the virus was followed by an outbreak in the city of Auckland in August 2020, likely as a result of a managed isolation and quarantine (MIQ) system failure at the border [20,33]. The wider Auckland region faced another lockdown from late February to early March 2021 [26]. However, community transmission was rapidly eliminated again [26]. Then, in August 2022, NZ entered another national lockdown due to community transmission of the Delta variant [26]. While restrictions were lifted in most of the country, Auckland remained in a form of lockdown until 3 December 2021, when the new COVID-19 Protection Framework – switching from an elimination to a suppression strategy – came into effect [26,34].

Public health interventions in Iceland in response to COVID-19

Pandemic plan and legal framework. Iceland's National Crisis Coordination Center was activated on 31 January 2020 to coordinate the country's pandemic response [35]. Iceland's existing Pandemic and Influenza Preparedness Plan was updated and activated in January 2020 [23,36], well before COVID-19 was declared a pandemic. Iceland's primary objective was to ensure that national infrastructure, especially the healthcare system, would not be overwhelmed [23–25]. The strategy relied on mass testing and early diagnosis of cases, isolation of cases, rapid contact tracing, and quarantine for close contacts [23,35].

In March 2020, Iceland's 2008 Civil Protection Act (related to national preparedness) was activated, which provided the government with the authority to put in place certain restrictions [24,36]. The 1997 Act on Health Security and Communicable Diseases outlines additional regulations and the roles and responsibilities of certain government officials and others during an infectious disease outbreak [24,36]. A formal coordination commission for emergency crisis response was also established and included relevant authorities and stakeholders in line with the existing national emergency preparedness plan [36].

Border restrictions. In February 2020, travel from China, Iran and South Korea was designated as high risk and Icelanders returning from those countries were advised to quarantine at home for 14 days [37]. By 19 March 2020, all travel outside of Iceland was designated as high risk and Icelanders were advised not to travel abroad [18]. However, Iceland's response did not involve an official border closure to non-residents, although from 20 March to 15 May 2020,

foreign nationals, except European Union/European Economic Area, European Free Trade Association or UK nationals, were banned from entering the country for non-essential purposes [36,38]. Additionally, from 24 April 2020 a 14-day quarantine was required for all travelers entering the country [18,22,36]. On 15 June 2020, the 14-day quarantine policy was replaced by a new border screening program that required testing on arrival and self-quarantine while waiting for results [22,27]. However, this policy led to an increase in community transmission, and several clusters were linked to travelers who had tested negative on arrival [22]. Therefore, the border restrictions were tightened again and from 19 August 2020, all arrivals were required to self-quarantine and present two negative polymerase chain reaction (PCR) test results at least five days apart before leaving quarantine [22]. Government managed quarantine and isolation facilities were temporarily used in Iceland from 16 February 2021 [39]. Placement in a government managed facility was based on a risk assessment (i.e. whether the traveler could properly isolate at home and/or if the traveler was arriving from a country with high COVID-19 incidence as defined by the Chief Epidemiologist or the European Centre for Disease Prevention and Control) [39].

Lockdown and warning level system. Iceland's strategy did not involve a lockdown [22,36]. However, there were other restrictions on gatherings. On 16 March 2021, gatherings of more than 100 people were banned [18,40] and on 24 March 2020, gatherings were further restricted to a maximum of 20 persons and visits to hospitals and nursing homes were no longer allowed [18,40]. When the rules were strictest, gatherings were limited to 10 persons [36,40]. Iceland also temporarily recommended limiting travel across municipal and regional borders [36]. A color-coded warning system was put in place in early December 2020 [40]. Each color had a different set of restrictions on public gatherings associated with it and a map was published online to help individuals make decisions about their own behavior [40]. However, in July 2021, the color-coded warning system was retired [40].

On 16 March 2021, middle schools, high schools, colleges and universities in Iceland were closed for four weeks [18,36,41]. Nurseries, daycare centers and elementary schools largely remained open throughout the pandemic subject to infection control measures [18,36], although at times there were restrictions on the number of students allowed to gather and this meant that in most pre-schools and primary schools there were periods where children attended school only every other day [40]. Restaurants

and bars, indoor sports facilities, and cultural events were temporarily closed or access was restricted, and it was recommended that non-essential workers temporarily work remotely [36].

Testing. Initially, testing in Iceland was limited to travelers returning from high-risk areas, contacts of confirmed cases, and symptomatic persons [18,25]. Then, on 13 March 2020, population screening became available to all residents [18]. At the beginning of the pandemic, a local biopharmaceutical company, deCODE Genetics, partnered with Icelandic authorities and the National University Hospital of Iceland to enable a free testing policy [22,25,35,42]. At first, the company used its own laboratory, equipment and staff to start a testing lab, then in July 2020, the National University Hospital took over testing and screening at the border from the company [42]. The public-private partnership allowed Iceland to test a higher proportion of its population with PCR tests than any other country early in the pandemic [22,43]. On 23 June 2021, healthcare centers started using rapid antigen tests to diagnose cases as well [44].

Contact tracing, isolation and quarantine. At the beginning of the pandemic, the Directorate of Health worked with the Department of Civil Protection and Emergency Management to create a team of 60 contact tracers [18,35,36]. The Government then worked with a group of private companies, in consultation with Iceland's Data Protection Authority, to create Rakning C-19 tracing digital app, which was released in early April 2020 [35,36,44]. Infected cases were required to isolate at home, initially for a period of 14 days [29]. During the Omicron variant outbreak, the isolation period was reduced to seven days [44]. Contacts were initially required to quarantine for 14 days [45] but that requirement was reduced to five days for household contacts and replaced with special precautions (e.g. masking, monitoring for symptoms, avoiding vulnerable persons) for all other contacts during the Omicron outbreak [44].

Masking. Mass masking was not required at the beginning of the pandemic in Iceland, but on 14 August 2020 masks became mandatory for those in occupations requiring close proximity (e.g. hairdressers), on public transport and when physical distancing could not be maintained [22,40]. Furthermore, on 21 September 2020, the Ministry for Education, Science and Culture indicated that students, teachers and staff at secondary schools and universities should wear masks at all times [44].

Vaccination. The Icelandic Government developed a national vaccine strategy plan to vaccinate the population [31] and on 28 November 2020 the regulation on COVID-19 vaccination prioritization entered into force [44]. The order of priority was (i) healthcare professionals in emergency wards, (ii) healthcare professionals in outpatient wards, (iii) people living in aged care facilities, (iv) first responders and other essential workers, (v) healthcare professionals in primary care, (vi) individuals aged 60 years or older, (vii) individuals with underlying health conditions, (viii) teachers and staff at schools and certain welfare and social workers, (ix) individuals living in sensitive social and economic situations and (x) the remainder of the general population [46]. Iceland did not require vaccination for any occupational groups or specified settings [47]. On 28 December 2020 the first shipment of Pfizer/BioNTech COVID-19 vaccine arrived in Iceland and vaccinations began the next day [44]. By 7 June 2022, approximately 77% of the total population had been vaccinated with at least two doses of vaccine (Table I).

Easing of restrictions. On 25 February 2022, all public restrictions in Iceland were lifted, including limits on gatherings, and physical distancing and masking requirements, although self-isolation was still required for all COVID-19 cases [40].

Public health interventions in New Zealand in response to COVID-19

Pandemic plan and legal framework. NZ's COVID-19 response initially followed its influenza pandemic plan, which was revised in 2017 and outlines a mitigation strategy to reduce the health impact of a pandemic [20,76,77]. In March 2020, the NZ Government passed the COVID-19 Public Health Response Act, which provided the health sector with emergency powers to address the pandemic [20,78].

Border restrictions. NZ introduced border restrictions from February 2020 onwards starting with health screening of passengers arriving on flights from mainland China, Hong Kong, Japan, Singapore and Thailand [20,79] and then anyone transiting through mainland China was required to home quarantine for 14 days after arrival [20,80]. In early March 2020, it was then announced that anyone arriving from Iran or Italy would also be required to self-isolate for 14 days after arrival in NZ, and by mid-March this was extended to all international arrivals [20,79,81]. By the end of March, NZ had shut its international border to anyone who was not a citizen or permanent resident, with few exceptions [20,80]. In June 2020,

Table I. Health service readiness and key epidemiological features of COVID-19 and country-specific features in Iceland and New Zealand.

	Iceland	New Zealand
General overview		
Total population (2022)	376,248 (as of 1 January 2022 [9])	5,127,100 (as of 31 March 2022 [11])
Land area (km ²)	100,830 [48]	263,310 [49]
Population density (2022)	3.73 people per km ²	19.47 people per km ²
Urban population (%)	94% [50]	87% [51]
Pre-pandemic life expectancy at birth (2018)	83 [25]	82 [25]
Pre-pandemic gross domestic product (GDP) per capita in US\$ (2019)	\$58,200 [52]	\$45,250 [52]
Proportion of GDP related to tourism in US\$ (2019)	8.0% [14]	5.5% [15]
Income inequality Gini coefficient (0–1 scale, in which 0 is perfect equality and 1 is perfect inequality)	0.25 (as of 2017 [53])	0.35 (as of 2014 [53])
Health service readiness (at start of pandemic (i.e. 2019))		
Nurses per 1000 population	15.4 [54]	10.2 [54]
GPs per 1000 population	3.9 [55]	3.4 [55]
Intensive care unit beds per 100,000 population	4.3 [56]	5.1 [25]
Acute care hospital beds per 1000 population	2.3 [57]	2.5 [57]
COVID-19 epidemiological characteristics* (up to 1 June 2022, unless otherwise noted)		
Total cases	179,000 [8]	1,170,000 [19]
Total confirmed cases per 1000 population	474	228
Total deaths from COVID-19	153 [8]	1194 ^b (as of 6 June 2022 [10])
Total deaths from COVID-19 per 1000 population	0.41	0.23
Case fatality risk	0.09%	0.10%
Excess deaths per 100,000 population	29 (as of 20 June 2022 [13])	–23 (as of 20 June 2022 [13])
Ranking in OECD for lowest excess mortality rate since the start of 2020 (low number is best)	Second (as of 20 June 2022 [13])	First (as of 20 June 2022 [13])
COVID-19 control measures*		
Containment and Health Index (a composite of 13 policy measures) – peak level (see Figure 3 for the overall pattern)	69.5 (starting on 27 March 2021 [58])	93.5 (starting on 2 September 2021 [58])
Date of the first border control measures	February 2020 ^c (travelers arriving from China, Iran and South Korea required to quarantine for 14 days upon arrival [37])	2 February 2020 (entry restrictions for passengers arriving from or transiting through mainland China [59])
Date of the first mandatory mask requirements	14 August 2020 [40]	31 August 2020 [20]
Date that reverse transcription polymerase chain reaction testing began	31 January 2020 [18]	22 January 2020 [60]
Date that rapid antigen tests became publicly available	14 June 2021 (administered by health services for travel purposes [61]; later required for attendance at events [62])	15 December 2021 (administered by pharmacies [63])
Total tests performed for SARS-CoV-2	1.95 million (28 February 2020 to 7 June 2022 [8])	2 March 2022 (available for home testing [64])
Total tests per 1000 population	51.90 (28 February 2020 to 7 June 2022 [8])	7.21 million (22 January 2020 to 7 June 2022 [60])
Date that vaccination began	28 December 2020 [65]	1440 (22 January 2020 to 7 June 2022 [60])
Date at which 50% of the total population fully vaccinated ^d	30 June 2021 [65]	29 December 2020 [66]
Date at which children and teenagers became eligible for vaccination	23 August 2021 (12–15 years old [44])	13 October 2021 [66]
Total vaccination doses administered	5 January 2022 (5–11 years old [44])	19 August 2021 (12–15 years old [67])
Number of people fully vaccinated ^e	812,000 (as of 7 June 2022 [65])	17 January 2022 (5–11 years old [68])
Percent of eligible population fully vaccinated ^d (i.e. five years of age and older)	291,000 (as of 7 June 2022 [65])	10,700,000 (as of 6 June 2022 [66])
Percent of total population fully vaccinated ^d	81% (as of 7 June 2022 [65])	3,980,000 (as of 6 June 2022 [66])
Number of people who received at least one booster dose	77% (as of 7 June 2022 [65])	83% ^e (as of 6 June 2022)
	207,000 (as of 7 June 2022 [65])	78% (as of 6 June 2022)
		2,660,000 (as of 7 June 2022 [66])

(Continued)

Table 1. (Continued)

	Iceland	New Zealand
Percent of total population that received at least one booster dose	55%	52%
Any government funding for improving ventilation in schools (and date it began)	No funding noted	22 January 2022 (5000 air filtration units ordered for schools [69], with additional filtration units and carbon dioxide monitors dispatched since that date [70])
Macroeconomic changes		
GDP change in 2020 (<i>vs.</i> 2019)	-8.27% [52]	-1.22% [52]
GDP change in 2021 (<i>vs.</i> 2020)	8.32% [52]	7.76% [52]
Peak unemployment level (any quarter of 2020–2021)	7.2% [71]	5.3% [72]
Government provision of financial assistance as a proportion of GDP in 2020 and 2021	8.0% [73]	19.3% [74]

^aSome values were rounded to three meaningful digits.

^bThis number includes deaths that occurred more than 28 days after a case was reported, and COVID-19 deaths that have been reported with incomplete details.

^cExact date of initial quarantine advice for travelers returning from China, Iran or South Korea was unclear.

^dVaccination is considered complete in Iceland after two doses of vaccine. Vaccines available in Iceland include Pfizer/BioNTech, Moderna, Oxford/AstraZeneca, and Janssen. It has been reported that 45,647 people in Iceland received an additional mRNA vaccine dose after Janssen, which originally required only a single dose [65]. Vaccination in New Zealand is considered complete after two doses of vaccine. Vaccines available in New Zealand include Pfizer/BioNTech, AstraZeneca, and Novavax.

^eAs of 30 June 2021, the population under the age of five years was estimated at 305,510 [75]. This was subtracted from the 2022 total population estimate to derive the eligible population.

all returning citizens and permanent residents were required to enter government MIQ facilities for 14 days, and additional testing and masking requirements for persons in MIQ facilities were later introduced [20,82–84]. MIQ facilities were primarily repurposed hotels [20,82] and because the facilities were not built for purpose there were a number of system failures in which the virus spread into the community [82].

Lockdown and Alert Level system. In NZ, COVID-19 cases increased steadily after the initial introduction of the virus. On 23 March 2020, the Prime Minister announced a nationwide lockdown that would take effect on 26 March [26]. The implementation of the lockdown was supported by the declaration of a national state of emergency on 25 March [26]. The initial lockdown was set at the highest Alert Level 4 and then subsequently lowered to Alert Level 3 (slightly less restrictive) [26]. The lockdown remained in place until 13 May 2020 [26].

Movements within the country were restricted based on different Alert Levels, and in some cases roadblocks or checkpoints were put in place in some communities [19,85]. Most schools were closed at Alert Level 4 (i.e. only the children of essential workers were allowed to attend) and remained highly restricted at Alert Level 3. Schools reopened to all children under Alert Level 2, but with physical distancing and hygiene requirements [19,26]. Only essential workplaces were permitted to open under Alert Level 4, albeit with physical distancing requirement, including medical practices, pharmacies, grocery stores, gas stations and lifeline utilities [19,26]. NZ eventually went down to the lowest Alert Level 1 on 8 June 2020 and later experienced several changes in Alert Levels, including several additional lockdowns during subsequent community outbreaks [26].

In October 2021, the NZ Government announced a shift away from their elimination strategy and towards a suppression strategy [86,87]. Then, on 29 November 2021, NZ began using a new traffic light system under the new COVID-19 Protection Framework [88]. The traffic light system was designed to replace the lockdowns that were part of the original Alert Level [88]. Under the traffic light system, restrictions were highest at the Red setting, limited restrictions at the Orange setting, and no restrictions at the Green setting [34].

Testing. PCR testing for SARS-CoV-2 began in late January 2020 in NZ for travelers who had been in China, Italy or Iran [20,60]. Testing capacity was initially at 1500 tests per day in March 2020 [20,89]

but was quickly increased to 3700 tests per day in April with a goal of reaching a capacity of 5000 tests per day [90]. A total of 379 community testing centers were established nationwide [91]. By August 2020, daily testing totals had reached over 26,000 [20], and by August 2021, daily totals reached over 49,000 tests [92]. However, demand for testing rose rapidly during the Omicron variant wave in early 2022, and many laboratories were overwhelmed, resulting in a backlog of over 32,000 PCR tests by 1 March 2022 (testing capacity had been calculated on the basis of pooling specimens, which became non-viable once prevalence rose markedly with the arrival of the Omicron variant [93]). Rapid antigen tests did not become widely available to the public until 2022 [64].

Contact tracing, isolation and quarantine. On 24 March 2020, the National Close Contact Service began using a manual contact tracing process [94], and in May 2020, a digital application (app) for contact tracing was launched by the NZ Government [20,95]. Use of the smartphone app was initially voluntary and it relied on the scanning of individual QR codes that were unique to each business [20,95]. Uptake of the app was initially low but increased in August 2020 when it became mandatory for all businesses and many transport services to display a QR code poster [20,96,97]. Early in the pandemic, NZ introduced a requirement for cases to isolate in MIQ facilities (i.e. repurposed hotels) for 14 days, and close contacts were also placed into quarantine. The measures were then relaxed during later phases of the pandemic. During the Omicron variant outbreak, case isolation was reduced incrementally to seven days of home isolation, and contacts were limited to household members, who were required to quarantine at home for seven days [98].

Masking. Prior to August 2020, the Ministry of Health did not require or recommend the use of face masks for the general public [20]. However, the outbreak in Auckland in August 2020 led the NZ Government to update its advice on masking and it strongly recommended the use of a face covering at Alert Levels 2 and 3, especially when unable to maintain physical distancing, and required mask use on public transport from 31 August 2020 [20]. As of 1 June 2022, face masks were still required in most public indoor settings under Red and Orange traffic light settings, with some exceptions [99]. At these settings, employees at certain businesses were required to wear a medical grade face mask (e.g. food and drink business or service, close-proximity businesses (e.g. hairdressers), events) [99].

Vaccination. The NZ Government allocated NZ\$3m in funding for a COVID-19 vaccination strategy, with an aim to secure a safe and effective vaccine as quickly as possible [100]. Ten million NZ dollars were allocated to support domestic research, NZ\$5m was allocated to support potential domestic manufacturing capability, up to NZ\$15m was set aside for international research collaboration and NZ\$7m was allocated to the vaccine alliance Gavi, which distributes vaccines to lower income nations [100]. The first batch of Pfizer/BioNTech COVID-19 vaccine arrived in NZ on 15 February 2021 and vaccinations began with border and MIQ workers shortly thereafter [101]. The COVID-19 vaccine rollout prioritized those people most at risk of harm from the virus and those who lived and worked in places with higher risk of exposure [102]. Specifically, Group 1 included border workers and MIQ workers and their household contacts (started receiving vaccines in February 2021); Group 2 included frontline healthcare workers and people living in high-risk settings (started receiving vaccines in February 2021); Group 3 included a number of priority populations including the elderly and those with underlying health conditions (started receiving vaccines in May 2021); and Group 4 included the remainder of the general population (started receiving vaccines in July 2021) [102]. By 6 June 2022, approximately 77% of the total population had been vaccinated with two doses of vaccine (primarily Pfizer/BioNTech) and over 2.5 million booster doses had been administered (Table I). In NZ, vaccination was strongly promoted through a range of vaccine mandates that required vaccination for specified occupations (e.g. healthcare workers [103]) and indoor settings specified under the traffic lights system (e.g. restaurants, bars and gyms) [104]. These mandates began in late 2021 and most were lifted progressively in the first half of 2022.

Easing of restrictions. In October 2021, the NZ Government announced a shift away from their elimination strategy and towards a suppression strategy in response to widespread community transmission of the Omicron variant [86,87], and in 2022, border restrictions were also loosened in stages [105]. The border was scheduled to reopen to all tourists and visa holders on 31 July 2022 [105]. This stage signaled a move to a mitigation strategy [106].

Commonalities and differences between Iceland's and NZ's responses

There were many commonalities between Iceland's and NZ's responses. Both nations had universal existing healthcare coverage [20,25] and existing pandemic

plans targeted towards influenza [20,23,36,76,77]. However, neither country had a dedicated national institution to respond to infectious diseases. After the COVID-19 pandemic began, there was a push in Iceland to establish a National Institute of Epidemiology [42]. In NZ, the institutional environment for public health is complicated by an extensive health sector reform process that started immediately prior to the pandemic and is still continuing [107].

The timing of the first detected cases and the first waves were similar in both countries (see 'Summary of the COVID-19 status in Iceland and NZ up to 1 June 2022' above). Both countries rapidly adapted and implemented similar control measures, including testing, contact tracing, isolation, and quarantine, gathering limits and physical distancing requirements, although both nations were relatively slow to require mass masking (i.e. not until August 2020). Rapid border management was likely facilitated by the fact that both Iceland and NZ are island nations with only one (Iceland) or a few (NZ) international airports. However, both nations had to work quickly to increase testing [36,90] and contact tracing capacity [36,94] and purchase additional personal protective equipment for healthcare workers [20,31,44,45,108].

Iceland also worked to increase the availability of telehealth early in the pandemic. Landspítali University Hospital in Reykjavik created an outpatient clinic to oversee the centralized follow-up of all COVID-19 cases in Iceland [56,109]. Doctors and nurses made frequent phone calls to all cases and recorded their symptoms in a central data registry [29,109]. Cases were color-coded according to the severity of their illness, which helped to predict poor outcomes [109]. More severe cases were contacted more frequently by telehealth providers and were provided with immediate access to in-person care through a separate urgent care clinic on the hospital campus if their symptoms worsened [109]. Incorporating the use of telehealth helped to avoid exposures in healthcare settings (e.g. prevented infectious patients from using emergency departments) and averted hospital admissions [109].

With regard to public engagement, there was clear communication involving regular briefings by senior officials in both countries [22]. At the start of the pandemic, both countries had daily press briefings that were nationally broadcast. In Iceland, the Chief Epidemiologist, Director of Health and the Chief Constable of the Civil Protection Department of the National Commissioner of the Icelandic Police typically appeared together for press briefings [44]. In NZ, the Prime Minister and the Director General of Health, and later the Minister of Health, all frequently

appeared at the briefings [80]. In both countries, early communications about the pandemic were framed as a shared threat that needed to be faced together. In Iceland the phrase ‘we are all civil protection’ was commonly used [24], while in NZ, there was frequent reference to the ‘team of five million’ [110]. Scientists also played a particularly prominent role in the response, and there was a high level of public trust in the response in both countries, especially early in the pandemic [22].

Both countries also introduced economic interventions shortly after the first cases were detected [25]. For example, in Iceland, a short-term work scheme was introduced to help households and businesses [111], and an extensive response package that included state-backed loans for businesses, tax payment deferrals and financial support for certain sectors (e.g. tourism, aviation) was announced in March 2020 [73,111]. In NZ, a wage subsidy scheme was introduced in March 2020, and welfare payments were increased in April 2020 [20,112]. Additional assistance for essential workers, small businesses and certain economic sectors (e.g. tourism) was also provided [20,112–114].

Issues with healthcare system capacity were experienced by both countries. In Iceland, a healthcare reserve force (composed of doctors and nurses who had recently retired or moved into different jobs) was developed at the beginning of the pandemic [45] and intensive care unit (ICU) capacity was increased by postponing elective surgeries and converting postoperative recovery rooms into ICU wards [56], but urgent staffing issues were still experienced during peaks in COVID-19 cases [115]. For example, the Landspítali National University Hospital was operating at an emergency level (its highest level of preparedness) from 28 December 2021 to January 2022 and experienced considerable strain due to a combination of Delta and Omicron cases [116–118]. Similarly, in NZ, several hospitals reported reaching occupancy limits, experiencing staffing shortages and deferring planned care (including some major surgery) in May 2022 during their Omicron wave [119–121].

There were several key differences between Iceland’s and NZ’s responses. Critically, both countries articulated different strategies. Iceland never articulated an elimination strategy and focused on mitigation, even though the country did appear to eliminate community transmission temporarily. This strategy was selected largely due to economic concerns [29]. Iceland’s response did not involve the use of lockdowns [22,36], nor did it involve an official border closure [18,22,36]. Meanwhile, NZ initially planned to follow a mitigation strategy as outlined by its influenza pandemic plan [20,76,77] but then

shifted to an elimination strategy, employed the use of a strict lockdown and largely closed its international border (though low levels of two-way travel continued throughout the pandemic) [26,80]. In late 2021, NZ announced a shift to a suppression strategy and in 2022 began to reopen its border in stages, marking a shift to mitigation [86,87,105].

There were also differences in case-based and population-based interventions. For example, self-isolation and self-quarantine were required for cases and their contacts in Iceland (municipalities and health authorities were required to provide a free place to stay for those who were unable to self-isolate at home – e.g. hotels) [18,36]. However, in NZ, most cases were required to enter MIQ facilities after elimination was achieved [122]. Once NZ shifted to a suppression strategy, cases were then required to self-isolate at home [123]. Iceland conducted over 3.5 times more tests per 1000 population (Table I). Testing intensity affects the number of reported cases and potentially even deaths that are assumed to be due to COVID-19. Furthermore, Iceland began its vaccination campaign in December 2020, several months earlier than NZ (although as of June 2022, they had similar vaccination rates – Table I). Iceland was part of a broader European effort to purchase and distribute vaccines, and the country’s vaccination uptake was initially dictated by the supply of vaccines, which arrived in small shipments. Vaccination rates in both countries may also have been impacted by lower uptake in certain subpopulations (e.g. lower uptake in some immigrant populations in Iceland, and lower uptake by Māori in NZ) [66,124]. However, Iceland also chose to end all public restrictions much earlier than NZ. As of June 2022, NZ still had a traffic light system in place [34].

Iceland had a higher pre-pandemic GDP per capita than NZ, and a higher proportion of GDP related to tourism (Table I). Both countries saw a decrease in GDP in 2020 relative to 2019 due to COVID-19, but Iceland experienced a more dramatic decrease than NZ (–8.27% *vs.* –1.22%, respectively; Table I). Peak unemployment levels were also higher in Iceland than in NZ during the study period (7.2% *vs.* 5.3%; Table 1). However, GDP increased substantially in both nations in 2021 relative to 2020. Government provision of financial assistance as a proportion of GDP in 2020 and 2021 was twice as high in NZ as in Iceland.

Discussion

Main findings and interpretation

Overall, both countries did relatively well in their pandemic responses, with their excess mortality

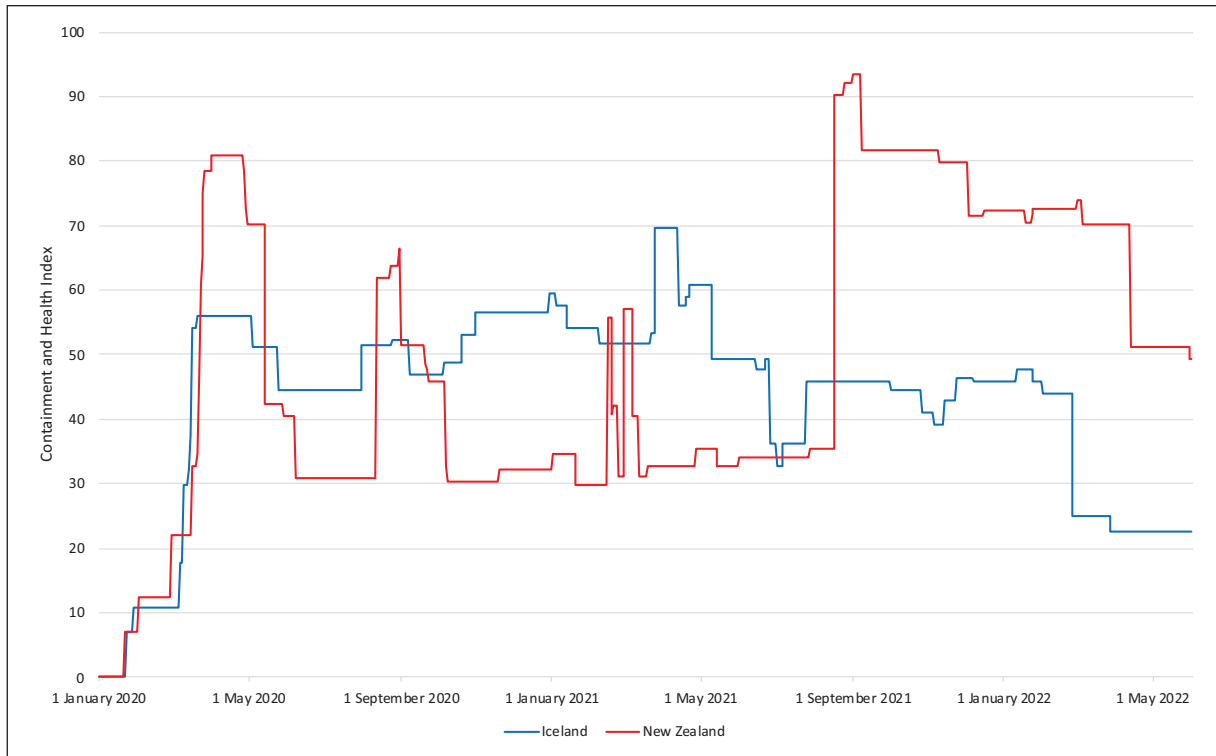


Figure 3. COVID-19 Containment and Health Index from 1 January 2020 to 1 June 2022 in Iceland and New Zealand [58]. The Containment and Health Index is a composite measure based on 13 policy response indicators rescaled to a value from 0 to 100 (100 = strictest) [58].

being the lowest in the OECD (lowest in NZ and then second lowest in Iceland). This positive outcome may reflect the relatively proactive responses of their governments, but also the benefits of some additional time to learn about the pandemic before cases arrived in their territories.

It does not appear that either country was in a better position to respond effectively to the COVID-19 pandemic. Neither Iceland nor NZ had extensive pandemic control infrastructure in place beforehand. However, Iceland may have been at a slight advantage due to its smaller population size, especially in terms of surveillance and contact tracing efforts. Some pandemic controls, including testing and contact tracing, are strongly constrained by the total numbers that a system is required to process. For example, early in the pandemic NZ did not have sufficient contact tracing capacity and expansion of the contact tracing workforce was deemed an urgent need in a rapid audit of the system [94].

While a smaller population may have been to Iceland's benefit in some ways, cases, and deaths per 1000 population, were slightly higher in Iceland than in NZ. This difference may be because Iceland's response was slightly less restrictive during the first wave of COVID-19 and during the later Delta and

Omicron variant waves (Figure 3). However, Iceland's response was arguably still relatively effective, even without the use of lockdowns or an official border closure. Public trust likely played an important role in Iceland's successful response and reduced the need for the enforcement of stringent and costly interventions. For example, an exploratory analysis of COVID-19 infection and fatality rates and factors associated with pandemic preparedness in 177 countries, including both Iceland and NZ, found that high levels of trust in the government and interpersonal trust were associated with lower standardized infection rates and higher vaccine coverage [125].

Iceland's success at keeping COVID-19 cases and deaths relatively low without the use of stringent restrictions led to the question: could NZ have achieved similar results without a border closure and MIQ system, and without the use of lockdowns? It seems to us unlikely that NZ could have achieved similar results without substantially increasing testing capacity. Iceland conducted almost four times more tests per 1000 population than NZ during the study period. While efforts to increase testing capacity in NZ progressed rapidly in the first year of the pandemic, a backlog developed during the initial part of the Omicron variant wave in early 2022 because

many laboratories were overwhelmed by the number of tests that required processing [93]. However, as noted above, testing is a pandemic control measure that is constrained by the volume that the system is required to process.

Considering the impact of alternative pandemic responses has methodological challenges. Disease modelling suggests that had NZ delayed implementing its lockdown, the pandemic wave would have been larger and taken longer to control, and elimination might have become impossible [126]. Furthermore, NZ's pandemic control efforts were likely complicated by the nation's high levels of structural inequities in health. For example, there was evidence that COVID-19 transmission chains became established in groups that experience high levels of deprivation and marginalization (e.g. people living in emergency and transitional housing, and therefore less able to comply with isolation and quarantine requirements) during the Delta variant outbreak in Auckland, NZ [127].

Despite a number of economic support measures, both countries saw a contraction in GDP in 2020, although Iceland saw a more substantial contraction of GDP in 2020 and a higher peak unemployment rate during the study period. This difference may reflect, in part, the country's high level of reliance on its tourism sector, but it is also possible that the measures taken in NZ were more effective for supporting its economy. While government provision of financial assistance as a proportion of GDP in 2020 and 2021 was twice as high in NZ as in Iceland, Iceland's pre-pandemic GDP per capita was higher than NZ's and Iceland may have lower levels of socio-economic deprivation. Therefore, the need for government support was possibly higher in NZ. An assessment of the economic and financial impact in Iceland and NZ over a longer period is needed to observe the full effect of the COVID-19 pandemic. However, such analyses will be complicated given the confounding effects of other world events (notably the war in Ukraine and associated sanctions impacting global trade and inflationary pressures in most countries in 2022).

Strengths and limitations of this analysis

A strength of this study was the ability to obtain key data on two high-income island nations with relatively effective COVID-19 pandemic responses. This study also involved authors with direct experience of the pandemic in both nations. However, many dimensions were not considered or were beyond the scope of this study, including the pandemic's impacts on short- and long-term morbidity (notably long

COVID). This analysis has not included direct and indirect impacts of pandemic control measures on mental health, education, different economic and workforce sectors, and social cohesion (e.g. as illustrated by the riots outside the NZ Parliament in early 2022 [128]). It would be particularly important to compare the impacts of the pandemic on health equity between these two countries, including its impact on Māori and other ethnic groups.

Future research could expand on the range of impacts of the pandemic and response over a longer time period. Key factors that influenced these outcomes, such as public trust and the role of mis/disinformation, deserve further study. Further cross-country comparisons would also be useful to add to the case study reported here and the previously published NZ–Taiwan comparison.¹⁹

Recommendations and lessons from both countries

There are several lessons that countries, especially high-income countries, can learn from the COVID-19 experience in Iceland and NZ. Iceland and NZ may have had advantages as small island nations in terms of having more time than many countries before the pandemic arrived, and by having better options for tight border controls. Nevertheless, there are several areas that could inform preparations for future pandemics or disease outbreaks. Our recommendations are as follows:

1. Have a flexible pandemic plan (i.e. adaptable to different pathogens, including potentially bio-engineered agents) that is easily and frequently updated.
2. Clarify in advance (ideally in pandemic plans and cost–benefit modelling studies) how a country will choose its response strategy (e.g. elimination versus suppression versus mitigation) for particular pandemic scenarios [129]. This planning should ideally include how to switch strategies as a pandemic evolves as a way of coordinating the choice of interventions, which flows logically from the strategy chosen [130].
3. Be prepared to activate emergency plans and powers early and ensure that legislation is already in place for this to happen.
4. If it does not already exist, consider establishing a national institution to manage the prevention and control of infectious disease threats, especially pandemics, and work on increasing capabilities for future emergencies.
5. Select and apply outbreak control measures (e.g. border quarantine, contact tracing) to align with

local conditions and resources. This capacity should include quantifying and modeling system capacity and supporting marginalized populations to help them to adhere to public health requirements.

6. Have a plan for how and where isolation and quarantine will occur. While Iceland and NZ approached quarantine and isolation requirements differently, these control measures were important in both countries. However, there was still room for improvement. For example, NZ's use of hotels as MIQ facilities led to at least 10 border system failures between 17 June 2020 and 15 June 2021 [82]. Purpose-built quarantine facilities would likely be more effective than the use of home-quarantine or re-purposed hotels [82]. There may also be some benefits to having permanent, built-for-purpose isolation and quarantine facilities available for future infectious disease outbreaks and pandemics. However, there would likely be greater up-front costs associated with building new quarantine facilities. Therefore, an integrated health and economic analysis should inform such a decision.
7. Provide clear and consistent communication to the public, including key communities. Regular media briefings by officials in both Iceland and NZ were likely important for building trust and public cooperation with infection control measures [22].
8. Follow the precautionary principle for decision-making surrounding infection prevention and control. For example, the use of masks (ideally high-performing respirator type) earlier in the pandemic may have benefited both countries, even though at the time there were some uncertainties around their effectiveness for widespread public use (universal masking). Additionally, for temperate countries, there is an overlap of pandemic control measures with those measures needed to combat annual winter respiratory infection epidemics [131].
9. Explore public-private partnerships to maximize the pandemic response. The public-private partnership between deCODE Genetics, Icelandic authorities and the National University Hospital of Iceland was very successful for ramping up testing in Iceland [22,25,35,42].
10. Further develop digital tools to support contact tracing, personal vaccination records, testing notification, patient follow-up and other components of the response with ethical and legal consideration of privacy issues. Digital contact tracing applications were not available for a couple of months after the first COVID-19 cases

were detected in Iceland and NZ (i.e. apps were available in April and May 2020, respectively).

Conclusions

Responses to the COVID-19 pandemic in Iceland and NZ were the most effective in the OECD in terms of reducing excess mortality and can provide lessons for other high-income countries. At a strategic level, there were obvious benefits in suppressing or eliminating transmission of COVID-19 for the first phase of the pandemic (18–24 months) to give time for vaccine development and rollout. In terms of intervention, the Iceland experience illustrates the effectiveness of high levels of testing and case management, and the NZ experience shows the value of effective border controls and short intense lockdowns to eliminate transmission. It may require a longer time frame to observe the net impact of the pandemic responses in both countries. For example, it is unclear whether Iceland will see higher cases or deaths after removing all public restrictions in 2022 or whether NZ will see an increase in cases or deaths during the winter of 2022 (June–August). However, the successful responses in both Iceland and NZ up to June 2022 warrant further examination to identify generalizable principles and transferable interventions that could help to prepare for future pandemics in these countries and elsewhere.

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