HIGH SCHOOL EDITION
Journal of Student Research
Volume 10 Issue 4 (2021)

Canada's Future Pandemic Plan: A Reflection of COVID-19

Emily Xu[1]

[1]Havergal College

ABSTRACT

COVID-19 is one of the most recent and devastating pandemics the world is facing. Canada, despite preparation with developing national and provincial pandemic plans, experiencing a delay of transmission of COVID-19, and maintaining international connections, Canada experienced disappointing challenges. This paper evaluates COVID-19 and Canada's actions towards research, surveillance, health care, case tracking, vaccines, and social communication, as a measure of evaluation on Canada's preparedness. Here a combination of data is used, including statistics of Canada's case/death count, along with analysis of many other countries around the world, including South Korea, Israel, and the United States. With many countries implementing various regulations at different time periods during the growth of COVID-19, this paper considers and interprets the importance of various government interventions. SARS-CoV-2 is extremely transmissible and mutable, emphasizing the importance of rapid efforts to mitigate impacts and to focus on the most vulnerable. As COVID-19 continues to evolve, without any effective control measures, Canada would continue to see a disproportionate influence of COVID-19. Additionally, since a future pandemic is unavoidable, the COVID-19 pandemic is an amazing event that showcases Canada's places of improvement and development. This proposed plan outlines elements that Canada should consider, as we continue to fight against SARS-CoV-2, and for the future epidemics/pandemics.

Foreword

As Canada continues to tackle the current pandemic, COVID-19, the understanding of a proper Pandemic Plan for future preparedness is essential. We have come to realize the devastating threat an outbreak can have on our modern society despite well-established domestic vaccine manufacturing, past plans for treatment and mitigation available to provinces, local governments, communities, families, and individuals, and scientific advancement that would additionally aid the effects of a pandemic.

Canada needs to continue to advance the health-care system and prepare for the unavoidable pandemic in the future. COVID-19 is not only an event that displayed the flaws in Canada's inter-dependent system; it is also a chance for Canada to correct these flaws for future crises. It is crucial that a coordinated effort between all levels of the Canadian government is strengthened and maintained to tackle any pandemic.

Each pandemic poses unique threats, varying by the origin and molecular characteristics of the virus. These variations between each and every outbreak differentiates a virus's ability to mutate, spread, and transmit, making pandemics a recurring threat. Though we likely don't know when the next pandemic will happen or how severe it might be, a plan like the one proposed here will support by creating a safeguard that would mitigate the extreme harms.

Introduction

Covid-19:

COVID-19, caused by the SARS-CoV-2 virus, is part of a family of viruses known as coronaviruses. This family of viruses can cause illnesses in humans and animals, and has been identified in seven different forms, including being responsible for SARS, MERS and COVID-19 (UK Research and Innovation, 2020). The main characteristic of coronaviruses is the effects they have on organs such as the respiratory tract, gastrointestinal tract, liver, kidney and brain in humans and animals (Artika, et. al., 2020). In some situations, coronaviruses can cause mild cold-like symptoms, while some people require hospitalization due to severe respiratory dysfunction.

Molecularly, coronaviruses are large enveloped viruses with a single-stranded RNA genome (Alipoor, et al., 2021). Their spherical shape with spikes of proteins on the outer layer allow them to bind to and infect healthy cells within a human body. The spikes of proteins (S) on SARS-CoV-2 are a source of entry into epithelial cells (and other cells) via ACE2 (angiotensin converting enzyme-II) receptors; coronavirus particles are relatively robust and can survive harsh environments infectious for 1 to 4 days (Artika, et. al., 2020). This robustness accounts for COVID-19 transmission via non-human contact such as hard surfaces (Artika, et. al., 2020). Although specific data show that the risk of infection of Covid-19 by contact is 5 out of 10,000, it is still extremely alarming that viral RNA can be found on surfaces over two weeks after contact with a patient (Lewis, 2021). Additionally, a chance of 5 out of 10,000 may seem small, however, the chances of touching contaminated surfaces is high, especially in weakly ventilated rooms and crowded spaces (Lewis, 2021).

During infection, the coronavirus first attaches itself to a host cell by the binding of its spike (S) protein with the cell's ACE2 receptors (Neuma, et. al., 2016). The S protrudes from the host-derived viral envelope and helps cellular entry receptors. As the host and spike protein interact, they promote the viral uptake and fusion of the virus at the endosomal or cellular membrane (V'kovski. et. al., 2020). Following, the release and uncoating of the genomic RNA is immediately translated and replicated. Translated structural proteins then interact through the ER-to-Golgi compartment and to the N-encapsidated where the newly produced genomic RNA grows into the lumen of secretory vesicular compartments (V'kovski. et. al., 2020). Finally, virions are then secreted from the infected cell through the process of exocytosis.

The main cause of illness is because the ACE2 receptors are occupied with S, and unable to detect proper signals and perform regular functions. Specifically, ACE2 is an important negative regulator of the renin-angiotensin system, which monitors systemic fluid-salt balance and blood pressure (Clutter, 2020). Proper signaling would promote dilation of blood vessels by converting hypertensive angiotensin II into angiotensin 1-7, and help reduce blood pressure (Clutter, 2020). ACE2 receptors are located in many organs in the body but are specifically located in the lungs where coronaviruses can enter through inhalation of respiratory droplets (Clutter, 2020).

An important reason why COVID-19 directly affects patients' breathing is because of a malfunction of a type of lymphocyte known as cytotoxic T cells (Clutter, 2020). This cell, during healthy conditions, is able to arrive at a scene and recognize and destroy any infected cell; afterwards, phagocytic cells will then clean up the infected cell. However, in patients experiencing severe cases of COVID-19, elevated levels of both IL-6 (interleukin 6) and IL-8 (interleukin 8) correlate with T cell exhaustion, reducing their ability to fight infections. Additionally, IL-6 can inhibit the development of lymphocytes, which can weaken the immune response (Clutter, 2020).

Further, the biggest concern in fighting coronaviruses is their potential to have high mutation and recombination rates, which are more likely due to their single-stranded RNA genome (Lau, et. al., 2015). This trait is a concern considering their ability to rapidly infect many species and effectively adapt to new hosts, such as bats and civets. Additionally, the majority of COVID-19 cases are asymptomatic (around 80%) or show mild symptoms with a low percentage of people experiencing severe respiratory failures (Alipoor, et al., 2021). This characteristic of COVID-19 is one reason why the pandemic was difficult to control; many patients did not know that they were infected with

COVID-19 and were able to spread it to other people. This knowledge emphasizes the importance of detecting asymptomatic patients and the need for urgent strategies with testing and isolation.

Pandemic Impact:

Understanding general pandemic characteristics can facilitate strategic pandemic prevention planning, but as mentioned, pandemics vary in many ways. As used by WHO (World Health Organization), in order to sufficiently identify the severity of a pandemic, we should be able to answer these questions: (WHO Pandemic Influenza Risk Management, 2013, pg. 29)

1. How rapid are new cases appearing?
2. What are the types of illnesses and complications related to the virus?
3. Which population of people are most affected by the virus?
4. Is the virus sensitive to antiviral agents?
5. How many people are getting sick/ill?
6. What are the impacts on the health-care sector, including specifics on health-care utilization and the health-care work force?

By answering these questions, governments should be able to create a general outline on how to go about tackling the pandemic. Specifically, guiding decisions regarding vaccine production and strategic distribution, antiviral uses, school closures, social distancing strategies, health-care facility management, and more. Additionally, for specific details related with the severity of a pandemic, the public and policy makers should further consider the transmissibility and viral factors, the seriousness of the disease and distinct levels of symptoms, and the impact.

Key Components of Being Prepared and Responding

1. Research

One of the only ways to truly predict and get ahead of the future is to do research. It is already known that the major cause of pandemics are zoonotic viruses. Just like SARS-CoV-2, many viruses have been detected in animals first, and were later transmitted into humans in several ways (Pike, et al. 2010). Investing in epidemiology, virology, and scientific research with animals that are known to carry viruses, scientists and health-care researchers would learn more about possible deadly viruses and/or further advance human health. In fact, zoonotic diseases are estimated to cause more than 60% of all known infectious diseases in humans that were spread from animals (CDC Zoonotic, 2021).

It should also be noted that even though research is a significant way to address gaps in knowledge and finding effective prevention, treatment, and control measures, most pandemic related research can be done during the pandemic period and concluded years afterwards (Pan-Canadian, 2018). Despite this, it is important to take advantage of Canada's powerful research community and conduct zoonotic virus research before the viruses begin showing up in the human population. In order to support pandemic research, key considerations include identifying research needs, funding resources, developing and maintaining partnerships and research networks, and improving protocols and ethical review processes.

Key approaches include:

I. Identification of research needs— it is important to prioritize and periodically review past research. There are specific viruses that are common in specific geographic locations; focus on viruses that may cause future pandemics or discover them by investing in advanced research/education. Many Canadian and international agencies have historical databases that would provide helpful information. These documents also provide support for current issues.
II. Networks and Connections— Networking in municipal, provincial and national health agencies and organizations would allow for increased collaboration on specific studies. Before and during a pandemic, sharing knowledge on research and frequently updating the scientific community would only additionally prepare for future unknowns.
III. Immediate Research response— by developing, investing, and engaging in specific/relevant subjects, governments would be able to plan in advance and rapidly. With critical knowledge already known by the scientific community, many advanced plans that include preliminary agreements would be approved beforehand, inversely increasing civilian trust, further funding in research, and strong networking.
IV. Utilizing knowledge— Many important decisions during a pandemic are made quickly. By using past evidence and newer research findings and translating studied strategies helps enable confidence with effectiveness. COVID-19, for example, is the most recent pandemic that helped update Canada's strategies on vaccine study and distribution, public health safety, medical and therapy, etc. Such events, plus a periodical update on strategies, is essentially to help decision-makers develop the most optimal plans and suggestions.

2. Epidemiological Surveillance, Laboratory Activities and Networking

The importance of surveillance and well monitored laboratory activity is to make timely and effective responses. By enhancing surveillance on data obtained from public health officials, hospitals, and researchers, public health decisions would be made and executed in a timely and appropriate manner. Developing effective pandemic surveillance programs would allow for:

I. Monitoring geographical spread
II. Identifying the trend and development of the virus
III. Understanding the intensity and effects of the pandemic
IV. Following changes in the antiviral and antigenicity of the virus

One lesson learned from COVID-19 is both the dangers and benefits of researching viruses. Even though the specific origins of SARS-CoV-2 remain unknown, some evidence shows that the virus leaked from a Coronavirus lab in Wuhan, China. China is known to have a high potential for pathogenic coronavirus emergence, based on correlation with coronavirus species and the geographical location located in China (Fan et al., 2019). It is a prevailing hypothesis that SARS-CoV-2 is a laboratory-generated virus that was mistakenly handled and managed to leave the lab, resulting in the spread of the virus (Mallapaty, 2020). However, there is insufficient evidence to support this claim and continues to be a topic of investigation at the moment.

3. Public Health Flexibility

Public health flexibility can include many factors, but one specific consideration is the ability to quickly adapt to large influxes of patients. By planning for a potential range of scenarios, such as high patient volume and absent staff, there

would be an increased demand for health care services. Understanding places of improvement and additional requirements to the existing health care system, and implementing these changes in a short period of time is what defines a flexible public health system.

Steps to establish health care flexibility:

I. Individual measures: provide easy access to health advice for individual protection and prevention of infection spreading. Individuals should have access to hand hygiene, masks, and be familiar with the pandemic through campaigns and proper information sources.
II. Community measures: guidance to minimize transmission in public settings including workplaces, schools, childcare centers, elder facilities, remote and isolated communities, and more. By implementing social distancing and other safety measures quickly, the rate of infection could be controlled.
III. International travelling measures: interventions with travelling, screening, and isolating would limit the risk of exposure to additional asymptomatic sources of transmission.
IV. Surveillance measures: under most circumstances, a pandemic has various waves. By managing, investigating, and recommending measures before and during a pandemic, there will be less dependence on public health. On a larger scale, it should be suspected that there will be a lower number of cases and increased preparedness.

Canadian hospitals that have experienced a staggering increase in cases with the second and third waves of COVID-19 were able to efficiently adapt to the various stresses. For example, many Canadian hospitals were able to reconstruct their emergency departments in order to accommodate for an increase in emergency health care delivery. A specific example would be a hospital in North York that was able to completely alter their ED system, including installing new ventilation systems, and managed to continue operations after 33 hours (Yu, et al., 2020). Even in rural hospitals, increased patients were managed by increasing equipment and accommodations through networking.

4. Health Care and Clinical Care System Preparedness

Each pandemic differentially affects different demographics of a population. How is Canada going to improve the health care system and respond to a shock of limited capacity? Additionally, which groups are the most vulnerable and most affected by the virus? With limited health care, especially in isolated or remote communities, Canadian governments need to find ways to reach-out and provide care through: telephone access, ambulatory care, emergency services, long-term and palliative care, home and community care, and hospital care. Surges in patients with life threatening illnesses, does not only involve the need of additional health care workers, but also community service providers, volunteers, and workers for electronic data management systems.

Fundamental Considerations:

- Ongoing surveillance on targeted groups.
- Adequate staffing and healthcare professionals with proper education and training as front line working staff. Appropriate environments to carry out care.
- Sufficient supply of hospital beds, respiratory devices, medical drugs and therapies, and widely available testing/screening devices.

A significant fault of COVID-19 was the notable number of cases and deaths seen in people aged 80+ in Canada. They accounted for 17.63% of all cases and around 72% of all deaths in the country (Yu, et al., 2020). Data also shows that patients over the age of 65 years old with pre-existing comorbidities are at higher risk of death than younger populations. There are two possible reasons for this trend; first, the percentage of elders entering ICU facilities was considerably low compared to the high death rate. Second, many long-term care home facilities were not well

equipped and had weak regulations and budgetary constraints that led to issues of poor working conditions and low quality of care (Yu, et al., 2020). Many elders, in the beginning of the pandemic, experienced overwhelmed health care workers and shock to an alternate system. It is expected that during a pandemic, individuals will experience increased stress and emotional burdens, but by reflecting on past pandemics like COVID-19, better guidance and planning is expected for the future.

5. Medical Mitigation Measures: Case Tracking and Tracing, Vaccines, Respiratory Devices

Medical mitigation measures vary depending on the characteristics of the pandemic, but the most effective mitigation measures include case tracking/tracing and vaccines. To ensure preparedness, making sure to create greater availability to testing (at home or clinical), apps and public resources to tracing, researching the pandemic virus as quickly as possible, and developing effective vaccines, are some factors to consider.

During the beginning waves of COVID-19, Canada, despite being a well-established nation, faced difficulties with maintaining high testing rates with the lack of laboratory supplies and preparedness for large testing capacity (Yu, et al., 2020). However, access to testing, case tracking and tracing have been seen to have beneficial effects when pin-pointing specific locations to focus on. For example, in South Korea, acknowledgment to tactics of vigorous testing and case tracing during the early stages of COVID-19, allowed for an effective protocol of: test, trace, and isolate (Scott, et. al., 2021). By testing individuals that are either positive with COVID-19, governments were able to isolate these patients, either at home or in health-care facilities. By tracing, officials were easily able to detect and warn for possible outbreaks and suggested isolation. One reason why the first two steps were successful was that because it tactically captured individuals with higher chances of susceptibility and allowed for numerous an-symptomatic individuals to avoid further spreading. As of April 2021, South Korea has seen only an average of 700 cases per today, while in the United States, it is an average of 70,000 (Scott, et. al., 2021). South Korea was successfully able to flatten out their epidemic curve and reduce the societal and educational harm by controlling the root of transmission (Scott, et. al., 2021).

Continuing with vaccines, Canada was one of the slowest countries to deliver and provide available vaccination shots. Beginning on December 14, only three out of 100 Canadians were receiving at least one dose, while in the US and UK, it was 14 and 21, respectively (BBC, 2021). One reason for this is the lack of capacity for domestic production of vaccines and the continuous delay, reduction, and cancellation of shipment.

Vaccines are extremely important to slow the transmission of COVID-19. Israel, for example, was one of the first countries to illustrate herd immunity with COVID-19 vaccines. Eran Segal, a computer scientist at Weizmann Institute of Science in Rehovot Israel, and his colleagues, were able to conclude with government data that vaccines were able to decline cases and hospitalizations (Mallapaty, 2021). As of mid-January, 90% of people over the age of 60 received their first dose, and only two weeks after, Israel's Ministry of Health showed a 41% drop of cases within the 60 years and older age group, and a 31% drop in hospitalization (Mallapaty, 2021). These trends were only seen once vaccines were administered, and not when governments placed lockdowns. These results not only prove the effectiveness of vaccines, but herd immunity as well; just like historical infectious diseases like measles, polio and chickenpox, which are now rarer because of herd immunity.

Finally, respiratory devices, face masks, and protection supplies, are essential items to mitigate transmission rates. Many CARS-CoV-2 patients with severe symptoms experienced acute hypoxemic respiratory failure which was the most common organ failure among patients in ICUs. There was an enormous increase in demand for respiratory support with around 42%-47% of patients experiencing moderate to severe cases of respiratory distress in need of intubation and invasive mechanical ventilation (Munshi, et.al., 2021). As for protective wear for civilians, since COVID-19 is spread from an infected person breathing out droplets and small particles, these particles can easily be breathed in by another person or make contact with their eyes, nose or mouth. For this reason, monitoring face mask, sanitizer, soap and other hygienic products availability is extremely important during an event of a pandemic.

Strategic Approaches

Case Tracking/Tracing:

Firstly, understand the community context by considering factors of dynamic, social, health, geographic, political and epidemiological characteristics. With such knowledge, the next steps that follow include engaging with the community members and leaders to ensure that everyone is well aware of the situation. By forming a plan addressing case tracking/tracing while also specifically aligning with the dynamic of the target community, is a crucial way to naturally implement such technology. The second aspect to consider is the use of the technology and specific concerns as to the use of the technology and consequences with data privacy. It would be noted that different communities have different concerns with personal privacy, and it would only benefit to prepare to communicate how the data collected with the use of case tracking/tracing, will be used, stored, and accessed. With civilian trust, the next step is to encourage the use of the simple and widely available case tracking/tracing apps as a method of cheap and efficient source of communication and education. As most people have access to their personal phones and the internet, the use of such apps/technology can be extremely accessible. However, it is also because of the high accessibility that individuals using the apps/technology should be contacted if suspected to be positive of the virus, and continued to be monitored regarding their condition during their quarantine. In other words, there should be more reliability and communication to continue to encourage the use of case tracking and tracing devices. Finally, as the number of users begins to increase, preparation of proper management and analytical systems for performance and data collections to improve civilian stately and government policies, should be additionally added. With a wide usage of case tracking and tracing, the data collected and stored, can later be used to develop better understanding of transmission rates and the general impact of the virus on various communities. Through analysis and research, this use of case tracking and tracing would not only support the community at the moment, but also in the future, as more is learned about the development of the virus.

Vaccines:

The first consideration to administering vaccines is to critically consider the different social factors of the community. For example, the various perspectives on vaccinations, government trust, cultural differences, education/past experiences, etc., can all influence the distribution of vaccines. Next, governments should begin to develop policies, resources and evidence to highlight the importance of vaccination on social and health factors within the community. With such action, implementing credible vaccination plans with proper management and monitoring elements would further ensure the trust of civilians. Afterwards, governments should begin advocating the importance of vaccination and immunization with the objective of its benefits, rights of health, and safety. This is extremely important because most people who are hesitant to get vaccinated are not fully aware of the importance of it. However, by communicating through social media and internet technologies, there must be careful contemplation with the threats of spreading awareness on platforms that are not biased and limited with proper information. Although, by collaborating with trustworthy organizations that can campaign and connect with the greater community, would help eliminate the miscommunication and slander of vaccination. The last step would then be identifying disproportionately targeted groups and prioritize in forms of supplies, staff, and options/availability of vaccines and locations. Connecting with local, nationals, and international leaders/organizations, is another way to increase the trust of civilians towards the government and scientific-health based research.

Self-Protection Supplies:

First, prioritize and organize distribution of supplies between hospitals, long-term care homes, households, and individuals supported by societal support. By prioritizing proper distribution of supplies, there would be better organization with understanding the most vulnerable groups as well as reducing the transmission of the virus with proper equipment. Next, Canada needs to develop and invest in domestic manufacturing facilities. This element is crucial to supplying enough supplies at the start of the pandemic since it would shorten transportation and waiting

time. By investing in domestic manufacturing facilities, this also requires the Canadian government to form and continue to maintain trustworthy connections and relationships. With this, during the earlier stages of the pandemic, Canadian governments and manufacturing companies could easily collaborate together and efficiently produce supplies for society. Additionally, governments could propose plans in advance that involve steps and agreements for possible rapid changes in production and the manufactured products. Lastly, regulate self-protection supplies that are highly demanded and periodically alter production output in relation to monitored trends of consumers. As the pandemic develops, and researchers learn more about the virus, various products that were in demand during the start of the pandemic may vary as civilians' shock recedes. Making sure that companies are manufacturing the right products at the right time would not only benefit the economy but ensure the health of society as well. Further, pandemics do not only last a few months, but instead, may have several waves. With this in mind, manufacturing should continue to improve flexibility and sustain any immediate demand of medical devices, such as, respiratory devices, hospital graded masks, disinfection products, vaccination supplies, etc.

6. Communication with Public

Communicating with the public is the most effective way to coordinate a rapid control of a pandemic. Without educating and providing resources to citizens in Canada, lack of urgency and trust will be noticed. A well-known outline that most countries follow is the Four-Phase plan:

I. Engagement relationship and trust building.
II. Environmental examination with team building and response training.
III. Early phase response (7 days).
IV. Stabilization and transition phase (day 10 to present).

As noticed, the very first focus of the plan is to engage and the trust of civilians. Canada is a very diverse nation with a majority of the population being foreign-born. (OECD, 2011) Because of this, it is a major consideration to acknowledge the different religions, cultures, and geographic lifestyles of Canadians. An example of how government communication and building trust plays a crucial role is with vaccines. In February 2021, an average of 76% of the population in 11 OECD countries showed a willingness to be vaccinated, which was an increase from December 2020, which was only 66% (Ipsos, 2021). Despite this relatively high number, by May 2021, more data showed that a quarter of the population in France, Germany, and the United States may refuse to get vaccinated. More specifically, more than 50% of those between the ages of 25 to 34 years old in France, and 33% of 25 to 34 years old in Germany, say they would likely not get vaccinated for COVID-19 (Kantar, 2020). This data seen in relatively well-developed nations is extremely alarming and shows the lack of trust and acceptance to vaccination, since it is expected that an educated population will be more accepting of better development. Even though Canada is not experiencing the same amount of rejection to vaccines as the US did, there was still complications with feeling safe. For example, around 80% of Canadians in a survey have expressed trust to the Pfizer and Moderna vaccines, while less than 50% responded that they trusted the Johnson and Johnson's vaccines and even less for Oxford-AstraZeneca (Rabson, 2021). This survey shows that many people are influenced by media news and only further demonstrates the importance of providing knowledge and updates on the pandemic to the public.

Conclusion

As Canada prepares for the next pandemic, as illustrated above, there are many factors that have to be considered. Whether it is to prevent the future pandemic or mitigate the impacts of one, there are steps that can be taken to reduce the disruption to society and our economy. By focusing on categories, such as: research, surveillance and laboratory activities, public health flexibility, health care and clinical care systems, medical mitigation measures, communication

with the public, and domestic and international relationships, Canada would be prepared in a well-rounded manner. This proposal plan would not only prepare Canada in the form of providing a better health system, but also prepare citizens for the unpredictable event. By following several of the key strategies that are laid out on this proposal, there will be noticeable growth in trust and cooperation by Canadians, leaders, and organizations. Additionally, by following this plan which includes many reflection-based suggestions from the Coronavirus Pandemic of 2019, Canada would be able to improve on many of the flaws seen during the execution of fighting COVID-19. Hopefully, in the pandemics that have yet to come, Canada as a nation would be more prepared socially, economically, and culturally.

References

Alipoor, S. D., Mortaz, E., Jamaati, H., Tabarsi, P., Bayram, H., Varahram, M., & Adcock, I. M. (2021). Covid-19: Molecular and Cellular Response. *frontiers in Cellular and Infection Microbiology*. https://doi.org/10.3389/fcimb.2021.563085

Artika, I. M., Dewantari, A. K., & Wiyatno, A. (2020). Molecular biology of coronaviruses: current knowledge. *Heliyon*, *6*(8). doi: 10.1016/j.heliyon.2020.e04743

Centers for Disease Control and Prevention. (2021, July 1). *Zoonotic Diseases*. CDC. https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html

Clutter, C. (2020, June 5). *The Biology and Immunology of Covid-19 Susceptibility*. American Society for Microbiology. https://asm.org/Articles/2020/June/The-Biology-and-Immunology-of-COVID-19-Susceptibil

Fan, Y., Zhao, K., Shi, Z.-L., & Zhou, P. (2019). Bat Coronaviruses in China. *Viruses*, *11*(3), 210. https://doi.org/10.3390/v11030210

Ipsos. (2021, March 11). *COVID-19 vaccination intent has soared across the world*. Ipsos. https://www.ipsos.com/en/covid-19-vaccination-intent-has-soared-across-world

Lan, J., Ge, J., Yu, J., Shan, S., Zhou, H., Fan, S., Zhang, Q., Shi, X., Wang, Q., Zhang, L., & Wang, X. (2020). Structure of the SARS-CoV-2 spike receptor-binding domain bound at the ACE2 receptor. *Nature*, *581*, 215-220. https://doi.org/10.1038/s41586-020-2180-5

Lau, S. K.P., & Chan, J. F.W. (2015). Coronaviruses: emerging and re-emerging pathogens in humans and animals. *Virology Journal*, *209*. https://doi.org/10.1186/s12985-015-0432-z

Lewis, D. (2021). COVID-19 rarely spreads through surfaces. So why are we still deep cleaning? *Nature*, *590*, 26-28. https://doi.org/10.1038/d41586-021-00251-4

Mallapaty, S. (2020). Where did COVID come from? WHO investigation begins but faces challenges. *Nature*, *587*, 341-342. https://doi.org/10.1038/d41586-020-03165-9

Neuman, B. W., & Buchmeier, M. J. (2016). Chapter One - Supramolecular Architecture of the Coronavirus Particle. *Advances in Virus Research*, *96*, 1-27. https://doi.org/10.1016/bs.aivir.2016.08.005

OECD. (2011). Society at a Glance 2011: OECD Social Indicators. *OECD*, 103. https://doi.org/10.1787/soc_glance-2011-en

O'Neill, A. (2021, July). *Canada: Population density from 2008 to 2018*. Statista. https://www.statista.com/statistics/271206/population-density-in-canada/

Pan-Canadian Public Health Network. (2018). *Canadian Pandemic Influenza Preparedness: Planning Guidance for the Health Sector*. Pan-Canadian Public Health Network. https://www.canada.ca/content/dam/phac-aspc/migration/phac-aspc/cpip-pclcpi/assets/pdf/report-rapport-02-2018-eng.pdf

Pike, B. L., Saylors, K. E., Fair, J. N., LeBreton, M., Tamoufe, U., Djoko, C. F., Rimoin, A. W., & Wolfe, N. D. (2010). The Origin and Prevention of Pandemics. *Clinical Infectious Diseases*, *50*(12). doi: 10.1086/652860

Rabson, M. (2021, May 7). *Canadians' trust in COVID-19 vaccines growing, but it depends on the shot: survey*. The Canadian Press. https://globalnews.ca/news/7841964/covid-vaccine-trust-canadians/

Rivière, E. (2020, November 23). *COVID-19 vaccine faces an increasingly hesitant public*. Kantar. https://www.kantar.com/inspiration/coronavirus/covid-19-vaccine-faces-an-increasingly-hesitant-public

UK Research and Innovation. (2020, March 25). *What is coronavirus? The different types of coronaviruses*. UKRI. https://coronavirusexplained.ukri.org/en/article/cad0003/#ref1

U.S. Department of Health and Human Services. (2017). *Pandemic Influenza Plan*. CDC, HHS. https://www.cdc.gov/flu/pandemic-resources/pdf/pan-flu-report-2017v2.pdf

V'Kovski, P., Kratzel, A., Steiner, S., Stalder, H., & Thiel, V. (2021). Coronavirus biology and replication: implications for SARS-CoV-2. *Nature Reviews Microbiology*, *19*, 155-170. https://doi.org/10.1038/s41579-020-00468-6

World Health Organization. (2017). *Pandemic influenza risk management: a Who guide to inform and harmonize national and international pandemic preparedness and response*. World Health Organization. https://www.who.int/influenza/preparedness/pandemic/PIRM_update_052017.pdf

Yu, A., Prasad, S., Akande, A., Murariu, A., Yuan, S., Kathirkamanathan, S., Ma, M., & Ladha, S. (2020, December). Covid-19 in Canada: A self-assessment and review of preparedness and response. *Journal of global health*, *10*(2), 12. doi: 10.7189/jogh.10.0203104