The Efficacy of Long-Term Elimination Efforts: A Case Study on New Zealand's SARS CoV-2 Assessment and Response

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Abstract

First detected in Wuhan, China as of late December 2019, the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) spread globally, prompting for international agents to revise their existing pandemic response plans. Whereas each country followed different paths to potential recovery, two main courses of action affected the efficacy of their response: short-term versus long-term sustainment of mitigation, documentation, and treatment efforts. This raised serious questions about the importance of early intervention and continuous monitoring for a country's return to normalcy after the coronavirus disease 2019 (COVID-19). To address this, we assessed New Zealand's trajectory from the months of early March to the present moment, late August 2020, and the effectiveness of its elimination strategy on the epidemiological spread of the disease, availability of hospital resources, societal and economic standing, and future medicinal/vaccination treatments. Specifically, New Zealand (NZ) reported their first case of COVID-19 on February 28th when a woman in her 60s entered the country after having travelled to Iran. That first infection eventually led to a total of 1,727 confirmed and probable cases, 1,568 recovered cases, and only 22 deaths. Key to their relative success was implementing a national Alert Level 4 lockdown and closing all borders to foreign travelers early on when they only had 205 cases. Testing was, and continues to be, one of their most utilized tools, with over 730,330 total tests being reported and therefore used to develop targeted strategies for halting widespread infection. This remains consistent with New Zealand's overall framework for elimination, in which they outlined their primary aims to be (1) remove all chains of transmission in New Zealand and (2) prevent the emergence of new transmission chains originating from cases that arrive from outside the country. While their plan left no room for complacency, it also took a significant toll on the economy, having it contract by 1.3% as their GDP fell by 7.2%, their national debt increased to 30.2%, and unemployment rates rose to 9.2%. Throughout it all, though, NZ stayed focused on treating emerging cases with medical (ventilators) and medicinal (antivirals and anti-inflammatories) options, as well as contributing to the global initiative of vaccine development that would aid in the long-term elimination of COVID-19 – a goal New Zealand sought out ever since its first cases.

Keywords: COVID-19, New Zealand, elimination, long-term, lockdown, global, spread

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Coronavirus disease 2019 (COVID-19) took the world by surprise despite of the looming threats an easily transmissible, potentially deadly viral infection posed for years on end to the scientific community. Their growing concerns had always been a matter of not if, but *when*, the next pandemic would strike harder than the last – COVID-19's emergence answered that. First reported in Wuhan, China on December 31, 2019, and later recognized as a pandemic by the World Health Organization on March 11, 2020, COVID-19 managed to evade local, national, and international agents in their fight against the spread of SARS-CoV-2 infections. As of

August 23, 2020, there have been over 23 million cases and 800,000 deaths across more than 188 countries [1], [2]. Yet, this is not the first time the world is hit by a coronavirus outbreak.

Going back as far as 2002, southern China became the first to experience one of the deadlier strains of coronavirus that strayed off from its milder manifestation as a common cold: *Severe Acute Respiratory Syndrome* (SARS). This zoonotic virus is believed to have spread from a supposed horseshoe bat reservoir to civet cats and eventually humans who came in contact with the mutated version. SARS-CoV then went on to affect 26 countries and totaled more than 8,000 cases and 774 deaths [3]. A decade later, another epidemic came about that resulted in the identification of a new type of coronavirus: MERS-CoV. Even though it originated in Saudi Arabia in 2012 after being transmitted from, yet again, horseshoe bats to an intermediate host (dromedary camels), *Middle East Respiratory Syndrome* (MERS) continues to affect society occasionally as new cases, and sometimes even serious outbreaks such as those in South Korea in 2015 and again in Saudi Arabia in 2018, are discovered every year [4].

Culminating in the present moment is the most recent strain of coronavirus that has completely redefined society's view of modern pandemics; without a doubt, SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) is a force to be reckoned with that perturbs scientists, medical professionals, government officials, and the general public alike. Each country that has been impacted by the arrival of COVID-19 into their borders has had to reevaluate their infrastructure, communication lines between leaders, allocation of resources, economic budget, and much more in respect to pandemic preparedness. The changes that have ensued and the policies that have been implemented are all indicative of the outlook of future management of public health crises at a global level. Comparing the implications of such actions pursued by first-world countries has thus been a point of focus for researchers hoping to uncover the hidden link that ties all successful responses to COVID-19 together. Whereas experts have reached a consensus on the effectiveness of proactive government efforts in recognizing the pandemic's threat early on and acting accordingly, specific factors that guide their individual handling of COVID-19 require further analysis.

Henceforth, we took this opportunity to review a country whose experience with COVID-19 has served as model for other regions of the world to follow in suit of: New Zealand. Albeit their geographic disposition as an island gave them a head start in controlling entry into and out of the country, all the while their general low population density further limited possible chains of transmission within the community, New Zealand's success is attributed to more than just these innate advantages [5]. Noting previous research's suggestion of a relevant correlation between low/no transmission of SARS-CoV-2 and sustained mitigation, this case study will closely examine the efficacy of long-term elimination efforts in handling COVID-19's various facets: infection, restrictions on hospital resources, predictive trends, economic downturn, social upheaval, and treatment options.

Infection and Fatality Rates

(Katherine Estrada)

The coexistence of humans and non-domesticated animal species, especially bats, has continuously contributed to global pandemics. Notably, bat virus spillovers have become increasingly common as humanity gradually takes over the natural habitats of animals, industrializing sites that are known to house large populations of wildlife. While there might be a limited understanding of the biology of bats, it is widely known that their bodies are susceptible to a multitude of DNA and RNA viruses, which can be hosted by bats without them developing symptoms due to evolutionary adaptations (like flight) and acquired immunity. However, the chain of transmission from an animal host to a human body is more complex than initially assumed.

Based on the observation of previous zoonotic viruses, scientists have been able to discern a highly probable origin of infection: spatial and temporal pulses of virus shedding [6]. The viral shedding originates from consistently infected bats that are releasing the virus from their bodies (episodic shedding) or the bat-to-bat transmission of the virus between their own population (transient epidemics). In order for the pathogen to spread, virions must survive outside the reservoir host and be of sufficient quantity to infect other organisms. Instead of being passed on directly to a human, most zoonotic viruses, such as MERS or SARS, hijack an intermediate host's system where the virus undergoes further mutations that enable for it to later inhabit and infect human bodies. Expectedly, this was the case for the current SARS-CoV-2 virus; after its genome was sequenced, it was discovered that the virus had a 96.2% match with the BatCoV RaTG13 virus strain found in horseshoe bats (*Rhinolophus yunnanensis*). This confirmed the existence of an intermediate host that had to have come in contact with the virus from horseshoe bats before entering the human population [7]. Following this discovery, scientists struggled to find the "perfect" intermediate host, testing animals that ranged from snakes to birds to pangolins. Whereas many news outlets claimed that the pangolin was as close as a 99% match to the SARS-CoV-2 virus, evidence shows that the actual result is an 85.5% to 92.4% similarity in genomes, with a notable match of 97.4% in the amino acid sequence of the S protein [8]. Given these details, it remains crucial for the global scientific community to continue in its search for an exact match as it might hold the key to preventing future community spread of SARS-CoV-2 and enhance our understanding of the continuous evolution of zoonotic viruses.

Initial Transmission of SARS-CoV-2 and the Infection Processes

Viruses that originate in bats can be passed on from an intermediate host to humans via contact with animal feces or raw infected meat. Once the virus infects humans, symptoms begin to take effect shortly after. While the source of contamination wherein humans first came in contact with the SARS-CoV-2 virus through an intermediate host remains uncertain, it is believed that the first infections occurred around late November of 2019, which allowed for a two-week incubation period to set in before symptoms started to show. Specifically, the Hunan Wholesale Seafood Market in Wuhan City is the place linked to a large portion of the first cases that appeared in China, with this location either being the origin of contamination or where infected hosts started spreading the virus to others.

From human to human, the virus is expelled from the infected host when they cough or speak, producing droplets that can enter the respiratory system of another individual and travel to the lungs. Here, it binds with the ACE2 receptors in the lower respiratory tract cells, a process in and of itself which is facilitated by the virus' S protein. While SARS-CoV-2 can also travel to the heart, kidneys, and gastrointestinal tract that have ACE2, it commonly enters and attacks the respiratory system first. Once the viral membrane and host cell fuse, the ACE2 will be cleared and the host's own S protein will be activated. The activation of the S protein is what allows for the virus to enter the host cells and release its genomic material, mRNA, into the cytoplasm. Using the host cell's ribosomes, the mRNA is translated into specific M, S, and E protein molecules. These are then insulated in the endoplasmic reticulum and moved to the endoplasmic reticulum-Golgi intermediate compartment (ERGIC) [9]. The mRNA strand is replicated using RNA-dependent RNA polymerase. This replicated genome program enters the N protein and moves to the ERGIC to meet with the other proteins and form virus particles that are ready to be expelled from the body.

The Immune System's Role in Fighting COVID-19

After the incubation period, the body becomes aware of the virus and immediately attempts to fight against it by activating its immune system. Using the receptors of antigen presenting cells (APC), the body identifies an infection's location by recognizing any component that makes up the virus. This then activates proinflammatory proteins as a first line of defense; the body activates T cells that attack and kill CoV-infected cells, as well as produces antibodies, generally IgM and IgG, which have their own pattern response. However, based on the age of a patient and their overall lifestyle, their body might not have an effective enough immune system to combat a pending virus. In fact, some individuals have delayed or weak responses to the virus, releasing their IgM and IgG later than needed which could essentially make the infection worse on their bodies [10], while others might not even show any symptoms of infection but still continue to spread it as their bodies replicate the viral genome. Due to this, it is difficult to control the virus since not all patients seek testing at the start of infection.

COVID-19's Global Manifestation – New Zealand's Comparative Standing

Currently, there are 23 million cases of diagnosed coronavirus in the world, but there could potentially be more individuals who have the virus without being aware of it. Take for instance the first cases in Wuhan – no one could have imagined that their symptoms would lead to the present situations, with some not even conscious of the fact that they were carriers of such an infectious virus. Due to this false perception of health and miscommunication within communities about the threatening virus, some individuals continued to travel around the world and hence prompted the beginnings of a worldwide pandemic. This remains true for all countries, including New Zealand, whose first case was reported on February 28th when a woman in her 60s entered the country after traveling to Iran. That single case has led to over 1,727 patients contracting COVID-19; what differentiates New Zealand from the rest of the world, though, is their effective response to initial cases, which ultimately resulted in 1,568 recovered patients and only 22 deaths. It was their strict government policies aimed at eliminating the epidemic, coupled with their medical facilities' management of the crisis, that has contributed a fatality rate as low as 1.3%.

Now, considering their newly found cases after months of being COVID-free, the reproduction ratio (R) is estimated to be 1.07, while their rate of growth is about 0.02 [11]. Aware of the fact that from the moment the virus enters an individual, it will take anywhere between 3-10 days for the symptoms to begin showing, New Zealand encourages and enforces that everyone stays home and only leave under necessary pretenses. Although the exact incubation period has yet to be confirmed, scientists have found the median to be 7.76 days and the mean to be 8.29 days [12], further underscoring the urgency of quarantine and contact tracing in combination with increased community testing.

Hospital Resources and Future Models

(Eddy Dominguez)

With the availability of better testing procedures and an improved medical response to the virus, New Zealand began investing in hospital resources in February of 2020, an entire month and a half prior to the global response efforts that took place in the first half of March. This acclimated response accounted for the inevitable influx of patients from the possible influenza-like pandemic, which allowed the country's medical professionals to brace themselves for the worst, all the while enabling for a majority of their hospitals to place maximum priority onto COVID-19 positive patients during the Alert 4 lockdown that took effect on March 25th. According to the official New Zealand Ministry of Health, at Alert Level 3, many non-urgent and non-elective services are deferred, check-ups are only allowed over the phone, and visitors that have tested negative for COVID-19 can only come in one at a time to visit infected patients[13]. At this level, though, most essential services, such as treatment for long-term illnesses and breast cancer screenings, are kept open, whereas when moving up to an Alert Level 4 lockdown, services in hospitals are strictly focused on COVID-19, with more emphasis being placed on testing and tracing clusters of possible COVID-19 suspects through the NZ COVID Tracer app and intense hospital surveillance. This huge shift in prioritization based on their alert system, as well as the enforcement of strict quarantine for any potential patients and relatives the infected patients could have come in contact with, allowed New Zealand hospitals to manage the initial rise of COVID-19 patients in each district comparatively better than other countries. As a matter of fact, NZ drafted an official COVID-19 Surveillance Plan that called for hospitals to play a bigger role in case detection and management; medical professionals were encouraged to investigate any influenza and acute respiratory infections as potential COVID-19 cases and were able to explore the patient's activity and behavior from there [14]. Their government was thus able to effectively track potential clusters of infection and individuals at risk in such a manner that New Zealand's elimination tactic was able to strike at the root of the pandemic and, as Prime Minister Jacinda Ardern said, "go early and go hard".

Limitations and Advantages of New Zealand's Surveillance Program

Certain issues have arisen from the COVID-19 elimination effort as seen on August 22nd when the official New Zealand Facebook recommended checking up with doctors regardless of whether or not symptoms were related to COVID-19, to which individuals commented having issues with their District Health Boards running out of funds or deferring doctor checkups [15]. Despite that, New Zealand's vigorous application of lockdown and surveillance proved to be useful, with the Institute for Health Metrics and Evaluation's prediction models showing the majority of resources (beds, ventilators, ICU occupancy, etc.) available, while O'Sullivan et al,'s SEPIR (Susceptible, Exposed, Pre-symptomatic, Infected, and Recovered) models demonstrated relative infectiousness being not only flattened, but almost stomped out to zero [16], [17]. Going of that, from the available 2,905 total beds and 65 ICU beds, New Zealand only used around 30 beds, nine of which were in the ICU, and required eight invasive ventilators at the peak of their pandemic. That is only 0.73 beds per 100,000 people (1% capacity), and 0.21 ICU beds per 100,000 people (13.8% capacity). By comparison, Denmark, another first world country with a comparable population, required, at its peak infection ,116 ICU beds (which was 14 more than they had available) and 108-109 invasive ventilators [18].

Impact of Sustained Testing Approach to COVID-19

New Zealand's success in essentially eradicating the COVID-19 threat can also be attributed to their stringent COVID-19 testing effort. According to "New Zealand's national testing strategy for COVID-19 for June to August 2020", their plan to streamline and improve the efficiency of testing included three main parts [19], with an additional fourth component. Part 1 included testing individuals in "primary/secondary care with relevant symptoms," allowing hospitals to allocate testing for individuals exhibiting the aforementioned symptoms under their surveillance. In Part 2, any individuals who tested positive for COVID-19 would be added to official records and then traced (through the NZ COVID-19 app or other official records) until the source of their infection was found. Then, close contacts would be informed and tested, sometimes even re-tested if necessary, to prevent the further spread of COVID-19. After huge spikes in cases were settled, Part 3 occurred, wherein testing became less frequent, while surveillance systems continued to monitor the conditions of individuals by using all of the data collected to create predictions and models. Lastly, Part 4 directed efforts to border testing, from individuals in managed isolation/quarantine to international airport staff. With proper implementation and long-term enforcement, these steps have permitted New Zealand to break down the testing process into priorities and organized procedures, all of which emphasize domestic testing and allocation before handling border evaluations.

At the end of the day, testing remains one of the most utilized tools at New Zealand's disposal, with 730,330 total tests being administered from March to August and up to 26,000 tests being performed a day [20]. In fact, the testing is so well documented that all confirmed and probable cases are on the official NZ Ministry of Health website, along with any possible clusters that could indicate more cases and tests being required, are updated every day at around 1:00 P.M. This organized and focused application of COVID-19 testing allows health officials to develop targeted strategies centered on further deterring widespread infection – an objective which is supported with future models indicating around 0.36 infections per day, 0.01 deaths per day, and almost 99% available hospital resources [16].

Mitigation Efforts

(Massiel Morell)

The theme of "long-term" suppression that has consistently evidenced itself in New Zealand's quantitative analysis of infection and fatality rates, as well as the country's testing and surveillance strategies, epitomizes the guiding principles of New Zealand's COVID-19 mitigation efforts. Behind the country's success in having a total of 1,727 confirmed and probable cases, 1,568 recovered cases, and only 22 deaths [20], lies the government's pandemic response plan that adapted to the global environment it was exposed to – whereas mitigation was the first course of action considered from January to February, a comprehensive re-evaluation of other countries' failures with "flattening the curve," prompted the development, and thereby the effective implementation, of an elimination public health strategy that was officially issued on March 23rd, 2020 [21]. The elimination plan called on four pillars (border control, case detection and surveillance, contact tracing and quarantine, and community support of control measures), in adherence with two principles (equity and wellbeing), to guide New Zealand's targeted response to the global health crisis [22].

Elimination on the Spectrum of Mitigation versus Suppression

In terms of pandemic planning, there existed five possible routes for New Zealand to take during the pandemic's early stages: exclusion, elimination, suppression, mitigation, or no-intervention [23]. However, this paper will focus on the three main strategies that allow for an in-depth, comparative analysis of the country's response efficacy and risk management: elimination, suppression, and mitigation. Adhering to the Harvard Global Health Institute's Key Metrics for COVID Suppression, *mitigation* is defined by a "reduction in the rate of R (the reproduction number of the virus) through diagnostic testing and contact tracing", while *suppression* is viewed as an attempt to "get to zero or near zero case incidence [24]." Mitigation strives to minimize a pandemic's peak, increasing the response as the pandemic progresses, whereas suppression aims to keep the number of cases at a minimum for as long as possible, hoping to delay the pandemic instead of preventing it. The distinction between both comes down to the intensity of implementation, the hierarchy of controls, and the end results; a mitigation model gradually adjusts to an epidemic by slowing down transmission in order to avoid reaching a country or region's full-capacity of hospital resources and hopes to establish herd immunity throughout that process, as opposed to the suppression strategy, which, from the start, works to lower the epidemic spread to a reproduction number (R) < 1 until effective vaccines are available [25]. Albeit the appropriateness of each strategy in managing COVID-19 is ultimately determined on a case-by-case basis depending on the political climate, economic standing, and social environment of a nation, in terms of first-world countries like New Zealand and the United States, reports, such as Ferguson et al.'s on the impact of "non-pharmaceutical interventions (NPIs)", come to the conclusion that mitigation alone is not suitable for handling healthcare demands [26]; with time, hospital systems are predicted to become overwhelmed to the point where the herd immunity that is acquired by avoiding the termination of all chains of transmission in a community is not enough to counteract the exponential rise of cases. Our paper thus follows the assumption that, whenever possible, a country's preferred plan should be suppression over mitigation.

Yet, while Ferguson et al. concedes to evidence being in favor of suppression models' effectiveness over that of mitigation models, it is New Zealand's elimination, "keep it out, find it and stamp it out" campaign that takes the lead when considering long-term versus short-term goals and enforcement. As Baker et al. puts it, an elimination strategy provides a "medium-term exit path" for return to domestic economic activity without the constraints of a circulating SARS-CoV-2 virus [21]. Where suppression's success relies on how long one can uphold measures before restrictions are gradually lifted and a second wave hits, elimination leaves no room for such relaxation of intervention methods and strictly abides by instated protocols until all chains of transmission within a country are "eradicated". In fact, *elimination* is delineated as the "eradication of an infectious disease at a country or regional level [27]." Therefore, without the absolute, confirmed absence of COVID-19, the elimination tactic indefinitely enforces a country's protocol of containment until there is no detectable community transmission. The difference between suppression and elimination ends up coming down to the timing and duration with which the same measures (contact tracing, identification and isolation of cases, testing and quarantine, social distancing orders, and border control) are applied – elimination perceives long-term sustainment of intervention as necessary to stop the epidemic, while suppression suffices with enough intervention to be relatively "safe" but still have ongoing cases. Notably, suppression's repetitive cycle of on-off intervention that depends on the availability of a vaccine to declare a country COVID-free is broken by a carefully coordinated elimination plan such as New Zealand's; the uncertainty of when and how a country will come out of the epidemic and not worry about further infection is removed from the equation by the elimination strategy's linear path to success, which clearly implements certain procedures and policies that are carried out until the entire domestic front of a country has no new SARS-CoV-2 virus infections (excluding infections detected in incoming travelers) for at least 28 days (twice the maximum 14 day incubation period) [28]. With this in mind, even though critics question the sustainability of elimination in countries larger and not as geographically advantaged as New Zealand, the reality of the matter is that the stability New Zealand has managed to present in the face of COVID-19 while securing the protection of the general public serves as a model for other countries' future developments in public health infrastructure, resource allocations, and open communication networks.

Breakdown of New Zealand's Elimination Plan

Specifically, New Zealand drafted its COVID-19 response plan with two guiding principles in mind: equity and wellbeing. The government acknowledged the pre-existing and future health inequities that could be exacerbated by the pandemic within the Māori and Pacific populations, those that have access to fewer socioeconomic resources, and other subpopulations based on "age group, gender, migration and labor-force status, the presence of underlying chronic health conditions, and disability." The disparities that could exist within the healthcare system were thus noted as a goal that the equity principle behind all COVID-19 control measures and mitigation responses should address; equitable access to the "determinants of health, healthcare, and the quality of care received" were weighted heavily throughout the process of evaluating, measuring, and monitoring the progression of the epidemic, all the while the plan's "wellbeing principle" focused on maximizing health benefits and minimizing health risks [29].

As such, with the founding values of their elimination efforts laid out, New Zealand proceeded to adopt the following methods of intervention: border control; disease surveillance; physical distancing and hygiene measures/cough etiquette; testing for and tracing all potential cases; isolating and quarantining cases and their close contacts; and broader public health controls depending on the alert level the country/region was in [22]. Each of these protocols are designed to be implemented in varying degrees of strictness with the hopes of achieving the elimination tactic's two primary objectives: removing all chains of transmission in New Zealand and preventing the emergence of new transmission chains originating from cases that arrive from outside the country. For instance, in accordance with the second aim, major emphasis is placed on border management in order to *keep the virus out*. Such has been the case since March 19th, 2020, with the risk of importing COVID-19 cases into New Zealand being drastically reduced by maintaining borders closed to all foreigners (the exceptions being critical health workers and partners or dependent children of New Zealand citizens/residents who originally reside in NZ, have a visitor/work/student visa, or are travelling with the NZ citizen/resident) [30]. On top of that, further border measures continue to mandate that arrival to the country be met with at least 14 days of "managed isolation or quarantine" and COVID-19 tests [31].

Finding the virus is the next step in New Zealand's elimination agenda. This has been accomplished to date via highly active case detection, which includes a large-scale surveillance and testing regime comprised of sentinel testing (random testing within communities, especially those disproportionately affected by COVID-19), targeted population-based testing, seroprevalence surveys (serology tests used to estimate percentage of population with antibodies against SARS-CoV-2), and even genome sequencing. As a matter of fact, it is with genome sequencing that experts have been able to model the decrease in the effective reproductive number (R_e) of New Zealand's largest cluster from 7 at the beginning of the outbreak to 0.2 by the end of March [32]. Whereas this acquired data stems from surveillance strategies, its implications give way to an assessment of the efficacy of the third pillar in New Zealand's elimination goals: contact tracing and quarantine in order to *stamp out the virus*. As the Ministry of Health outlines, the country's designation of successful contact tracing refers to "80 percent of contacts of a positive COVID-19 patient being traced and quarantined within four days of exposure to the case." As of early August, this has proved extremely effective in limiting transmissions, with genomic epidemiology revealing that only 19% of virus introductions into New Zealand resulted in a transmission lineage of more than one additional case.

Complimenting this successful standard of tracing is New Zealand's fourth and final pillar in eliminating COVID-19: continuous community support of control measures. This final guideline manifests itself in the country's 4-Level Alert System, which serves to outlines specific public health and social measures that must be taken during different periods of COVID-19 risk and containment. Essentially, the alert levels escalate as follows: Level 1 – Prepare (disease is contained), Level 2 – Reduce (disease is contained, but the risk of community transmission remains), Level 3 – Restrict (high risk the disease is not contained), and Level 4 – Lockdown (likely the disease is not contained). In addition to the "voluntary" use of PPE, physical distancing, and good hygiene, depending on the state the country finds itself in, one can expect to experience varying degrees of restrictions, ranging from no limitations on personal movement, gatherings, and workplaces to the cancellation and closing of all gatherings/public venues, travel, businesses, and educational facilities [33]. While New Zealand transitioned from a level 4 lockdown in late March to a level 1 maintenance alert in early June and back to a level 2 (with the exception of the Auckland region at an alert level 3) in early August, one thing that has remained constant throughout is the country's all-encompassing commitment to long-term elimination efforts; complacency has not set in once, with ongoing public support for these measures being maintained via clear communication and community building initiatives that help underscore the importance of consistency in New Zealand's targeted elimination plan.

Societal and Economic Impacts

(Dalilah Montesino)

As with all unprecedented emergencies, the COVID-19 pandemic has unearthed the stark socioeconomic inequalities that existed even in reasonably developed nations. The working class, disproportionately represented by communities of color, has borne the brunt of the risk of infection, yet has been less likely to have accessible healthcare infrastructure. To prevent further spread, New Zealand's government did not hesitate to shut down economic activities and implement contact tracing. Although these measures have proved to be highly successful in preventing casualties, dissenters argue that such restrictions cross the boundaries of civil liberties. The nation's plan of action has demonstrated an emphasis on *collectivism* – sacrificing individual rights for the greater good. In contrast, *individualist* cultures, most notably the United States, have adamantly resisted quarantine orders and contact tracing, claiming that such government measures would violate constitutional rights to life, liberty, and the pursuit of happiness. The prioritization of the self at the expense of the greater good has thus led to countless preventable fatalities and has inevitably prolonged the duration of the pandemic.

COVID-19 Trajectory for New Zealand and its Economic Implications

On March 25, 2020, New Zealand declared a state of emergency, moving to Alert Level 4 restrictions after local transmission of the virus was identified, which followed the closure of all borders to non-residents on March 19th. Upon the start of the lockdown, government officials promptly executed severe measures to contain the spread of infection by eliminating all non-essential businesses, dropping all occasions and mass get-togethers, closing schools, and restricting discretionary domestic air travel. As a result, the populace has had to quarantine in the safety of their homes, impeding social interactions. While this has led to increased technological usage amongst citizens of all age groups in order to connect with friends and family through virtual interfaces, as can be expected, the nation's economy also took a turn for the worst.

Particularly, according to the updated IMF fiscal forecasts, the country's economy contracted by 1.3 percent in the first quarter of 2020, with high-frequency indicators further highlighting more extreme withdrawal in the second quarter; the economy is expected to continue to fall by -7.2 percent for the remainder of 2020 until 2021 (which, by then, should start to pick up by 5.9 percent) [34]. Further economic devastation presented itself in the -0.1 percent decrease in the 2020 government balance, as well as the 30.2 projected percent increase of the country's national debt.

Amidst all this, there was, and continues to be, an evident trade-off between eliminating all chains of transmission and maintaining a stable economy; striking a balance between the two in order to guarantee both the public's safety and an eventual return to normalcy where daily lives can be resumed without monetary/social restrictions was hence a goal for New Zealand. This was gradually taken on as the country transitioned from a national lockdown to an Alert Level 1 on June 8th, 2020. Throughout the months of April and May, the nation reopened, moving from an Alert Level 3 (April 28) to an Alert Level 2 (May 13). By May 18th, schools had fully reopened, while bars followed suit on May 21st. What remained the same, however, was the closure of the border to all foreigners, as well as the required 14-day isolation/quarantined state of residents upon entry.

In addition to the lifting of certain restrictions, the government also strove to provide equitable aid to affected individuals – something they managed to do with the fiscal year 2020-21 budget and previous fiscal packages that amounted to a total of NZ$62.1 billion (21.3 percent of GDP) through fiscal year 2023-24. Of these measures, around NZ$20.5 billion were planned to be distributed by the end of June. The total amount also included the NZ$50 billion COVID-19 Response and Recovery Fund. With this it, NZ aimed to allocate funds to various sectors of society in order to alleviate the economic recession in the wake of the pandemic. The plan incorporated healthcare spending, a permanent increase in social spending to assist vulnerable populations, a 12-week wage subsidy to aid employers crippled by the effects of COVID-19, income relief for the unemployed, and loans of up to NZ$100,000 to small businesses [34].

Social Disruption and Persistence of Inequitable Situations during COVID-19

The lockdown has infringed upon various civil liberties in the New Zealand Bill of Rights Act 1990, particularly gathering in masse and expressing religion in gatherings. The Courts' choice to defer jury preliminaries after until 31 July likewise ensnares the privilege to preliminary without excessive delay [35]. Yet, the sensibility of these limitations has not been officially addressed in prosecution; the legitimate reactions to date center around the specialized vires of the requests and the reasonableness of the administrative system. As noted, network acknowledgment and consistency has been high. There was, notwithstanding, conflict over views of deferral in lessening to Alert Level 3, and afterward to Level 2, on the premise that instances of new contamination were decreasing and organizations unduly languishing. Significant exertion and subsidizing have gone into the consideration of the destitute during the lockdown, yet the monetary outcomes have so far been generally serious for the low-paid labor power in administration ventures – and have especially jeopardized the indigenous and minority ethnic communities by and large.

After the lockdown started, there was an appearance of "community checkpoints", where individual residents would examine bystanders regarding their movements [36].Specifically, some Maori citizens managed these checkpoints, taking note of the past history of Maori defenselessness to the flu in the mid twentieth century and the need to protect their communities from COVID-19. Be that as it may, network checkpoints on open streets could have no lawful premise, and drivers were not legitimately needed to stop and cooperate. Police, nonetheless, said they would work with Maori "to guarantee checkpoints are protected and not forestalling legitimate utilization of the street."

Although COVID-19 does not discriminate in terms of who can be infected or killed, racial inequalities do. Researchers at Otago University wrote on April 10th that Maori will “be more likely to experience severe COVID-19 outcomes [37].” This means that every decision point in the COVID-19 ecosystem will be shaped by some manifestation of racism, in the same way racism determines who is allocated tests or therapies, whose symptoms or pain is believed, who is targeted in public messages or marketing, and where healthcare centers are geographically located. Additionally, as a result of existing disparity, Maori peoples are bound to encounter issues and conditions that would intensify COVID-19. Maori as of now have less access to benefits that address issues like violence, work instability, and subsidized housing, and the administrations that are intended to help Maori remain interminably underfunded and exhausted, in spite of being profoundly beneficial for all socioeconomic groups. Maori are also disproportionately represented in essential jobs, such as supermarket workers and delivery services.

The Political Climate that Influenced NZ’s Response

New Zealand’s Prime Minister and her executive cabinet have been lauded for their pragmatism and urgency to act. Markedly, because of New Zealand’s small size, there is a strong central government and limited local government, resulting in a well-coordinated, cohesive national response. This unison and effectiveness in policy was complimented by the public’s reaction, which was driven by epidemiological information and scientific researchers, who themselves were widely sought for discourse in the media.

Key to the social context of COVID-19 is the fact that if governments attempt to return to normalcy, then it is very possible that preexisting socioeconomic inequities will divide society even further: the wealthy will continue to become wealthier, and the poor will be poorer, hungrier, unhealthier and angrier than they were before the crisis. New Zealand adopted Reagan neoliberalism in 1984 (after Roger Douglas, the Finance Minister of the Fourth Labour Government). As a result, New Zealand, where the adage ‘Jack’s in the same class as his lord’ epitomized the libertarian soul of early imperialism, has become progressively divisive and unequal; the 2018 GINI index was 30 percent, in the top three of the most economically unequal countries in the OECD [38]. The wealthiest ten percent of the populace own almost a fifth of the riches, while the most impoverished fifty percent own under five percent of the wealth. As such, the New Zealand government, like developed nations across the globe, has a chance to reevaluate its political and socioeconomic policies as a result of the COVID-19 pandemic

Treatment and Vaccine Development

(Arthur Perez)

Faced with the imminent threat of a global pandemic, countries rushed to explore several methods of prevention and treatment in order to counteract the severity of the highly infectious COVID-19. Since the pandemic's early stages, it was evaluated by physicians, medical personnel, and scientists alike that there was little to no concrete information on the pathophysiology of the SARS-CoV-2 virus, and as such, a variety of approaches were employed in hopes that currently-standing medical treatment could suffice in the absence of a targeted vaccine. While the most effective method to immobilize a rapidly spreading virus is to vaccinate the majority of the population in order to acquire immunity, the development of readily-available, safe vaccines require years of abundant testing prior to being administered to the global population. Thus, countries across the world were compelled to create novel strategies and medicine to oppose COVID-19. The main treatments that exist concurrently can be categorized as either *medicine* or *medical equipment*.

Usage of Ventilators as Primary Hospitalization Treatment Option

At the sight of a global pandemic, New Zealand decided that one of the main medical apparatuses that was to be utilized were ventilators, paired with drugs such as dexamethasone, lopinavir, ritonavir, and many others. These treatment options were chosen due to the specific symptoms that COVID-19 imposes on patients. Specifically, once COVID-19 surpasses its host's immune system, it can induce a fatal condition called "acute respiratory distress syndrome" (ARDS) [39]. ARDS prompts the alveoli of the lungs (the miniscule air sacs which allow for oxygen to enter the bloodstream and withdraw carbon dioxide) to be filled with fluid, which inhibits the lungs' oxygen-providing ability. ARDS, paired with the inability to rhythmically breathe due to the weakening of chest muscles, leaves many patients with the incapacity to properly diffuse carbon dioxide from their circulatory system or intake oxygen. As such, it seemed imperative that all physicians place patients with COVID-19 under the care of a ventilator to counteract the respiratory system's failure. With time, however, further studies and initial failures, such as the significant death rates of individuals under ventilators following infections in New York, incited uncertainty around the idea of employing ventilators as a primary method of intervention. This is because ventilators can cause pneumonia themselves and prompt trachea and lung damage from excessive force. The longer an individual is left on a ventilator, the greater likelihood of the occurrence of these risks. The results of such findings for an already unclear treatment reasonably led to health care providers' hesitation on imposing ventilator use on COVID-19 positive patients. As an alternative to ventilators, some doctors have begun using "high-flow nasal cannulas [40]." Despite these worries and alternatives, though, New Zealand retained the use of ventilators as one of the primary methods of care for infected patients which demonstrated, for the most part, effectiveness in saving individuals from the risks of COVID-19.

Anti-Viral and Anti-Inflammatory Medication Routes

To continue, physicians also incorporated medicinal treatments in the care of infected patients. In order to maximize the efficiency of the drugs being utilized, physicians targeted each stage of a coronavirus infection with a particular treatment. Namely, some specific treatments included antivirals, such as HCQ, LPV, and Remdesivir during phase 1 and 2 of the coronavirus stages. For many physicians, this plan seemed highly plausible as the aim of antivirals is to minimize symptoms and deplete the duration of a viral infection by intervening with specific aspects of a virus, whether it be its binding receptors or individualized enzymes. These assumptions were supported by several trials that other scientists conducted to measure the effectiveness of antivirals. For instance, Remdesivir has been shown to cut the duration of the symptoms in a clinical trial of more than 1,000 people [41]. Despite the potential effectiveness of an antiviral, there are also an array of limitations as viruses can "share" proteins with their hosts, prompting the antiviral to damage the patients' enzymes as well. During late or severe stages of the coronavirus, patients are typically administered host-immune/ anti-inflammatory drugs, such as tocilizumab, JAK inhibitor, and corticosteroids. These kinds of treatments proved to be generally effective, as late stage coronavirus typically prompted patients' immune systems to target the body.

As expected when dealing with a novel disease, many medications proved to be futile in treating COVID-19 in patients and the most successful course of action is still being investigated. For example, hydroxychloroquine, which had received heavy media attention, proved to be ineffective in curing coronavirus completely, a task that had been ascribed to the medication. One of the most potent drugs so far, though, according to several trials, has seemed to be dexamethasone: a steroid which calms down inflammation that is created by the immune system in the body. Notably, the UK's Recovery Trial showed the drug "cut the risk of death by a third for patients on ventilators and by a fifth for those on oxygen [41]." Other treatments include drugs that can relax the immune system in order to reduce the increased immune system response in severe SARS-CoV-2 cases that end up hurting the patients' bodies rather than protecting them, as well as "convalescent plasma" that can be given to patients as a way to combat coronavirus through "learned" antibodies. Important to note, too, is BioBeads technology: a possible treatment route New Zealand has been investing in. These BioBeads are miniscule, biodegradable polymers that have functional proteins attached to them; the technology is now being employed in the creation of AI-powered vaccines. Ultimately, all of these efforts, along with trials like "REMA-CAP, MRINZ, and ASCOT [42]," construe New Zealand's efforts to create novel practices targeted at successful treatment of COVID-19.

Global Outlook of Vaccine Development for COVID-19

Without a doubt, the most effective tool of all that can contribute to widespread immunity are vaccines. Simply put, vaccinations are serums that contain weakened viruses that are created in labs, and are the easiest, most effective way of counteracting viral infections. Despite the few risks they can carry, namely back mutations (when the live virus within vaccines revert backwards by undergoing mutations in the host to their illness-prompting form), vaccines can be the conclusion to the ongoing global pandemic. The two main kinds of vaccines include those that are considered to be "alive" or "inactivated". "Live vaccines" are typically created through "attenuation" or weakening of the "wild-type (disease-causing) virus". This process is achieved by cultivating a virus in tissues or temperatures which are divergent to the typical habitat of the virus. A different habitat can prompt the virus into mutating its genome, which inhibits their ability to cause diseases in humans. On that note, vaccines must undergo a three-step procedure in order to be readily manufactured to the public. As per the CDC, Phase I is when a small-scale sample of patients is chosen to receive the trial vaccine. Next, during Phase II, the study is broadened and "the vaccine is given to people who have characteristics (such as age and physical health) similar to those for whom the new vaccine is intended for [43]." Finally, during Phase III, the vaccine is directed to hundreds of patients and examined for potency and security. Currently, as of August 27, the New York Times reports that there are "twenty-three vaccines in phase 1, fourteen vaccines in phase 2, eight in phase 3, and two vaccines approved for early or limited use [44]." As the global incentive for vaccines continues, scientists approach the release of a potential vaccine for long-term prevention of COVID-19 – a goal New Zealand sought out since its initial plans.

Conclusion

All in all, in a time when countries are scrambling to handle the SARS-CoV-2 virus, New Zealand has managed to almost eliminate the threat of COVID-19 through their intense mitigation, research, documentation/organization, and political efforts. Deciding to strike "hard and early" and committing to the new pandemic immediately with an Alert 4 lockdown, New Zealand has set an example for other countries worldwide with their commitment to every aspect of pandemic management, showing just how dependent controlling a deadly virus is on infrastructure. As such, a recommendation we reached as a team is for several global powers to renovate their policies on public health and safety. Countries are beginning to understand just how mistaken and unprepared they were for such a pandemic, (lack of priority and attention to the virus, the delayed responses, withholding information, minimal research efforts), showcasing the need for a public health infrastructure update. New Zealand's public health system heeds early warnings, consistently tests and documents, has consolidated with health facilities and the government to make beneficial policies, and emphasizes public information campaigns – a system that virtually eliminated COVID-19 when majority of other countries did not.

Despite our cumulative efforts, some issues faced while writing this paper were the lack of credible information on programs specific to New Zealand and the limited number of third-party sources focused on NZ itself. This restricted the information we obtained about certain topics, with only a few providing reliable quantitative research specific to New Zealand. Additionally, all of the information used in this research paper was based on evidence/data collected as of recently. Organizations such as the WHO or the CDC have released counterproductive or conflicting information on COVID-19 (from little to no human-to-human transmission, to very high levels of human-to-human transmission), due to the volatile nature of a new pathogen. In the future, we could have novel or groundbreaking information on COVID-19 that is currently unavailable, making this paper subject to unreliability and a need for modification in the long-term.

Ultimately, further research could have been applied regarding how New Zealand's geography or culture had an impact on COVID-19, or how New Zealand's efforts are culminating to form a potential cure/vaccine. Nonetheless, our group learned the tedious yet vital steps on how to organize and communicate information collected through rigorous research and as well as navigation through official documents, videos, statements, databases, and figures.

Throughout this entire process, we had the opportunity to investigate and develop our knowledge of viral biology, country policy making, specific tools and strategies utilized by officials to understand how a virus is behaving, and the social/economic effects a pandemic could have. Undeniably, these skills cannot only help us write future research papers but also facilitate our understanding of the world's response and behavior to global pandemics and how we can approach them as aspiring medical professionals.

References

[1] *Coronavirus disease (COVID-19) Weekly Epidemiological Update* [PDF]. (2020, August 23). World Health Organization.

[2] COVID-19 Map. (n.d.). Retrieved August 23, 2020, from https://coronavirus.jhu.edu/map.html

[3] SARS (Severe Acute Respiratory Syndrome). (2012, April 26). Retrieved August 23, 2020, from https://www.who.int/ith/diseases/sars/en/

[4] Middle East respiratory syndrome coronavirus (MERS-CoV). (2019, March 11). Retrieved August 23, 2020, from https://www.who.int/news-room/fact-sheets/detail/middle-east-respiratory-syndrome-coronavirus-(mers-cov)

[5] Shepherd, M. (2020, August 10). How Geography Helped New Zealand Beat Coronavirus. Retrieved August 23, 2020, from https://www.forbes.com/sites/marshallshepherd/2020/08/10/how-geography-helped-new-zealand-beat-coronavirus/

[6] Plowright, R. K., Eby, P., Hudson, P. J., Smith, I. L., Westcott, D., Bryden, W. L., . . . Al., E. (2015, January 07). Ecological dynamics of emerging bat virus spillover. Retrieved August 20, 2020, from https://royalsocietypublishing.org/doi/10.1098/rspb.2014.2124

[7] Veronese, N., Demurtas, J., Yang, L., Tonelli, R., Barbagallo, M., Lopalco, P., . . . Smith, L. (2020, April 24). Use of Corticosteroids in Coronavirus Disease 2019 Pneumonia: A Systematic Review of the Literature. Retrieved August 20, 2020, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7193030/

[8] Astuti, I., & Ysrafil. (2020). Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2): An overview of viral structure and host response. Retrieved August 20, 2020, from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC7165108/

[9] Di Mauro Gabriella, Cristina, S., Concetta, R., Francesco, R., & Annalisa, C. (2020, July). SARS-Cov-2 infection: Response of human immune system and possible implications for the rapid test and treatment. Retrieved August 20, 2020, from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC7161502/

[10] Estimates for New Zealand. (2020, August 29). Retrieved August 29, 2020, from https://epiforecasts.io/covid/posts/national/new-zealand/

[11] Qin, J., You, C., Lin, Q., Hu, T., Yu, S., & Zhou, X. (2020, August 01). Estimation of incubation period distribution of COVID-19 using disease onset forward time: A novel cross-sectional and forward follow-up study. Retrieved August 29, 2020, from https://advances.sciencemag.org/content/6/33/eabc1202

[12] Rai, B., Shukla, A., & Dwivedi, L. (2020, August 26). Estimates of serial interval for COVID-19: A systematic review and meta-analysis. Retrieved August 29, 2020, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7448781/

[13] Health and disability services at Alert Level 3. (n.d.). Retrieved August 30, 2020, from http://www.health.govt.nz/our-work/diseases-and-conditions/COVID-19-novel-coronavirus/COVID-19-current-situation/health-and-disability-services-alert-level-3

[14] New Zealand, Health Intelligence Team. New Zealand's COVID-19 Surveillance Plan, New Zealand Ministry of Health, 19 May 2020. www.health.govt.nz/system/files/documents/pages/surveillance_plan_v4.1-210720.pdf.

[15] "Ministry of Health - Manatū Hauora." New Zealand Ministry of Health Facebook, Facebook, 22 Aug. 2020, 4:01 PM, www.facebook.com/minhealthnz.

[16] IHME: COVID-19 Projections. covid19.healthdata.org/new-zealand?view=trend.

[17] O'Sullivan, D., Gahegan, M., Exeter, D., & Adams, B. (2020, June 15). Spatially explicit models for exploring COVID-19 lockdown strategies. Retrieved August 25, 2020, from https://onlinelibrary.wiley.com/doi/full/10.1111/tgis.12660

[18] IHME: COVID-19 Projections. covid19.healthdata.org/denmark?view=trends

[19] New Zealand, Health Intelligence Team. New Zealand's COVID-19 Elimination Plan, New Zealand Ministry of Health, 2020, pp. 4-5. https://www.health.govt.nz/system/files/documents/pages/new_zealands_national_testing_strategy_for_covid-19_for_june_to_august_2020-290620_0.pdf

[20] COVID-19 - current cases. (n.d.). Retrieved August 30, 2020, from https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus/covid-19-current-situation/covid-19-current-cases

[21] Baker, M. G., Kvalsvig, A., & Verrall, A. J. (2020, May 19). New Zealand's COVID-19 elimination strategy. *Medical Journal of Australia*. doi:10.5694/mja2.50735

[22] COVID-19: Elimination strategy for Aotearoa New Zealand. (n.d.). Retrieved August 25, 2020, from https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus/covid-19-current-situation/covid-19-elimination-strategy-aotearoa-new-zealand

[23] Witton, B. (2020, June 26). Coronavirus: The five Covid-19 strategies New Zealand could have chosen. Retrieved August 25, 2020, from https://www.stuff.co.nz/national/health/coronavirus/121954176/coronavirus-the-five-COVID19-strategies-new-zealand-could-have-chosen

[24] *Key Metrics for COVID Suppression Framework* [PDF]. (2020, July 1). Cambridge: Harvard Global Health Institute.

[25] Kassem, A. M. (2020, March). COVID-19: Mitigation or suppression? *Arab Journal of Gastroenterology, 21*(1), 1-2. doi:10.1016/j.ajg.2020.04.010

[26] Ferguson, N. M., Laydon, D., Nedjati-Gilani, G., Imai, N., Ainslie, K., Baguelin, M. (2020, March 16). *Report 9: Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand* [PDF]. London: Imperial College COVID-19 Response Team.

[27] Baker, M. G., Kvalsvig, A., Verrall, A. J., Telfar-Barnard, L., & Wilson, N. (2020, April 3). New Zealand's elimination strategy for the COVID-19 pandemic and what is required to make it work [Editorial]. *The New Zealand Medical Journal*, *133*(1512). Retrieved August 25, 2020, from https://www.nzma.org.nz/journal-articles/new-zealands-elimination-strategy-for-the-covid-19-pandemic-and-what-is-required-to-make-it-work

[28] Baker, M., Wilson, N., Hendy, S., & Skegg, D. (2020, May 5). The need for a robust scientific definition for the elimination of COVID-19 from New Zealand [Web log post]. Retrieved August 25, 2020, from https://blogs.otago.ac.nz/pubhealthexpert/2020/05/05/the-need-for-a-robust-scientific-definition-for-the-elimination-of-covid-19-from-new-zealand/

[29] New Zealand Government. (2020, April 7). *Aotearoa/New Zealand's COVID-19 elimination strategy: An overview* [PDF]. New Zealand: Ministry of Health.

[30] Border restrictions: Who can enter New Zealand or request to travel. (n.d.). Retrieved August 25, 2020, from https://www.immigration.govt.nz/about-us/covid-19/border-closures-and-exceptions

[31] Travel to New Zealand. (n.d.). Retrieved August 25, 2020, from https://covid19.govt.nz/travel-and-the-border/plan-your-travel-to-nz/

[32] Geoghegan, J. L., Ren, X., Storey, M., Hadfield, J., Jelley, L., Jefferies, S., . . . Ligt, J. D. (2020). Genomic epidemiology reveals transmission patterns and dynamics of SARS-CoV-2 in Aotearoa New Zealand. *MedRxiv*. doi:10.1101/2020.08.05.20168930

[33] Alert system overview. (n.d.). Retrieved August 25, 2020, from https://covid19.govt.nz/covid-19/alert-system/alert-system-overview/

[34] International Monetary Fund (2020). Policy Responses to Covid-19. Retrieved August 27, 2020, from https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19

[35] Staff, T. (2020, May 26). New Zealand's Response to the COVID-19 Pandemic. Retrieved August 30, 2020, from https://blog.petrieflom.law.harvard.edu/2020/05/26/new-zealand-global-responses-covid19/

[36] Police position on COVID-19 checkpoints. (n.d.). Retrieved September 1, 2020, from https://www.police.govt.nz/news/release/police-position-covid-19-checkpoints

[37] King, P., Cormack, D., McLeod, M., Harris, R., & Gurney, J. (2020, April 10). COVID-19 and Māori health – when equity is more than a word. Retrieved August 30, 2020, from https://blogs.otago.ac.nz/pubhealthexpert/2020/04/10/covid-19-and-maori-health-when-equity-is-more-than-a-word/

[38] Henrickson, M. (n.d.). Kiwis and COVID-19: The Aotearoa New Zealand Response to the Global Pandemic - Mark Henrickson, 2020. Retrieved August 30, 2020, from https://journals.sagepub.com/doi/full/10.1177/2516602620932558

[39] MacMillan, C. (2020, June 02). Ventilators and COVID-19: What You Need to Know. Retrieved August 25, 2020, from https://www.yalemedicine.org/stories/ventilators-covid-19/

[40] Richards, S. (2020, June 18). Surviving COVID-19 and a ventilator: One patients story. Retrieved August 25, 2020, from https://www.uchicagomedicine.org/forefront/coronavirus-disease-covid-19/surviving-covid-19-and-a-ventilator

[41] Gallagher, J. (2020, August 24). Coronavirus cure: What progress are we making on treatments? Retrieved from https://www.bbc.com/news/health-52354520

[42] Tirumalaraju, D. (2020, April 17). New Zealand researchers work on three Covid-19 trials. Retrieved from https://www.clinicaltrialsarena.com/news/new-zealand-three-covid19-trials/

[43] Vaccine Testing and Approval Process. (2014, May 01). Retrieved from https://www.cdc.gov/vaccines/basics/test-approve.html

[44] Corum, J., Grady, D., Wee, S., & Zimmer, C. (2020, June 10). Coronavirus Vaccine Tracker. Retrieved August 28, 2020, from https://www.nytimes.com/interactive/2020/science/coronavirus-vaccine-tracker.html