Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Health Policy and Technology 9 (2020) 510–524

Contents lists available at ScienceDirect

Health Policy and Technology

journal homepage: www.elsevier.com/locate/hlpt

The COVID-19 pandemic in Greece, Iceland, New Zealand, and Singapore: Health policies and lessons learned

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ARTICLE INFO

Article history:
Available online 28 August 2020

Keywords:
COVID-19
Greece
Iceland
New Zealand
Singapore

ABSTRACT

Objective(s): This paper aims at providing an overview of the COVID-19 situation, health policies, and economic impact in Greece, Iceland, New Zealand, and Singapore. The four countries were chosen due to their ability to contain the spread and mitigate the effects of COVID-19 on their societies.

Method(s): We use document analysis based on the available national reports, media announcements, official coronavirus websites and governmental decrees in each of the four countries starting from the 1st of January o the 9th of August announcements. We apply a policy gradient to compare and examine the policies implemented in the four countries.

Finding(s): The four countries have different demographic, epidemiological, socioeconomic profiles but managed to control the pandemic at an early stage in terms of total number of positive cases. The four countries managed to absorb the health system shock and decrease the case fatality ratio of COVID-19. Early interventions were crucial to avoid expected life lost in case of no early lockdown. The pandemic triggered several economic stimulus and relief measures in the four countries; the impact or the economic rebound is yet to be fully observed.

Conclusion(s): We conclude that early, proactive and strict interventions along with leveraging previous experience on communicable diseases and the evolution of testing strategies are key lessons that can be synthesized from the interventions of the four countries and that could be useful for a potential second wave or similar pandemics.

Introduction

In a space of three months, the world has changed quickly as a result of the spread of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus reported in the final days of 2019. To date, only a few countries reported no positive cases within their borders. Due to rapid spread and the uncertainty regarding the nature, pathology, prognosis, spread of the virus, and day of confirmed positive cases between different countries, there was no unified regimen to deal with the pandemic on a clinical, social, or economical scale. Different countries adopted different measures for detection, treatment, mitigation, and elimination of the virus within their borders.

A number of the measures taken are influenced by the existing health care system and its ability to respond to an influx of COVID-19 cases. As a respiratory disease, patients with severe COVID-19 are likely to require intensive care and use ventilators. In addition to focusing on the virus, many countries have considered the societal and economic repercussions of the pandemic and therefore, have provided several economic initiatives to relieve those who are affected and to stimulate the affected sectors.

In this paper, we document and compare four countries with different demographic characteristics, health systems, and different varying timelines to combat COVID-19. The countries Greece, Iceland, New Zealand and Singapore have been chosen due to their ability to mitigate the effects of COVID-19 at an early stage and, in the case of one, eliminate community transmission of SARS-CoV-2;

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https://doi.org/10.1016/j.hlpt.2020.08.015

Table 1
Demographic profile of Greece, Iceland, New Zealand, and Singapore in 2018.

	Greece	Iceland	New Zealand	Singapore
Population (Millions)	10.73	0.36 [3]	4.95 [4]	5.7 [5]
Population Density per sq. km of land area	83	4	19	7953
Old age dependency%	34%	23%	24%	15%
Life expectancy at birth	81	83	82	83

Source: (2).
Notes: Old age dependency refers to the ratio of persons aged 65+, over the number of persons aged between 15 and 64.

their similar geographic nature as islands and peninsulas; and their economies which mainly rely on service producing industries. The first confirmed cases of COVID-19 in all four countries have varied, Singapore reported its first case on the 23rd of January, whereas the first confirmed cases were almost a month later for New Zealand (26th of February), Greece (26th of February), and Iceland (28th of February). The main objective of this paper is to investigate the health policies implemented by the four countries and to provide insights on the resulted health outcomes and the economic and fiscal impact. We explore the footprints of escalation and de-escalation of measures and policies to contain the pandemic in financial markets as well as macroeconomic indicators.

After this brief introduction, the second section provides a country description for the four countries in hand where we look at the demographic profile, health system, healthcare resources, and potential risk factors associated with COVID-19. The third section describes the methods. The fourth section delves into the results and findings divided as the different trends of COVID-19 in the four countries and policy; technology roadmap based on the available data till the 9th of August 2020; the healthcare response data; and the economic and financial indicators and measures. The fifth section is the discussion and conclusion.

Country and health system overview

Not only are each of the countries geographically different, but they differ culturally, economically and on a health system level. All of which are likely to have had an influence on how well its population has responded to the spread of SARS-CoV-2. Out of the four countries, Iceland has the smallest population (352,721 citizens), whilst Greece is the largest (10,731,726 citizens) [1]. In terms of population size, none of these countries reach the top 100 in the world [1]. Referring to Table 1, Greece has the highest population density and old age dependency percentage, the Greek population also has the lowest life expectancy at birth however it is above the European average [1,2]. On the other hand, Iceland has the smallest population and density with 4 people per km^2 of land, as well as the highest life expectancy at birth. Compared to the other countries, Singapore has the lowest percentage of old age dependency and the highest population density per km2 [1].

There are different typologies of health systems between the four countries. For instance, the Greek system is a mixed system that includes a predominant social health insurance (SHI) system and a supplementary Voluntary Health Insurance (VHI) market. On the other hand, both the New Zealand and the Icelandic systems are tax-based systems. Table 2 shows that New Zealand has the highest percentage of health expenditure as a percentage of GDP (9.3%) while Iceland and Greece have a similar percentage, they differ in terms of health expenditure per capita. Singapore has the least health expenditure percentage (4%). Greece has the highest out of pocket percentage expenditure and the lowest percentage of insured population (75%). Service provision in the four countries are mainly from public and also private providers.

Evidence from countries who have experienced the Sars-CoV-2 outbreak for longer suggests that those who have chronic conditions or engage in riskier health behaviors are more at risk from severe consequences of COVID-19 [16]. In terms of risk factors that might be correlated with the prognosis of the COVID-19 active cases, we look at the prevalence of chronic conditions, tobacco use and alcohol consumption. Table 4 shows that Greece has the highest percentage of +15-year-old population who are daily smokers (27%), while Iceland has the least (8.6%). As for alcohol consumption, New Zealand has the highest number of yearly liters per capita consumed (8.8).

Containing the spread of SARS-CoV-2 has meant implementing a number of initiatives that support the existing healthcare systems within a country. In terms of pre-existing healthcare resources, Table 4 shows different parameters to compare the four countries. For example, in terms of number of beds per 1000 of the population, Greece has the highest number of hospital beds (4.2). The severity of COVID-19 will mean that a number of intensive care unit beds will be required, out of the four nations Iceland has the highest number of beds with 9.1 per 100,000 people and the highest number of ICU beds/100,000 populations. New Zealand has the highest ratio of general practitioners compared to specialists, while Greece is the opposite. Iceland has the highest number of nurses per 1000 populations. Greece has an understaffing issue; the lowest number of nurses per 1000 population and the highest number of physicians per 1000 populations; while Singapore has the least number of physicians per 1000 populations (2.5/1000).

Table 2
Health system and expenditure of Greece, Iceland, New Zealand, and Singapore.

	Greece	Iceland	New Zealand	Singapore
Typology	Mixed system	Tax based	Public tax based	Mixed system
Total Health expenditure as% of GDP	8.4% in 2015	8.3%	9.3%	4% [8–12,15]
Private expenditure (out of pocket)	41%	17%	12.9%	31% [13]
Insurance	Mixed: SHI & VHI (supplementary)	Public	Public	Saving accounts + VHI Supplementary
Finance	SHI, Taxes. VHI, and users	Mostly public	Public tax based	Subsidies, saving accounts, medishield, medifund + VHI
Coverage percentage	Mainly dependent on employment 75% coverage in 2016	All citizens	Universal Health Coverage	+80% [14]
Providers	Public and private	Integrated public purchaser-provider relationship	Public and private	Public and private

Sources: (2)-(15).

Table 3
Health Behaviors and prevalence of Chronic Conditions.

	Greece	Iceland	New Zealand	Singapore
Alcohol consumption	6.5 liters per capita	Around 7.7 liters of pure alcohol per year	8.8 liters per capita	2 liters per capita [18,19]
Tobacco use	27%	12.4%	13.1%	13% [20]
Percentage of obesity in adults 2016 [21]	21.9%	24.9%	30.8%	6.1%
Top three conditions as proportion of mortality [22–25]	Cardiovascular conditions 38% Cancers 26% Communicable, maternal, perinatal and nutritional conditions 11%	Cardiovascular diseases 32% Cancers 29% Chronic respiratory disease 6%	Cardiovascular diseases 31% Cancers 30% Chronic respiratory diseases 7%	Cardiovascular diseases 29% Cancers 30% Communicable, maternal, perinatal and nutritional conditions 23%

Sources: (4)-(25).

Table 4
Healthcare Resources in Greece, Iceland, New Zealand, and Singapore.

	Greece	Iceland	New Zealand	Singapore
No. of beds	4.2/1000 population	2.91[]	2.61	2.4 [6]
GPs to Specialist ratio	1:16	1:6	1:3	1:0.7 [16]
No. of Nurses (per 1000 people)	approx. 3.31 lowest in EU	approx. 14.8	10.29	7.5 [16]
No. of Physicians	around 6.2/1000 population Highest in EU	Around 3.8/1000 population	3.5/1000 population	2.5 [16]
No. of ICU beds	6/100k population in 2012 Lower than average	9.1/100k	5.1/100 K [26]	11.4/100 K [17]

Sources: (4)-(17), (26).

Methods

Data definitions

The case definition for COVID-19 in New Zealand is a person who is unwell with an acute respiratory infection and has at least one symptom of coughing, sore throat, head cold or a loss of the sense of smell. While in Iceland, symptoms of COVID-19 are described to be cough, fever, cold-like symptoms, muscle pain, fatigue or sore throats, there have been some instances of abdominal pain and loss of smell and taste. In Greece, a case definition for testing if someone shows symptoms such as a fever, cough and difficulty breathing. It is also advised that COVID-19 can present with symptoms of muscle pain, fatigue, and difficulty breathing. At the current stage, testing in Greece is restricted to patients with severe acute respiratory illness who are or need hospitalization, as well as patients in hospitals, elderly (>70) care or chronic care, and health staff who develop respiratory infections with fever, coughs or dyspnea [27].

Testing in New Zealand can occur through a septum test or nasal swab, and all are expected to self-isolate until the results are confirmed. It is possible that a small number may not be tested and those that are not are still expected to self-isolate. In Iceland, initially testing was conducted on residents returning from high risk areas and contacts of confirmed cases. This was widened to include the general community who presented with symptoms, in addition a private testing agency has collaborated with the Directorate of Health to randomly sample the population. Singapore has not released detailed information about the country's testing strategy, in fact the number of tests were released twice in April and have since been reported on a weekly basis.

Data sources

Each of the respective governments provide daily updates of the COVID-19 pandemic, in particular they focus on the number of confirmed and suspected cases, number of recoveries and hospitalization information. In terms of transparency, each country has released information that not only involves the top-level epidemiology data (confirmed cases and deaths), but information on the number of people in isolation (non-confirmed cases), suspected cases, number of quarantined, number of people in hospital (general and intensive care unit wards), and the number using ventilators. To collect the available epidemiology data and policy information, we searched through national documents, such as media announcements, official coronavirus websites and governmental decrees in each of the four countries starting from the 1st of January o the 9th of August. Through this process we were able to collect information from New Zealand, Singapore, Iceland and Greece, using documents that were in English, a translation app and consulting a native speaker.

For Iceland and Singapore there is a dedicated COVID-19 dashboard, while Greece and New Zealand use their health departments, to provide an overview of the epidemiological information, and a breakdown of information linked to cases. [28–31] Additional government departments support this dashboard by providing information that is relevant to COVID-19, for instance the health department of Iceland provides a breakdown of the number of cases in hospital (until the 15th of May [32]), the number of medical staffs in isolation and the number of medical staffs in quarantine among additional health information. New Zealand has supplied the age group, gender and flight numbers (if they've recently travelled) relevant to confirmed cases; whilst Singapore switched from daily updates on gender and age, to a breakdown of the associated information by citizenship and visa type of confirmed cases since the 19th of March.[1]

None of the nations have reported an overview of the epidemiology data related to COVID-19 deaths, some of this information is provided in respective nation's media releases however comorbidity information is not included. New Zealand, Singapore, Greece and Iceland report information on whether the confirmed cases are in the community or were imported (contracted overseas). New Zealand provides information on the flights that the individuals came on, while Singapore reports the residency status of confirmed cases. All but Singapore are currently reporting information on confirmed cases at a regional level, while confirmed deaths are reported at a national level. There are four periods where Greece does not report the daily testing information, the 26th of March, 19th of April, 3rd of June, 5th to 7th of June and 15th of July. The

[1] Once or twice in the media releases the age and gender of some of the cases is released. However, there is not enough information updates to provide a full overview of confirmed cases by age and gender to date.

Table 5
SARS-CoV-2 Cases and Deaths, 10th of June 2020.

	Cases	Deaths	Proportion deaths/cases	Cases Per 100,000	Deaths Per 100,000	Cases Density (per Km^2)
Greece	5623	213	3.79%	29 [22]	1.71	0.02
Iceland	1962	7	0.36%	494 [2]	1.91	0.02
New Zealand	1219	22	1.80%	23 [4]	0.44	0.00
Singapore	55,104	175	0.32%	683 [7]	0.44	53.80

next reported day includes the data for the missing period, for example the 8th of June reports a 35,590 new test increase.

Policy gradient

To examine the impact of policy interventions on COVID-19 related outcomes, we use the policy categorization process and gradient proposed by Moy et al. [33]. This categorization process groups policy interventions for those that contain the spread of a virus, interventions for the prevention and care, policies to reduce the economic impact, as well as a categorization for measures taken by private sectors without government intervention and health technology interventions used for treating, testing and tracing cases of a virus. From these categorizations, it is possible to apply a gradient that represents the strictest or most dominant policy being used. To examine the impact of the most dominant policy on outcomes such as the daily rate of cases, we incorporate the gradients into each of the figures in the following sections.

Results

COVID-19 trends

Daily data COVID-19 cases, deaths, recoveries

As of the 9th of August 2020, Greece, Iceland, New Zealand and Singapore had reported 20,440 laboratory confirmed cases of SARS-CoV-2 between them, accounting for 0.6% of the world's confirmed cases [34]. Out of the four nations, Singapore has the most cases with 55,104, whilst New Zealand had reported the least with 1219 (see Table 5). Whilst Iceland has reported the lowest number of deaths (7), and Greece the highest with 213 COVID-19 related deaths. However, there are numerous differences between the four countries, such as the health systems, interventions put in place and size of the country, that may influence the overall rate and impact of SARS-CoV-2.

In order to compare the rates of growth of SARS-CoV-2, and the daily and cumulative trend over the course of the pandemic we revert the date of the first confirmed case to day one. As such we observe that Greece, New Zealand and Iceland are at 106 and 104 days, whilst Singapore has reached its 140th day. The daily number of cases in Greece, New Zealand and Iceland show a fairly normal distribution (see Fig. 1), indicating that the nations are past the peak. In fact, New Zealand has announced that it has eradicated the virus from its shores. However, the daily confirmed cases of Singapore show a left skewed distribution, as the country had maintained a low number of cases for the majority of the period observed but the number of cases has recently increased.

All four countries implemented medium level interventions to contain the spread relatively soon after the first case. Containment measures increased in strictness for New Zealand at the peak of daily cases, while Singapore escalated measures as the daily cases began to increase. Economic interventions began to be introduced approximately 20 days after the first case for New Zealand, Greece, Iceland and Singapore.

It is evident that all countries were experiencing a different daily rate of the virus as the pandemic progresses. To determine the daily rate of change in cases, we divided the daily new cases by the daily new cases from the day before. If the growth rate is higher than one, then the number of cases is increasing and if the rate of growth continues to increase then it could indicate that the policy interventions are not mitigating the spread of SARS-CoV-2. In Fig. 2, it is clear that each of the four countries has maintained relatively low daily growth rates, with the biggest spikes in growth occurring in Greece towards the beginning of the pandemic, and most recently at the 56th day. These spikes in Greece are likely to be driven by clusters of COVID-19 being discovered.

Both Singapore and Iceland have maintained growth rates between zero and three for the duration of pandemic so far. For the last seven days, the average rate of growth for Greece, Iceland, New Zealand and Singapore is 1.24, 0, 0 and 1.06 respectively. Despite the sum of factors being higher than one (meaning confirmed cases are increasing) for Greece and Singapore, the average number of daily cases for the last week has been 16, 0.125, 0 and 391, respectively.

It appears that all the countries are demonstrating similar epidemiology curves, however for a better understanding of how each country compares to the other we estimate the number of confirmed cases, COVID-19 related deaths, number of tests conducted and active cases (those not recovered or deceased) per 100,000 persons. On the 10th of June, Iceland had the highest number of confirmed cases of SARS-CoV-2 with 494 cases per 100,000 people compared to the other three countries (see Table 1). The country with the lowest number of confirmed cases per 100,000 was New Zealand with 22 per 100,000, however Greece also reported 29 cases per 100,000.

As observed in Fig. 3, the majority of Iceland's daily cases were in its fifteenth to fortieth days, whereas Singapore's picked up pace towards the seventy-fifth day. The number of daily cases observed in Iceland correspond to the number of tests conducted per 100,000 of the population. Iceland has also conducted the most tests per 100,000 on a daily basis. Testing per 100,000 of the population is much lower in New Zealand and Greece on a daily basis. Overall, Greece has tested 2246 people per 100,000, whilst New Zealand, Iceland and Singapore have tested 6096, 17,200, and 8568 people per 100,000, respectively.

Despite delaying the number of cases in the wider community in Singapore, there was a breakout of cases in the dormitories that house migrant workers. As a result, authorities increased testing in the dormitories and implemented dormitory wide quarantine to stem the spread.

Healthcare resource utilization

Hospitalization information provides an overview of how the health system is fairing with the number of COVID-19 cases within the country. The number of individuals with COVID-19 in hospitals have been reported on a daily basis for Iceland, New Zealand and Singapore. In addition to the hospitalization information, the number of individuals in the ICU have been reported in all countries for varying periods during the pandemic. As observed in Fig. 4, hospitalization rates have remained low in all countries excluding Singapore. After the 60th day the number of hospitalizations

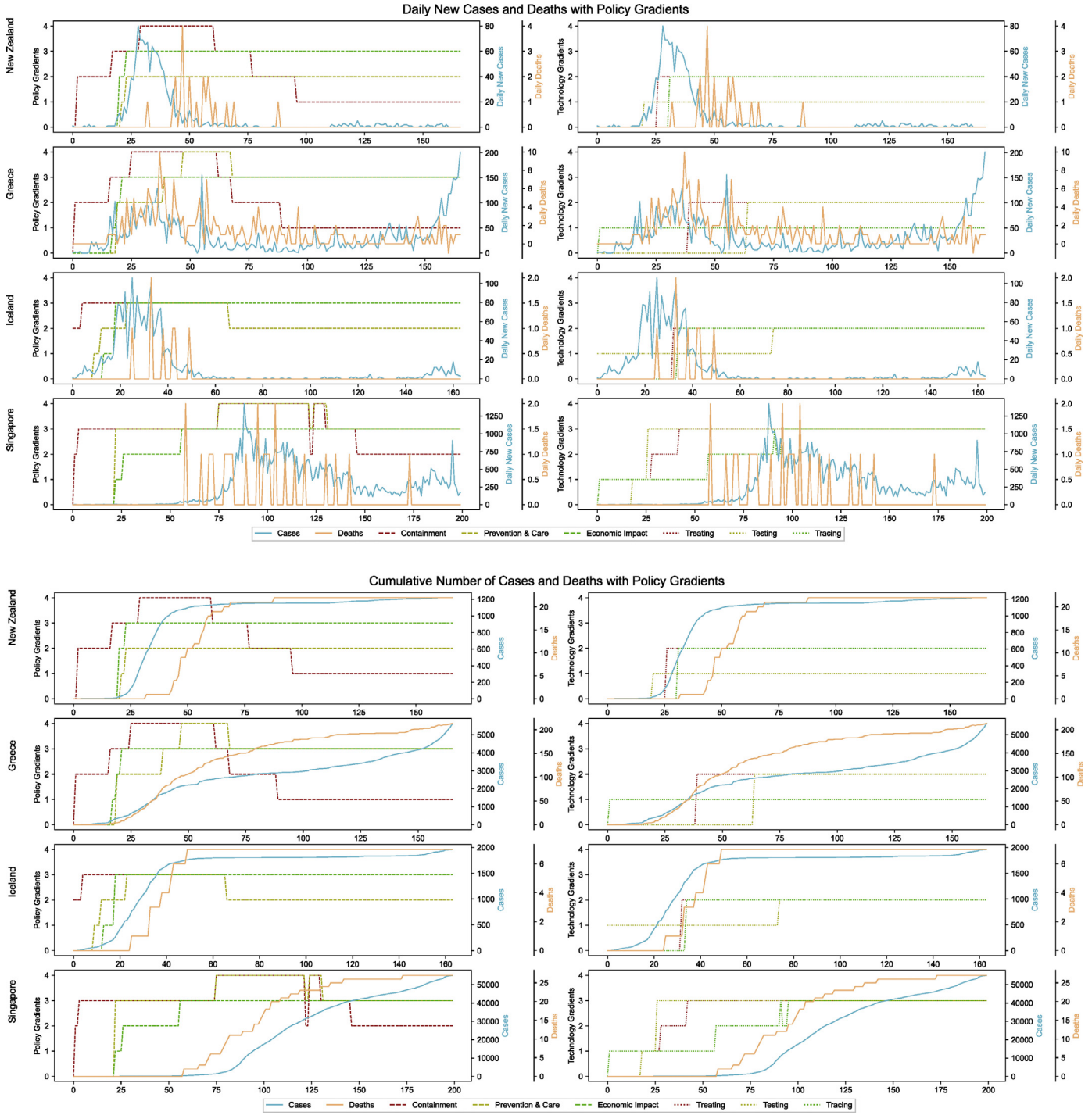

Fig. 1. Daily and Cumulative Lab Confirmed Sars-CoV-2 Cases.

in Singapore increased as the number of cases increased. However, the number of intensive care unit (ICU) submissions did not follow the same surge and whilst increasing have not jumped the same amount. Greece had the highest number of ICU cases on a daily basis compared to all other nations, however the number appears to be decreasing.

Daily data on age and gender distribution

Although SARS-CoV-2 virus is indiscriminate in those that can catch it, COVID-19 appears to severely affect those over the age of 60 more than other age groups, whilst children seem less likely to catch the virus. Each of the four countries provide data on the distribution of COVID-19 by different age groups and gender, although Singapore stopped providing age and gender for confirmed cases from the 19th of April. As of the 9th of August (see Table 6), more females (males) were confirmed with SARS-CoV-2 than males (females) in New Zealand (Greece). This equates to 478 male confirmed cases per 100,000, with 22 and 25 confirmed male cases per 100,000 and 30 and 23 confirmed female cases per 100,000 in New Zealand and Greece, respectively.

In terms of the distribution of laboratory confirmed cases by age group, all but Singapore have released up to date information.

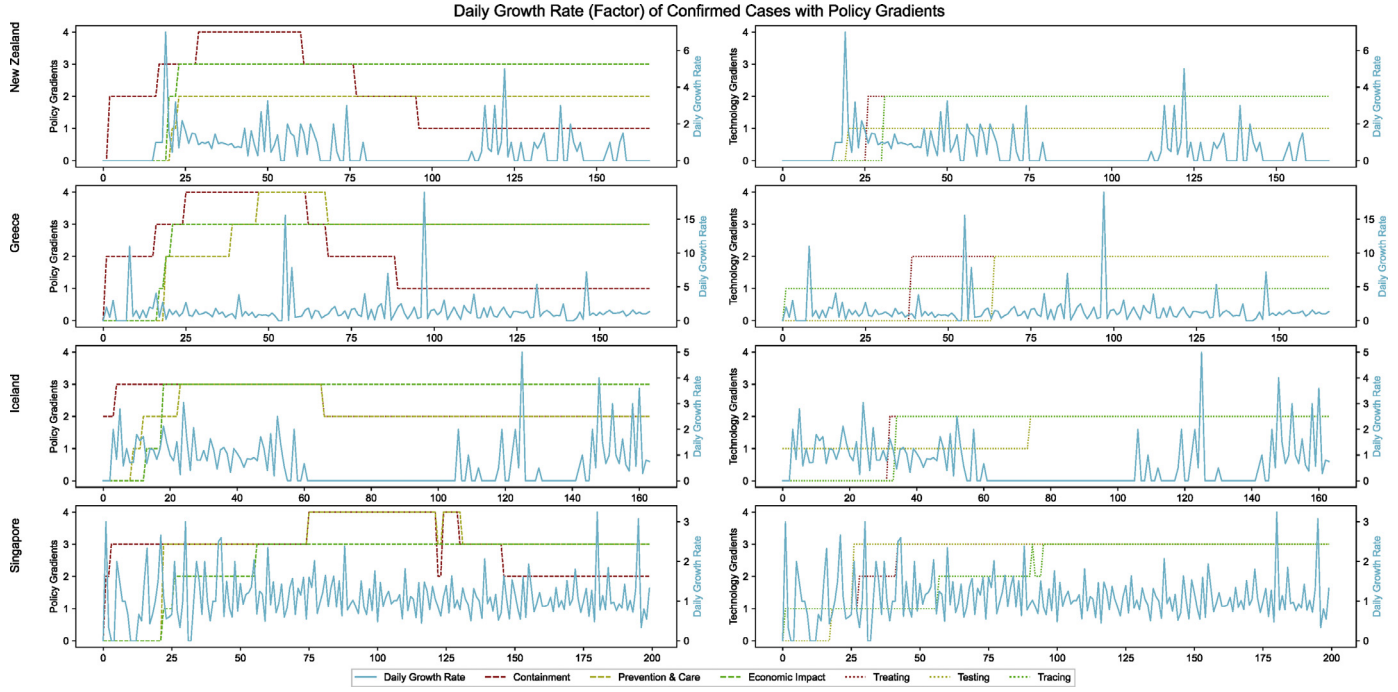

Fig. 2. Daily Growth Rate (Factor) of Confirmed COVID-19 Cases.

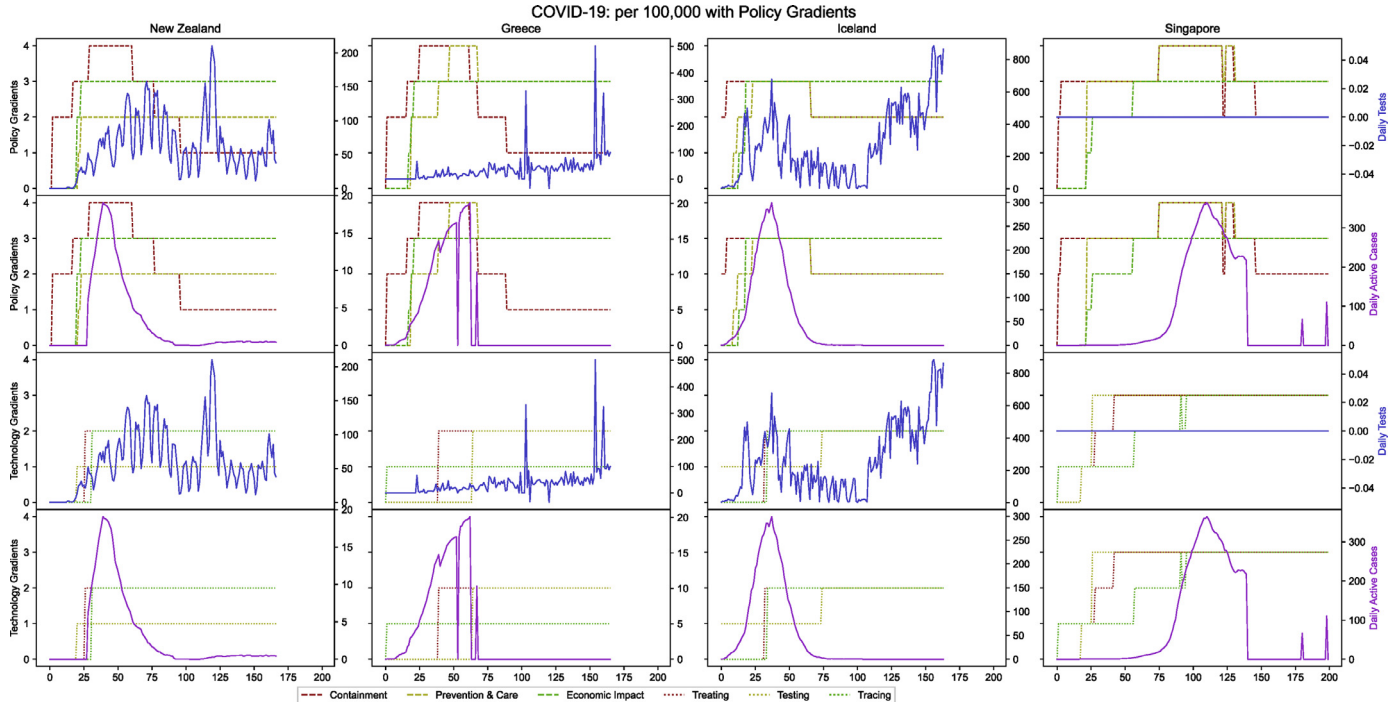

Fig. 3. Daily trends per 100,000 for COVID-19.
Note: Singapore does not report the daily testing numbers.

However, as each country uses different age group scales the following section reports the total counts for the 10th of June and does not convert to a comparable population level. Referring to Fig. 5, the majority of cases in all three countries are in the working population (considered the 18–64 age group). Whilst the least number of confirmed cases appears to be in children and youth. Each nation has reported a number of cases in the over 65 age group, who are considered to be the most at risk.

All four countries have reported information on the number of deaths and the corresponding ages of the deceased. Whilst this is not necessarily released on the dashboards, government media releases specify the ages (or age group) of those who have passed and tested positive for COVID-19. Overall, the number of deceased associated with COVID-19 in Greece, Iceland, New Zealand and Singapore are relatively low compared to other nations. The death rate in terms of confirmed cases was approximately 5% for Greece, 1.9%

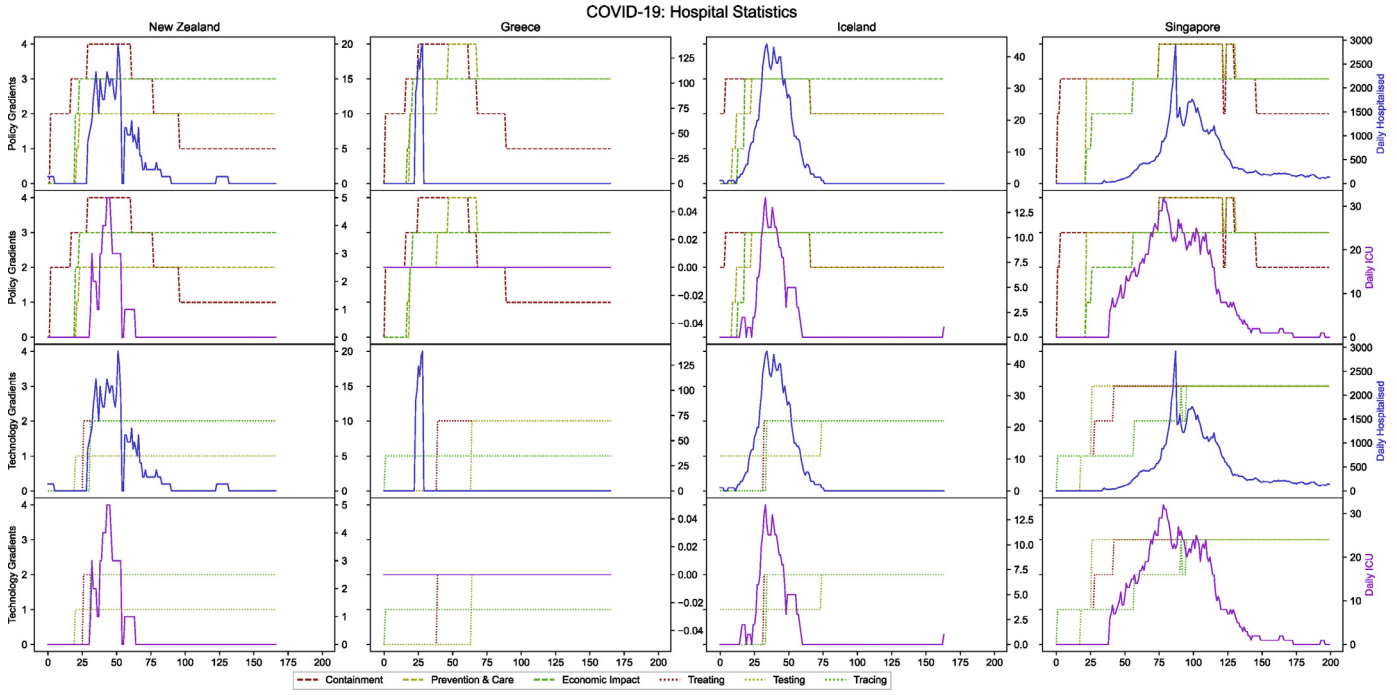

Fig. 4. Country Hospitalization Information
Note: around the 90th day Singapore reclassified its categorization of hospitals, and a number were moved into isolation.

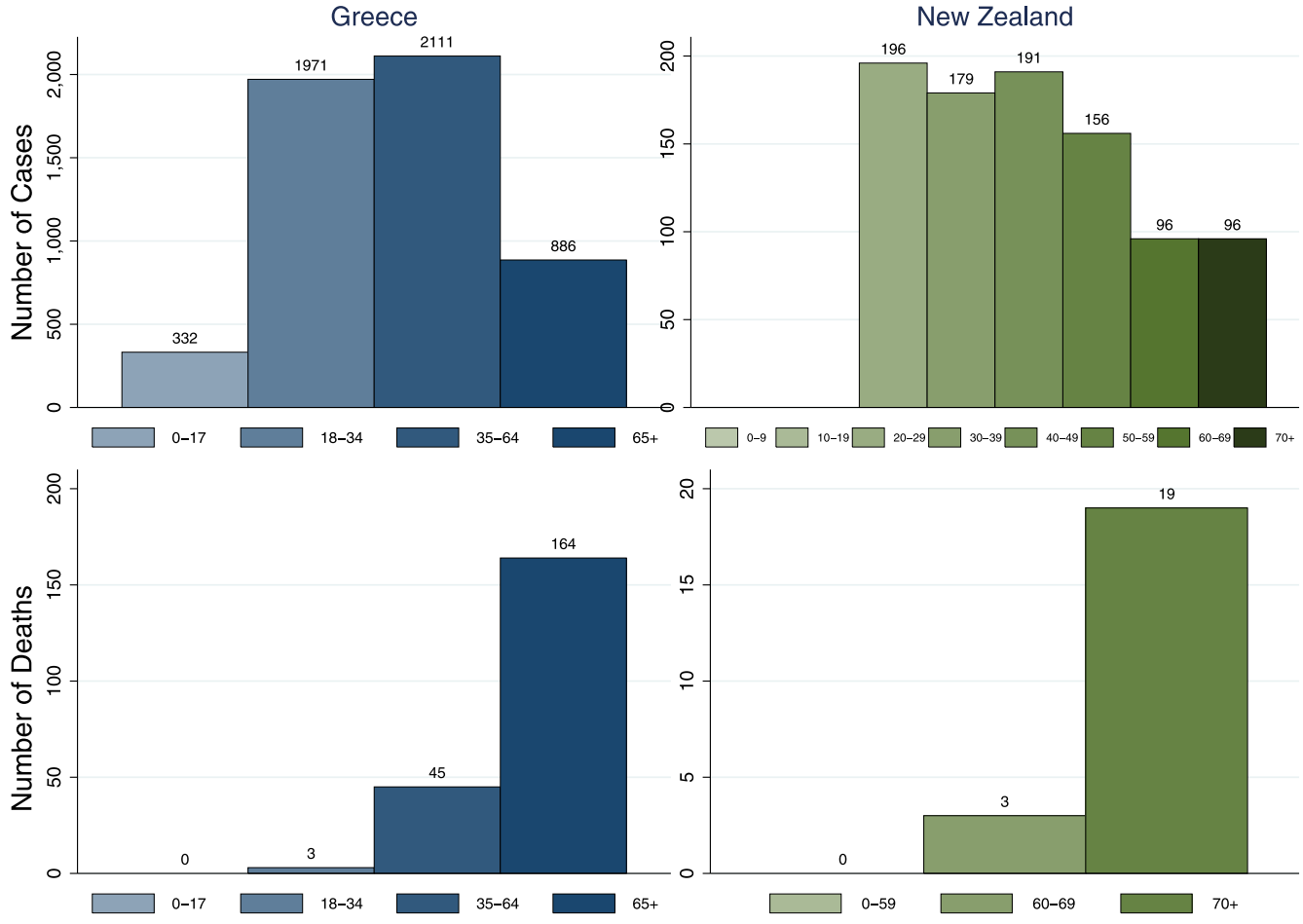

Fig. 5. Confirmed Cases & Deaths, by Age Group.
Note: Singapore has not released a breakdown of deaths, although some information is released in the Singapore Government's daily media releases. This figure demonstrates the associated deaths, as such this figure refers to the associated deaths and reports more for Iceland.

Table 6
Total COVID-19 Cases by Sex (10th June 2020).

		Greece	Iceland	New Zealand	Singapore
Male	Total	1580	–	533	–
	Per 100,000	30	–	22	–
Female	Total	1287	–	621	–
	Per 100,000	23	–	25	–

Note: As of the 19th of April and 15th of June, Singapore and Iceland, respectively, are no longer reporting the gender and age of confirmed cases of COVID-19. [35].

for New Zealand, whilst Singapore and Iceland reported death rates lower than 1% (refer to Table 1).

In all cases, the majority of deaths associated with COVID-19 are in the 65+ age groups, however both Greece and Iceland have reported associated deaths in the 30–39 and 18–34 age groups, respectively. Iceland and Singapore have reported two categories for deaths, one for COVID-19 as the cause of death and the other is death not caused by COVID-19 however the individual had tested positive. Two of the deaths in Iceland were not caused by COVID-19, the underlying cause is not publicly available. Whilst Singapore has determined that two of the deceased were not caused by COVID-19, one was caused by a pre-existing condition (ischemic heart disease) and the other is currently under police investigation.

Finally, whilst research has indicated that pre-existing morbidities are related to increased severity of symptoms and higher probabilities of death, limited information has been reported by each country on the pre-existing health status of those who test positive for COVID-19. A limited amount of health-related information is available on the deceased based on media announcements by the Ministry of Health in Singapore. It was reported that ten of the COVID-19 related deaths had pre-existing conditions that were related to cancer, chronic heart disease, diabetes, hypertension, hyperlipidemia, isometric heart disease and kidney disease. Seven of the associated cases had multiple morbidities [23].

Calculating years of lives lost

In order to estimate changes in mortality risk determine the benefits of public health and environments policies, the estimates of life-years saved by these policies is used as a measure of mortality risk [36]. Different COVID-19 policies will change the rate of mortality within a nation, and cause differences in the years of lives lost. To calculate the expected mortality and cost of loss of life caused by COVID-19 in the absence of any restriction, we categorized different rates of infection, namely 20%, 40% and 60%, as the best, medium and worst-case scenarios, which could be related to the level compliance of individuals to the health advice as a very important factor in containing the outbreak [37]. Using the Fergusen et al. in Imperial College study estimates for death rate per age cohort, we estimated the expected mortality rates per age cohort in each of the four nations in this study [38]. Taking the assumption that the average life expectancy at the age of 65 for each nation, we can then calculate the years of lives lost for each scenario. We should also note that individuals with age above 85 are given a few extra months to live. As we observe in Table 7, under the highest infection rate the mortality rate is greatest for those ages 70–79 in Iceland, New Zealand and Singapore, whilst the 80–89 age group is the most affected in Greece. However, despite of their lower IFR, the greatest years of lives lost is observed in all cases in the 60–69 age group due to their longer life expectancy. [39]

POLICY and technology road MAP

Globally, nations have reacted to the SARS-CoV-2 pandemic with public health and economic policies. Actions taken by these governments were focused on containing the spread of the virus and mitigating the economic impact on businesses and employees. For each of the four nations, we collected the majority of policies implemented in response to SARS-CoV-2 from the respective government media releases and government websites. For Greece, we included information reported in English language media outlets. The policies taken by Singapore, Greece, New Zealand and Iceland are presented in a policy timeline shown in Fig. 6.

Following the policy categorization process implemented by Moy et al., in panel A of Fig. 6 each of the policies is designated to one of three categories: policy intervention to contain the spread of the virus; policy interventions for treatment and cure; and economic impact policy interventions [33]. In panel B of Fig. 6, we see the distribution of government intervention based on the Government Response index created by [37]. Both demonstrate the in-

Table 7
Lost Life Expectancy in case of no restrictive policies in Greece, Iceland, New Zealand, and Singapore.

	Age Groups	Midpoint of Age Groups	Population	Deaths at Best Scenario	Death at Median Scenario	Deaths at Worst Scenario	Life expectancy at mid-point age	Lost Life Expectancy at Best Scenario	Lost Life Expectancy at Median Scenario	Lost Life Expectancy at Worst Scenario
New Zealand	60–69	65	531,010	2336.444	4672.888	7009.332	20.64	48,224.2	96,448.41	144,672.6
	70–79	75	359,040	3662.208	7324.416	10,986.62	10.64	38,965.89	77,931.79	116,897.7
	80–89	85	153,330	2790.606	5581.212	8371.818	1.14	3181.291	6362.582	9543.873
	90+	90	33,200	604.24	1208.48	1812.72	0.64	386.7136	773.4272	1160.141
	Grand Total		1,076,580	9393.498	18,787	28,180.49		90,758.1	181,516.2	272,274.3
Greece	60–69	65	1,243,217	5470.155	10,940.31	16,410.46	20.58	112,575.8	225,151.6	337,727.4
	70–79	75	940,663	9594.763	19,189.53	28,784.29	10.58	101,512.6	203,025.2	304,537.8
	80–89	85	652,712	11,879.36	23,758.72	35,638.08	1.08	12,829.71	25,659.41	38,489.12
	90+	90	127,216	2315.331	4630.662	6945.994	0.58	1342.892	2685.784	4028.676
	Grand Total		2,963,808	29,259.61	58,519.21	87,778.82		228,261	456,521.9	684,782.9
Singapore	60–69	65	762,636	3355.598	6711.197	10,066.8	21.12	70,870.24	141,740.5	212,610.7
	70–79	75	260,127	2653.295	5306.591	7959.886	11.12	29,504.64	59,009.29	88,513.93
	80–89	85	109,364	1990.425	3980.85	5971.274	1.62	3224.488	6448.976	9673.465
	90+	90	20,786	378.3052	756.6104	1134.916	0.12	45.39662	90.79325	136.1899
	Grand Total		1,152,913	8377.624	16,755.25	25,132.87		103,644.8	207,289.5	310,934.3
Iceland	60–69	65	36,635	161.194	322.388	483.582	20.85	3360.895	6721.79	10,082.68
	70–79	75	22,223	226.6746	453.3492	680.0238	10.85	2459.419	4918.839	7378.258
	80–89	85	10,258	186.6956	373.3912	560.0868	1.35	252.0391	504.0781	756.1172
	90+	90	2384	43.3888	86.7776	130.1664	0.85	36.88048	73.76096	110.6414
	Grand Total		71,500	617.953	1235.906	1853.859		6109.234	12,218.47	18,327.7

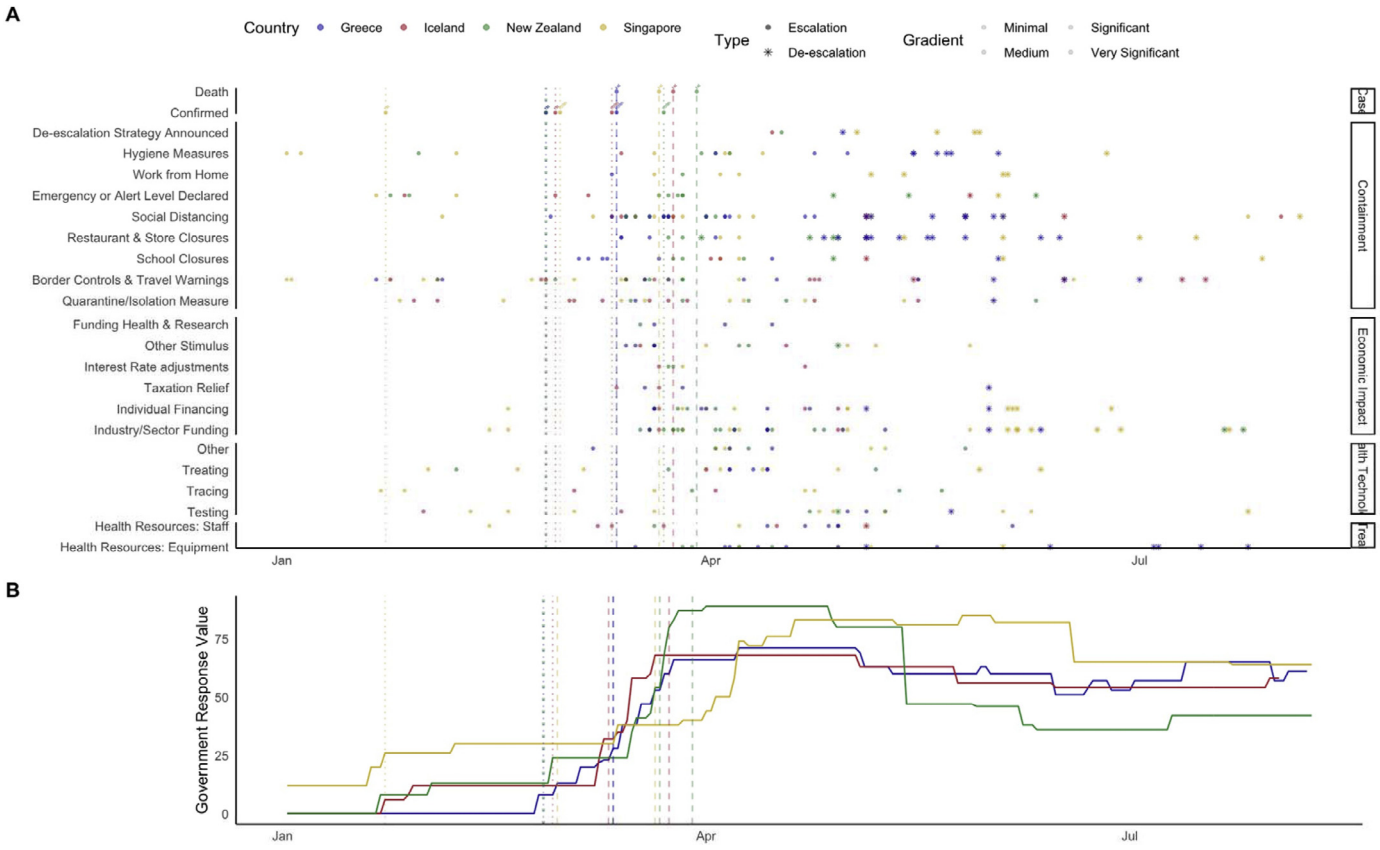

Fig. 6. Timeline of the policy interventions in Greece, Iceland, New Zealand, and Singapore.

creased government activity used to control or stop the spread of the virus.

Referring to panel A, we see that a majority of interventions are observed after the 100th case for New Zealand, Greece and Iceland. However, Singapore implemented hygiene and border control measures swiftly, before focusing on tracing contacts of confirmed cases. In addition, Singapore implemented fines up to $10,000 and 6 months in prison for breaking quarantine. In comparison to the other three nations, Singapore has focused on the use of technology to help manage the spread and increase citizens' awareness of crowded places and social distancing measures.

Whilst New Zealand and Greece locked down earlier than most nations relative to the amount of cases (see Fig. 7), Iceland never declared a full lockdown instead the number of people able to meet was restricted (maximum of 20). Rather there was a focus on containment and protecting health systems before implementing stimulus packages. Iceland utilized private industry and created a testing policy for anyone to be tested free of charge, providing the most detailed spread of the disease outside of the Diamond Princess case study [40,41].

Containing the virus involved a series of similar actions amongst the countries such as self-isolation, closing non-essential business, travel bans and technological innovation. Travel bans in Singapore and New Zealand were strict and did not allow non-residents entry into the county. Whereas Greece and Iceland were less stringent and restricted entry only to citizens from selected nations, although Greece did extend flight bans from several at risk countries. Regarding technological innovation, digital solutions such as tracing apps, smartphone alerts, telehealth consultations and health apps were used and promoted by all four governments.

The four countries have also implemented exit or de-restrictive policies after mitigating and absorbing the SARS-CoV-2 shock. These exit policies aim at facilitating mobility and reopening the economy and they depend primarily on the risk assessment of the local SARS-CoV-2 situation. An incremental approach was adopted in the four countries as they transition from strict to slightly less strict and eventually no interventions. Detailed description of the exit policies in the four counties is provided in the appendix.

Greece unfolded its four-level exit strategy with continuous risk assessment implemented on a daily basis on the 28th of April. The first level started on day 69 of SARS-CoV-2; the second level started on day 76; the third was on day 83; and the final level was on day 97 [41,42]. As for Iceland, the derestriction process had four main milestones that started on day 67 and then day 78 and day 81 and lastly day 88 [43]. New Zealand has implemented a four-level alert system that reached its peak, level four, on day 29 of SARS-CoV-2. On day 62, New Zealand started its exit policies/strategies by moving to alert level three and then to alert level two on day 78 and lately on the 8th of June 2020 to alert level one after 104 days from the first case of SARS-CoV-2 [44]. Finally, Singapore also has a four-level Disease Outbreak Response System Condition (DORSCON) colored system. Since day 11, Singapore is on the third orange level that indicates a severe status of the SARS-CoV-2 situation and a tight lockdown or circuit breaker has been imposed since day 72 or the 3rd April with the increasing surge of positive cases linked to the migrant workers. A provisional easing was implemented on day 101 with a plan to exit the circuit breaker by the 1st of June 2020 or day 131 of SARS-CoV-2 in Singapore [45–47].

Health care system response data

In all nations, the number of hospitalized cases has not overwhelmed the existing health care system, however there are a

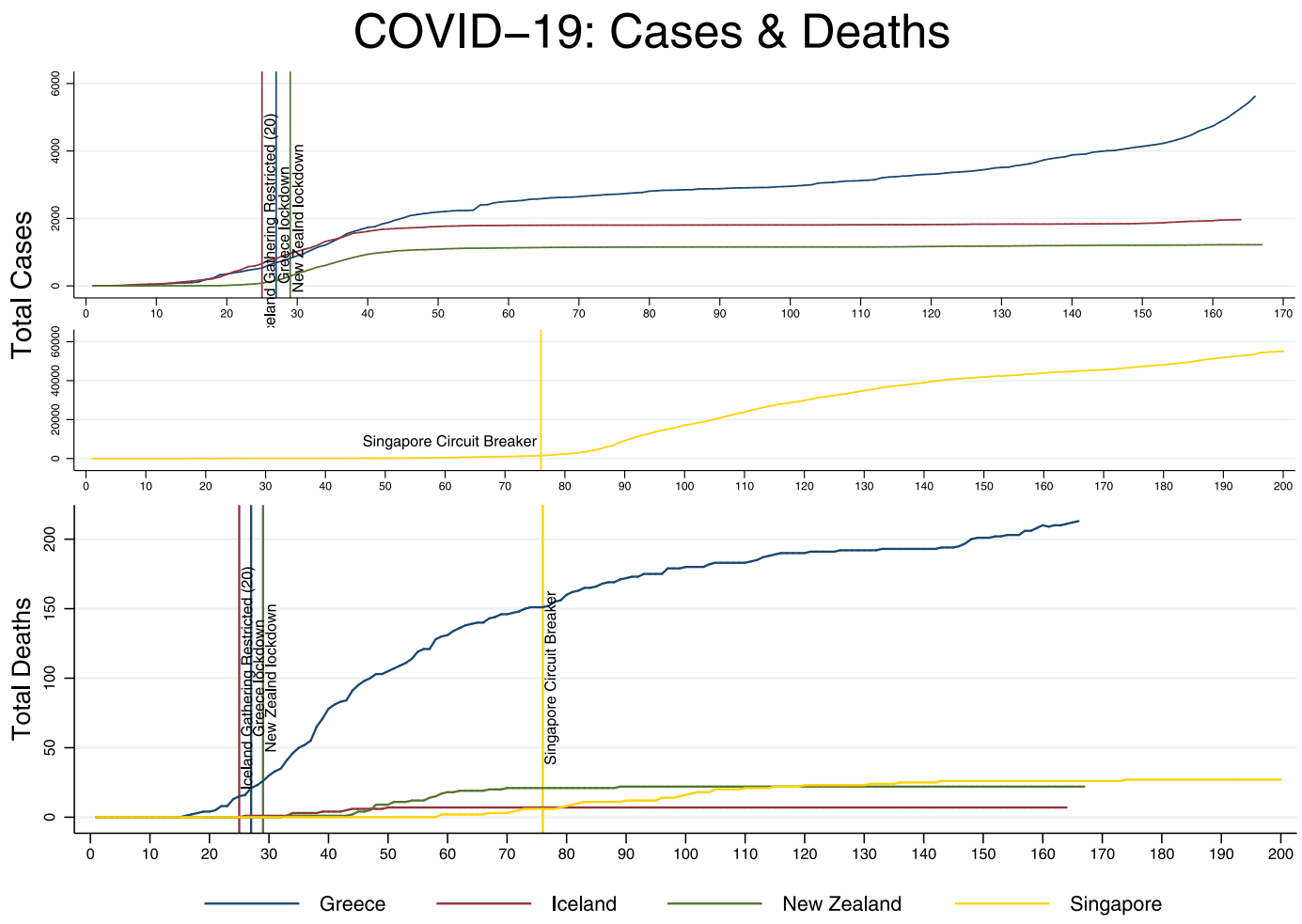

Fig. 7. COVID-19 Confirmed Cases & Deaths with strictest containment measure.

number of healthcare workers being affected by the virus in terms of confirmed cases and self-isolation as a result of being in contact with confirmed cases. Singapore has reported a number of confirmed cases of healthcare staff through their media announcements, with 66 confirmed cases amongst their health staff as of the 26th of April [48]. New Zealand reported on the 18th of April that 131 healthcare staff members were isolating and a further 43 had recovered. However, Iceland is the only country out of the four that has provided daily updates on the number of staffs in self-isolation and quarantine (see Fig. 8) [49].

Whilst all four countries' health systems have responded well to the virus, all are preparing for potential increases in cases that are beyond their existing health systems capacity. In fact, in response to the COVID-19 outbreak, the Greek government announced an increase in the number of permanent medical staff and the intention to reach 12 intensive care unit beds per 100,000 of the population [50]. The government has aided this goal by providing 15 million euros for health resources, and an additional 70 million euros to hire additional health staff. Since then, almost 3000 medical staff have been made permanent [51]. Greece has also begun to reduce the lockdown measures and allow certain systems to reopen, at the same time the nation is also preparing resources for an eventual surge of COVID-19 and influenza cases in the fall of 2020.

In Singapore, the government is increasing its ability to bring online additional ICU beds if they become needed. At present, Singapore has 150 vacant ICU beds, with an additional 300 able to be brought online. There are additional plans in place to bring another 450 online within the next few weeks [52]. In addition, general isolation beds have increased from 550 to 1500 beds since January and the National Center for Infectious Diseases has increased their negative pressure isolation beds from 100 to over 500 [52]. To increase the health staff capacity of the public health system, the government launched the SG Healthcare Corps on April 7th for private healthcare professionals to sign up. As of the 28th of April, an additional 3000 health care professionals had registered [53,54].

Those who show milder symptoms and are on the path of recovery from more severe symptoms of COVID-19 are placed in community care facilities in Singapore. To care for these individuals, Singapore created 10,000 beds in a number of facilities across the country. For those individuals who are recovering well and are healthy at the 14-day mark of the course of COVID-19, they are moved to a community recovery facility to stay where they are then assessed for discharge [54]. Singapore has 2000 recovery beds and will be expanding it to more than 10,000 beds by the end of June [54]. As well as these facilities, Singapore has created swab isolation facilities (totaling 4000 beds) where those who are unable to self-isolate can stay whilst they wait for their test results to come back [54].

Other measures have been taken by the four countries to help facilitate the movement of medical resources, such as the easing of importers licenses for medical protective gear in Singapore [53–55].

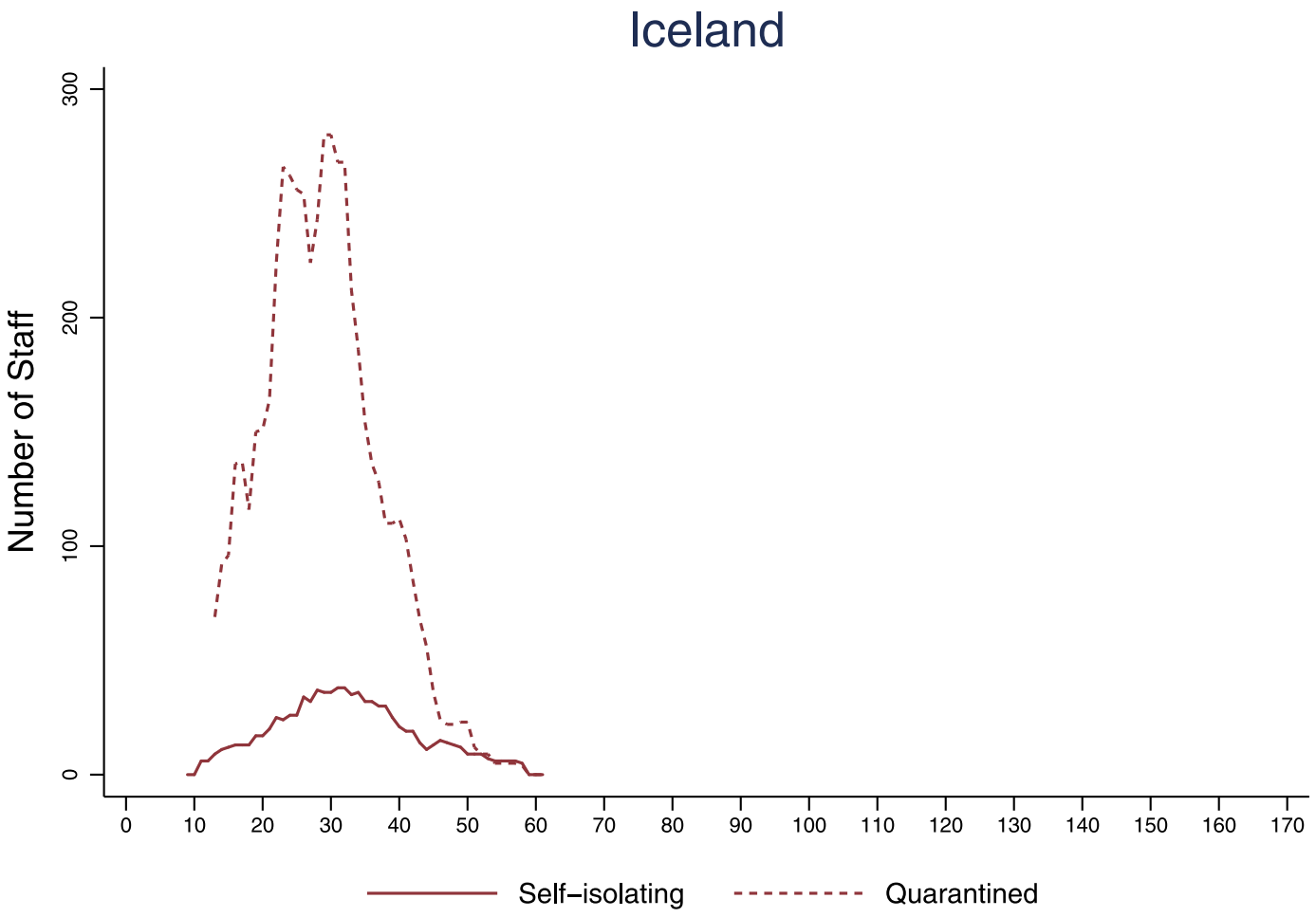

Fig. 8. COVID-19 effects on hospital staff in Iceland.

Economic and financial fluctuation

Fig. 9 demonstrates the performance of main stock market indices in four countries compared to S&P 500 in the United States. Since February 20th, all indices have crashed following US major market indices such as S&P 500. They experienced their lowest price on March 23, soon after WHO declared the emergency state. Greece's ATHEX Composite index has demonstrated the highest drop compared to other four main market indices. Given the health and financial measures introduced by governments, the market indices have started a climb. We observe relatively smooth market movements given the flattening of the epidemic curve following the hard restrictions in the majority of countries. However, market indices in Greece and Singapore have not fully recovered their values before start of the pandemic due to likely fear of second waive in the new cases.

The quarterly and monthly macroeconomic and financial indicators of four countries under study are demonstrated in Fig. 10. Although the majority of these indicators have not been published for the first quarter of 2020 thus missing the onset of the pandemic, we can still observe an extended level of economic contraction in these countries. For example, the economies of Iceland and Greece have shown the largest contraction due to the COVID-19 pandemic, with a decrease of approximately 10% in 2020-Q1 compared to 2019-Q4. Moreover, the exports and imports in New Zealand, Greece, Iceland, and Singapore have dramatically fallen in the first quarter of 2020 due to the restrictions implemented by many countries which has ultimately resulted in a break in the global supply chain.

In addition to fluctuations in the unemployment rate across these countries, we can also observe a decrease in the YoY inflation rate. The local exchange rates per US$ in New Zealand, Greece, Iceland, and Singapore have shown dramatical increase during the lockdown considering the fact that the US$ dollar is perceived safe-haven status as one of the main reserve currencies. The increase in the demand given the high level of uncertainty as well as the significant decline in the oil price are assumed to be the main reason for the depreciation of the four countries' local exchanges compared to US$. However, these exchanges have partially regained their values against US$. Government bond yields, both short-term and long-term, continue to drop by the end of July 2020 due to persistent concerns about the COVID-19.

We can also observe that the consumer confidence indices in these countries have hit their lowest since the beginning of 2019. Similarly, business confidence indices in these countries decreased during the pandemic given the COVID-19 outbreak has brought the economy across the four countries to a standstill. In Fig. 11, we see the impact that the pandemic has had on the retail and tourism industries. Except supermarkets and consumable sectors, the turnover in other sectors has fallen since February 2020. This is explained by the majority of lockdown restrictions being implemented in March. As individuals were prohibited from going out, except for necessary activities, their expenditure on fuel and motor vehicles is reduced compared to the same period last year. Al-

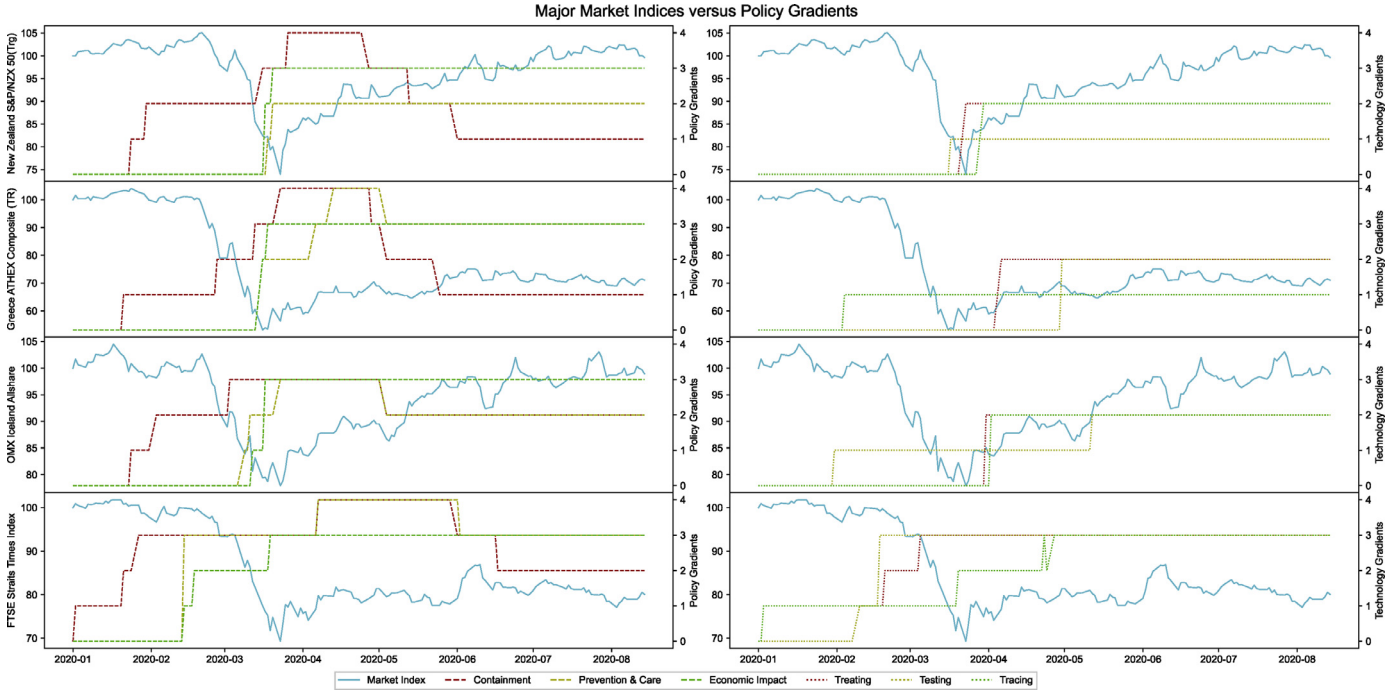

Fig. 9. Main market indices in Greece, Iceland, New Zealand and Singapore.

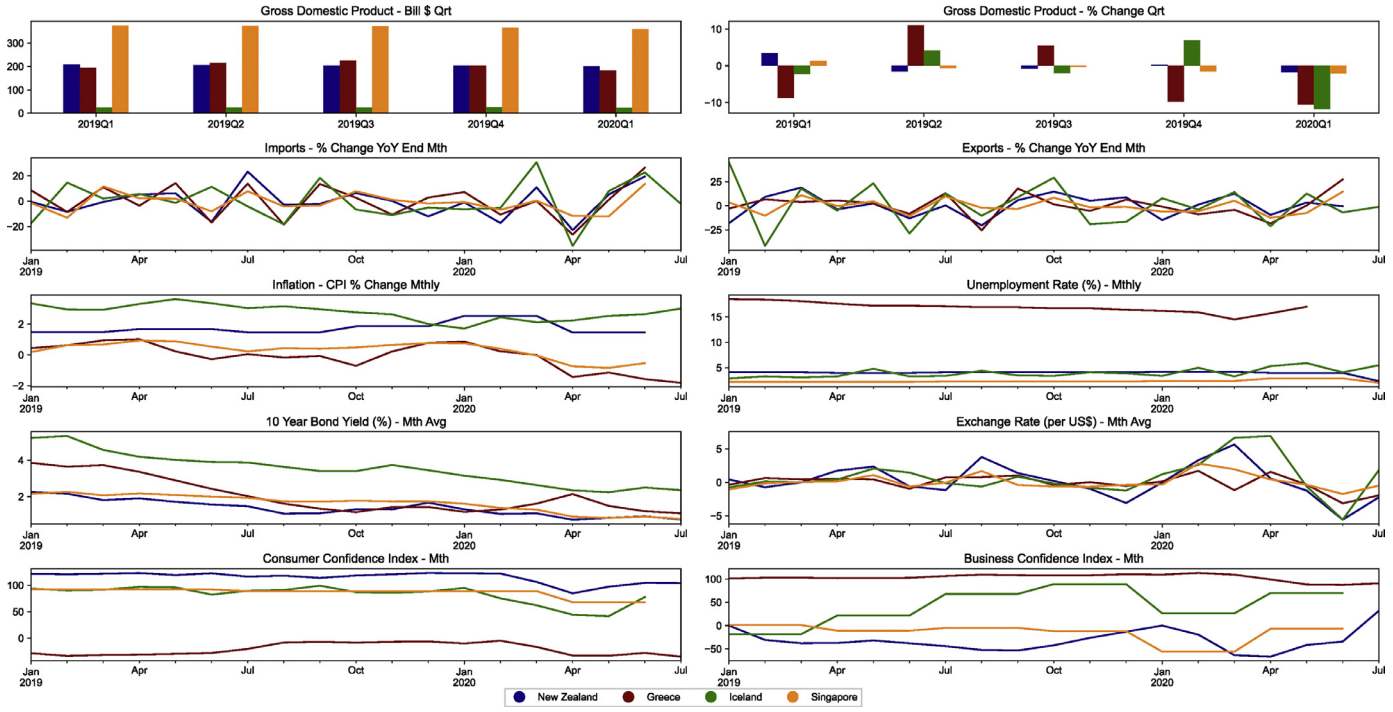

Fig. 10. Macro economic factors of New Zealand, Greece, Iceland, and Singapore during the COVID-19 Pandemic.

though the retail industry has demonstrated signs of normal activity amid the de-escalation of restrictions, it has showed negative YoY% change in majority of categories in Greece. This could be particularly related to the rise in the daily new cases of COVID-19 patients.

When it comes to discretionary spending, it is clear that individuals have reduced their purchases throughout the pandemic as a result of the high level of uncertainty and unemployment rate. Tourism has been heavily impacted by government interventions causing an incredibly low number of foreign visitors, with more than 50% decrease compared to the same period in 2019. Such a drop in a sector clearly indicates there is a need for continuous support for the workers and business in the tourism industry. As a part of this, job keeper and job seeker support packages should be fairly distributed among the hardest hit businesses such as the tourism industry. Fig. 12 demonstrates weekly job seeker support or the cumulative wage subsidy as well as the community activity of New Zealand. Due to the easing in the restrictions, where the majority of businesses have started opening, we see that the subsidies provided by the New Zealand government flatten during May

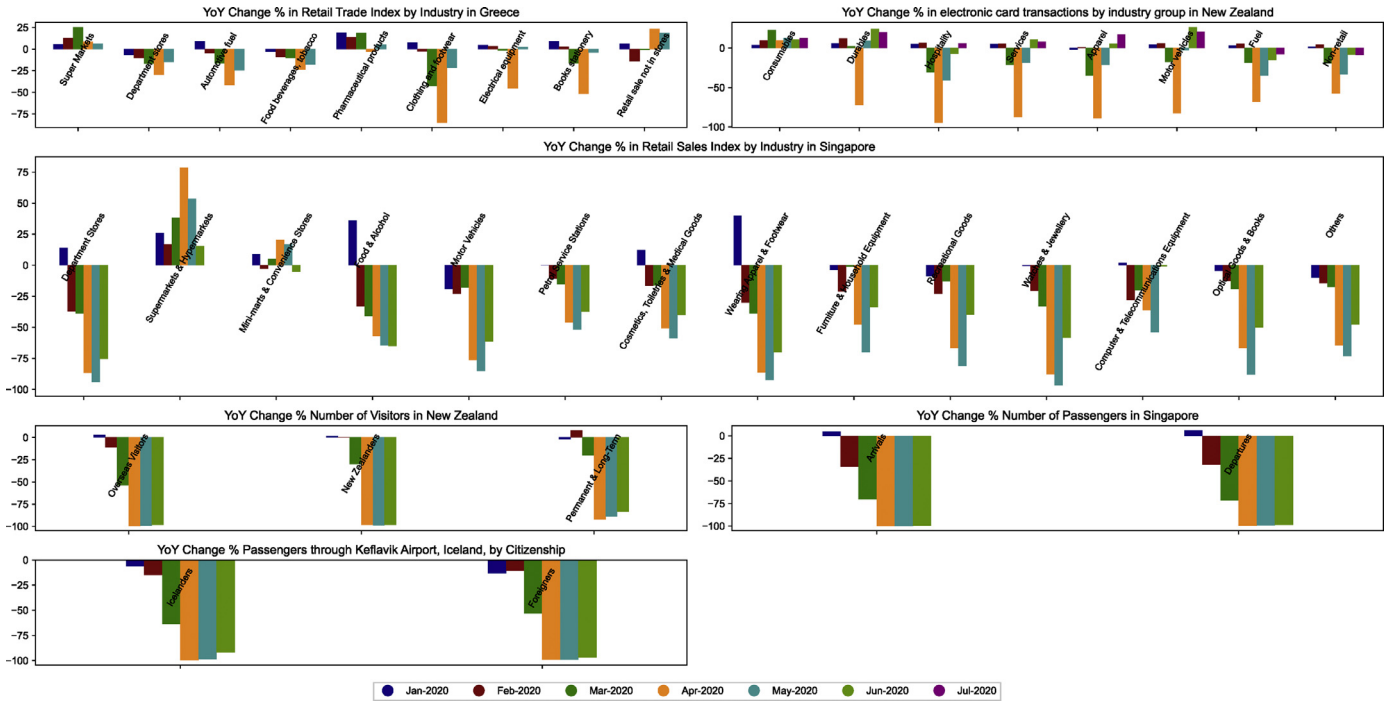

Fig. 11. Economic Impacts of COVID-19 in New Zealand, Greece, Iceland, and Singapore.

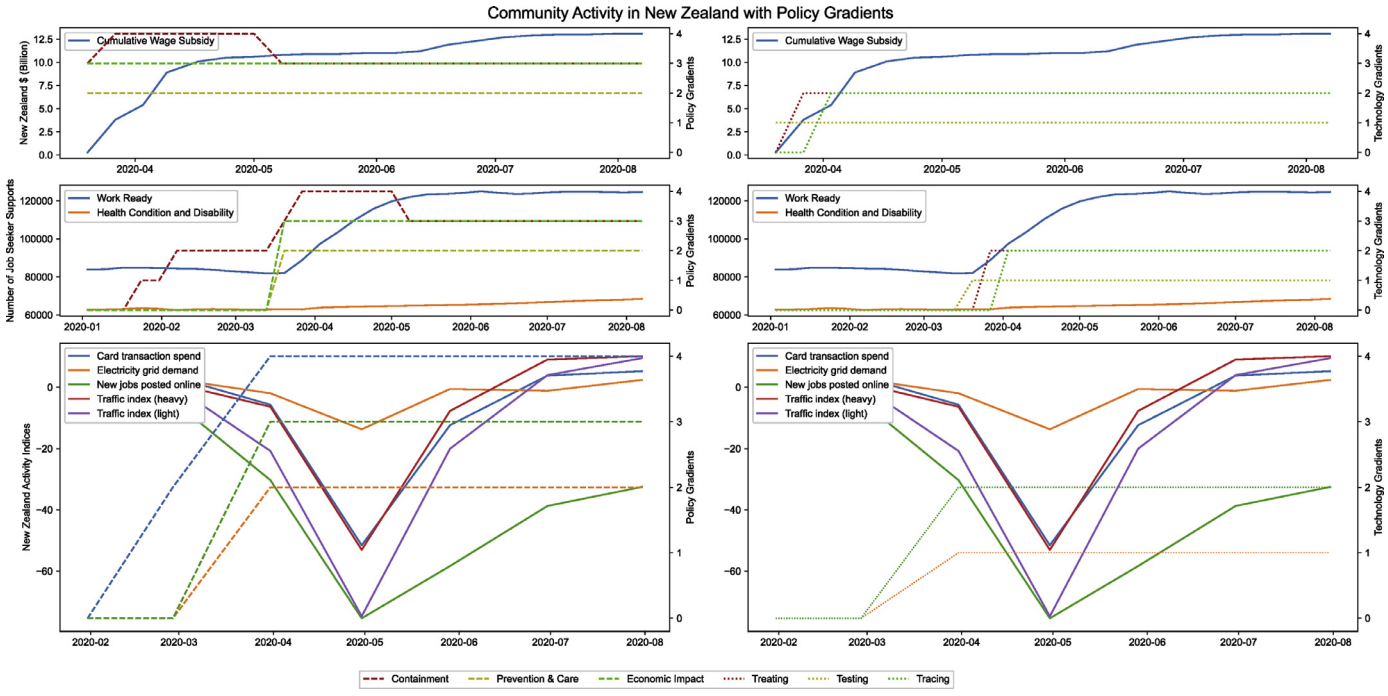

Fig. 12. Job seeker and job keeper fiscal support from New Zealand as well as the community activity.

2020. In addition, we can see that various activity indices, including card transaction spending, electricity grid demand, and traffic indices, have been normal after re-opening the economy.

Discussion and conclusion

This paper presents the COVID-19 situation in four different countries addressing several health, economic, and social aspects thus providing a comprehensive overview up to the 10th of June 2020. Although Greece, Iceland, New Zealand and Singapore have different heterogeneous demographic, and health systems profiles, they were lauded among countries with an effective response to COVID-19 at early stages. One of the reasons for this early success in containing the pandemic might be due to the geographic nature of the four countries. Three of the countries are islands: Iceland, New Zealand, and Singapore, and Greece is a peninsula with a large number of islands. These peculiar geographic profiles have indeed played a role in easier and faster isolation of the four countries and thus, early control of the pandemic. This is especially reflected in the low number of total cases, new cases, total deaths, and daily deaths in the four countries at early stages of the pandemic.

The only noticeable exception is in Singapore where the curve of the total positive cases showed an exponential pattern from day 80 onwards. This is due to the outbreaks in the country's migrant dormitories, which are densely populated and difficult to socially distance in. In addition, Greece has seen a steady although small increase in numbers which may be due to the increase in testing and a more widespread testing strategy. Iceland also announced plans to implement nationwide testing which is easier to implement in Iceland due to the small population number.

The four countries maintained a low case fatality ratio (CFR) with Singapore having the lowest CFR of 0.09%. It is noticeable how Singapore has the lowest CFR and the lowest deaths per 100,000 regardless of the fact that it has the least health expenditure as percentage of GDP. This might be primarily attributed to the readiness of the health system for such events based on the experience with previous pandemics like SARS and H1N1. Additionally, this low CFR could be attributed to early intervention by the Singaporean government. As shown in Fig. 6, Singapore initiated its response 21 days prior to the detection of the first positive case; the response included advice for Wuhan-bound travels and a temperature check in sea checkpoints and airports.

Greece has the highest CFR with 5.30% but compared to other European Mediterranean countries such as Italy, Spain, France, and Turkey, the Greek CFR remains relatively lower. Compared to the four countries, the high CFR could reflect the high old age dependency as shown in Table 1 and could also reflect the fact that the positive cases are higher in older age groups compared to the other three countries as shown in Fig. 5. Additionally, the high CFR in Greece could be related to the testing strategy, which focuses on severe cases. Iceland has the highest number of deaths per 100,000 populations among the four countries and this is mainly due to the small population number and the fact that the number of confirmed cases is concentrated in the younger age groups as shown in Fig. 5.

The mitigation policy interventions as shown in Table 3 and Figs. 8–11, show that the early policy interventions as seen in Singapore and the strict early policies as seen in Greece, Iceland and New Zealand might also be correlated to the relative low number of positive cases and deceased cases at early stage of COVID-19. This is also reflected in the low number of hospitalizations and ICU admissions in the four countries in Fig. 4. This indicates that the health systems of the respective countries managed to absorb the influx of new cases without reaching full capacity/saturation.

Health technology tools used by the four countries have been used as health promotion tools to promote COVID-19 literacy; to keep the public updated with the daily status; and to promote essential healthy habits to mitigate the spread of the pandemic. Additionally, the health technology policy applications played a role in tracking positive cases and their contacts in the four countries, which proved useful in early detection of new cases, isolation, prevention of further infections. The tracking technology might also have played a role in the surge, which Singapore experienced since day 80 as the implementation of the tracking application in day 58 might have widened the scope of testing and therefore resulted in the detection of a large number of cases.

In addition to the pandemic's impacts on health systems, the economic and financial impact in the four countries is ostensible. Several measures and policies implemented by the four countries along with their economic and fiscal responses in order to contain the pandemic. The economic and fiscal measures implemented by the four countries resulted in immediate relief for relevant stakeholders however, the assessment of the full effect will need a longer time period to observe amidst the COVID-19-related economic hardships. Despite all economic and fiscal support packages provided by these countries, we can observe that the major market indices have recently started moving smoothly across four countries. However, we see a significant drop in exports and imports by the four countries that signals the break in the global supply chain. If this continuously happens, we will ultimately see the increase in unemployment and inflation rates and GDP will collapse.

The COVID-19 pandemic has also hit the consumer and business confidence indices, thus, neither consumers nor businesses feel safe during such a tough period. Due to the high level of uncertainty amid the COVID-19 pandemic, the local exchanges have depreciated compared to the US$ dollar, which can be related to the boost in the demand for US$ given its safe-haven status. On the other hand, short- and long-term government bond yields have hit their lowest in spite of their lower risk compared to other securities such as equity stocks. However, these countries hope to recover the damage by providing continuous support and implementing existing policies. These measures will get employees back to their jobs, guarantee their wages and salaries, and boost the economy.

Important lessons can be learned from the management of the COVID-19 pandemic in the four countries. Firstly, building upon previous experience and capacity to respond to future pandemics as shown in the Singaporean experience. Secondly, the early and strict policy interventions to combat the spread of the pandemic within borders as seen in the Greek and New Zealand case. Thirdly, the proactive and responsive policy intervention since day one of the infection globally as seen in Singapore. Fourthly, the evolution of the testing strategy to a nationwide approach to detect cases at an earlier stage and prevent serious complications. Regardless of the differences in the demographic, epidemiological, health system profile, some of these lessons can be applied even in countries with larger borders, bigger populations, or less stable economy. As the four countries have unfolded their exit strategy to the new normal, ongoing/future research should observe the developments and the indicators for a potential second wave and the concurrent health system and economy performance.

Acknowledgement

The authors would like to acknowledge Tom Walley and Thomas Otten for their remarks on the paper and Emmanouil Mentzakis for his support with translation.

Author Statements

Funding

No funding received for the development of this research.

Declaration of Competing Interest

No conflict of interest to declare.

Ethical approval

No ethical approval required for this research.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.hlpt.2020.08.015.

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