Geog497

Senior Thesis Outline

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**The effectiveness of CTAs and related policies in Covid control,**

**a comparison study of Shenzhen and Seattle**

## Introduction

Since the end of 2019, the Coronavirus has heavily affected life in multitudinous ways and resulted in countless losses. As Covid still prevails, I wanted to collect data and understand, or offer some insights on, the effectiveness of certain measures in fighting against the virus. We can learn from or study some of the effective experiences and workflow, helping us minimize the costs and losses in the future. After careful selection, I decided to focus on Contact Tracing Apps, or CTAs, which are mostly used by countries or regions with developed internet infrastructure and seem to be effective (Lewis, 2021). Since the CTAs are one of the latest measurements that help the government with contact tracing and pandemic control, they are worth researching their effectiveness under different scenarios and government structures.

For now, there is very limited literature and public data available for scrutinizing the effectiveness of CTAs. This study analyze data since the beginning of Covid to March 1$^{st}$, 2021, most of the analysis is done by analyzing proxy variables and estimating the potential effectiveness of the applications, giving insights on some directions to follow up further. Besides the effectiveness, or benefits, this project also looks at the side effects that the CTAs could bring to the local communities, especially minorities and low-income communities. I

chose to compare the CTAs mechanism and related government policies in Shenzhen, China, and King County, WA, since they both did a decent job in the aspect of Covid control, but they have very different policies and application mechanisms bearing the fact that each of them has their own problems as well.

**Research Question**

This research compares the Covid control policies and the use of Contact Tracing Apps (CTAs) in Shenzhen, China, and King County, WA. Both city are metropolis with a large number of population, which makes contact tracing more important for Covid control. The research will first examine the differences between the government's policies of pandemic control and contact tracing response. The discrepancy between CTAs design, mechanism, and the ways of defining close contacts will also be explained. This section provides the background for a better understanding of the differences in government policies and CTAs for the two areas.

This research will employ public data available to analyze the effectiveness of contact tracing apps for both regions. The analysis will include visualization using existing data and construct timelines of the pandemic and usage of CTAs in several periods in 2020 and 2021, demonstrating how CTAs and their improvements have effects on certain indicators such as hospitalizations, people in quarantine, daily cases, and deaths. The timeline will be divided based on different Covid mutations that were dominant in the areas, as well as the version updates of the CTAs. Based on biological evidence and available statistics, combined with changes in government’s pandemic control policies, we can evaluate the effects of CTAs.

After analyzing the effectiveness of CTAs on pandemic control, the research will discuss the overall impacts of CTA on society, mainly focusing on employment and commuting within the regions of study as an exploratory study.

## Literature review

Covid tracing tools are important measures to control the virus from spreading. There are three classifications of digital tools for contact tracing: outbreak response tools, proximity tracing tools, and symptom tracking tools (WHO, 2020). After the lockdowns, CTAs are considered one of most effective tools to control Covid, yet the effectiveness of tracing apps depends on the coverage and people's values, which leads to disparate applications and policies (Kostka & Habich-Sobiegalla, 2021). However, derivative effects come with CTAs are noticeable, for example, the saving lives or saving livelihoods problem, the quarantine disparity --- the poorer population might go under quarantine more frequently, harming their financial stability (Klenk et al., 2020). Quarantine policies also play an important role here, Shenzhen adopted a forced, isolated 14-days quarantine policy (Shenzhen, 2022), unlike King County practices voluntary quarantine policies. They both have different Covid containment effects and financial impacts. Accessibility is also a concern, children, the elderly, and people with disabilities may have a hard time accessing the app (King County, 2022).

The government also takes other measures to do contact tracing besides CTAs. In Shenzhen, China, the intensive manual contact tracing helped to pin down all the close contacts (Zou et al., 2020). This, however, cannot be done perfectly by every country or

region. According to Lewis (2020), the U.S. is one of the worst countries in contact tracing since more than half people cannot provide close contact details. Research has shown that government credibility “can enhance residents' helpful actions against COVID-19 and reduce effects from unfavorable actions” (Xiang et al., 2020). Thus, a credible and trustworthy government is also one of the crucial factors in pandemic control.

In China, the government maintains a strong and unwavering interventionist policy, called the “zero-tolerance” policy, which has been proven to be effective, at least in the short-term, and important in epidemic control (Li et al., 2020). Related to the history of Chinese governmental policies, this trend is clear that the government tended to be negligent and then overreacted, and different state policies may speed up the spread in the beginning. Besides, the sustainability of these policies is debatable, since it is economically expensive and shows a diminishing return (Tan & Chen, 2021). On the other hand, the U.S. government that aims to “lead the world’s humanitarian and health assistance response to the COVID-19 pandemic,” according to the White House, seems ironically confused about the situations and inconsistent in their Covid policies (Carter & May, 2020). During Biden’s administration, the U.S. Covid policies seem to become clearer, which is to control the pandemic using several strategies and safely, slowly reopening the economy (The White House, 2021).

In terms of urban governance, different strategies are employed as well. In Shenzhen, most communities are gated, and use a management mechanism called gird governance. Even though it increases social security and resolves conflicts within the neighborhood, this strategy also decreases the autonomy within communities (Tang, 2019). On the American

side, the city governments are more autonomous, so as neighborhoods. The King County local government has focused more on pursuing sustainable and high-level development goals, including mitigating climate change, social justice, and improving infrastructures (King County, 2017).

People have discussed a lot on how Covid has affected daily life. Che et al. (2020) show that during the pandemic in China, migrant workers, especially the ones that obtain rural household registrations experienced an increase in unemployment and suffered from "unequal pay". Therefore, the preexisting gaps between the unemployment and income among people with different household registration types enlarged. As for now, Shanghai has been in lockdown for four weeks due to Covid outbreak. Chinese government is now has shifted from the "zero-tolerance" policy to Covid to "Dynamic Covid-Zero" policy, a summary of China's experience in dealing with the spread of the Covid variant, considering how to control the epidemic at a higher level, at a lower cost, and in a shorter time (Liu et al., 2022). However, this strategy has encountered some issues that cause quite a few frustrations and complains among people (Zhang, 2022).

On the other side of the world, Brough et al. (2021) point out the enlargement of the gaps of ways of commuting between different groups of people in King County, WA. The educated and the wealthier switch to private commuting and work from home easily, compared to the poor and uneducated groups who cannot afford these changes. The use of contact tracing apps can possibly enlarge the social disparities that are already made worse by Covid.

However, with the detailed analysis of all factors around Covid, there's limited literature on the impacts of CTAs, which makes a study focus on CTAs contributions to pandemic controls necessary, especially when the pandemic is still prevalent.

## Methods and Source

For the first sub-question, regarding the differences in government Covid control policies and CTA mechanism, I will examine mostly qualitative data, including government documents and policies, interviews, and timelines published by validated sources. The study will focus mainly on the quarantine policies and response procedures to close contacts. Two important variables to be distinguished here are government response time, and general quarantine days, since these two variables will be important to the questions discussed below.

For sub-question two, the study will collect data to visualize the general pandemic curve and timelines, as well as the dominant Covid mutation strain of a certain period. By collecting the number of people in hospital or quarantined, combining the biological factor, infectious rate of the covid Mutation, and vaccination rate, it will present an overall trend of effectiveness of government responses in different periods. Within the effectiveness trend, some potential insights or aspects, for example the hospitalization, or death rate, can be pointed out for further research on the effectiveness of CTAs. When CTAs data are more widely available, the current research will be helpful to locate the specific aspects of interests that help narrow down the scope of estimations.

For the last questions, evaluating the overall effect of Covid and CTAs had on the society, a mixed method will be used. The demographics of the population of Covid patients will be analyzed based on either zip code, cities, or census tracts, and compared with the demographics of the regions, to detect the potential influences on the income or social inequality that may be enlarged by Covid and CTAs. Besides the demographics, data of hospitalization, positive rates, and other Covid related statistics will also be gathered and visualized, presenting a more coherent understanding of the areas that are under health and geographical inequalities. To understand the impact of Covid and CTAs on the overall society, data on commute, income, and unemployment based on different political boundaries will also be collected and compared. The final section will present the potential areas that are suffering from health, income, and environmental inequalities, and their situations during the pandemic.

**Analysis and findings**

With reference to the first question, King County and Shenzhen have very different quarantine policies and CTA mechanisms (Fig.1). Overall, Shenzhen's policies are very strict, including various testing on people under mandatory quarantine as a response to the CTA's result, all the policies are regardless of vaccination status. King County side, on the other hand, does not have very detailed quarantine policies. Vaccination status are one of the important determinants on quarantine instructions. The CTA mechanisms are also different in two regions, the CTA used in Shenzhen, or the Health Code, is a small program that runs on WeChat, a Chinese social media, and uses GPS to locate users and categorize users by their

distances to an infected case, while the WA Notify, which used by the King County, uses Bluetooth to pass on information of the contacted people within certain distances. As a result, the Health Code in Shenzhen is more efficient yet has higher data ethical issues as the phone numbers and WeChat are all related to personal ID. On the other hand, King County's WA Notify, even though it protects users' privacy, cannot reveal cases fast enough since it's completely anonymous and it is dependent on users to report themselves.

On the response time, based on King County's policies, the decisions of whether to be quarantined are made subjectively. For the time of the CTA to notify a close contact, the time also varies. As stated in the table (Fig.2), the application will only notify potential close contacts if the infected person reports themselves, which makes the potential response time extremely long, but once reported, the application will notify all potential close contacts within a day.

About the response time in Shenzhen, the graph below shows the hospital admission time and the symptoms detected times for the first response (n=415) in Shenzhen, before the CTA is introduced. We can see that most of the patients are sent to hospitals after showing symptoms, a few of them are sent to the hospital the same day they become symptomatic. Fig.3 gives us a clearer image of the average response time of the Shenzhen government during the first outbreak. While some cases are sent on time, most of them are behind, making the response time to be around 3 days. Combining both figures (Fig.2, Fig.3), we can observe that there was a large number of red nodes in the middle, meaning that there is a leak in the contact tracing; this leak has tremendous effects on slowing down the response time.

| | Shenzhen | King County |
|---|---|---|
| Quarantine policy | 1. With Health code of Red: 14 days quarantine, testing every day for the first week, and testing on day 10, 14.<br>2. With Health code of yellow: 4 days quarantine, testing on day 1,3,7,14.<br>3. From out of country of Hong Kong, 14days quarantine + 7 days stay home quarantine, with negative COVID testing result within 7 days<br>(Shenzhen, 2022) | 1. If not vaccinated, 5 days minimum, test on Friday with test on the fifth day, if not symptomatic, the quarantine will end.<br>2. if vaccinated and boosted, not need to quarantine, high quality and well-fitting mask required<br>(King County, 2022) |
| CTA Mechanism | Chinese health code mostly uses GPS location. The health code changes color when it detects the user was in the area of a infected case around 250 meters and stayed in area for more than 1 hour within four days before the infected case was quarantined. Or it will change color if a user enter a medium or high risk area.<br>(Zhejiang News, 2021) | When you enable WA Notify, your phone exchanges random, anonymous codes with the phones of people you are near who have also enabled WA Notify. The app uses privacy-preserving Low Energy Bluetooth technology to exchange these random codes without revealing any information about you. If another WA Notify user you've been near in the last two weeks later tests positive for COVID-19 and follows the steps to anonymously notify others, you'll get an anonymous notification that you've had a possible exposure.<br>(DOH, 2022) |

Fig.1 Comparison of Quarantine policies CTA Mechanism Between Shenzhen and King County

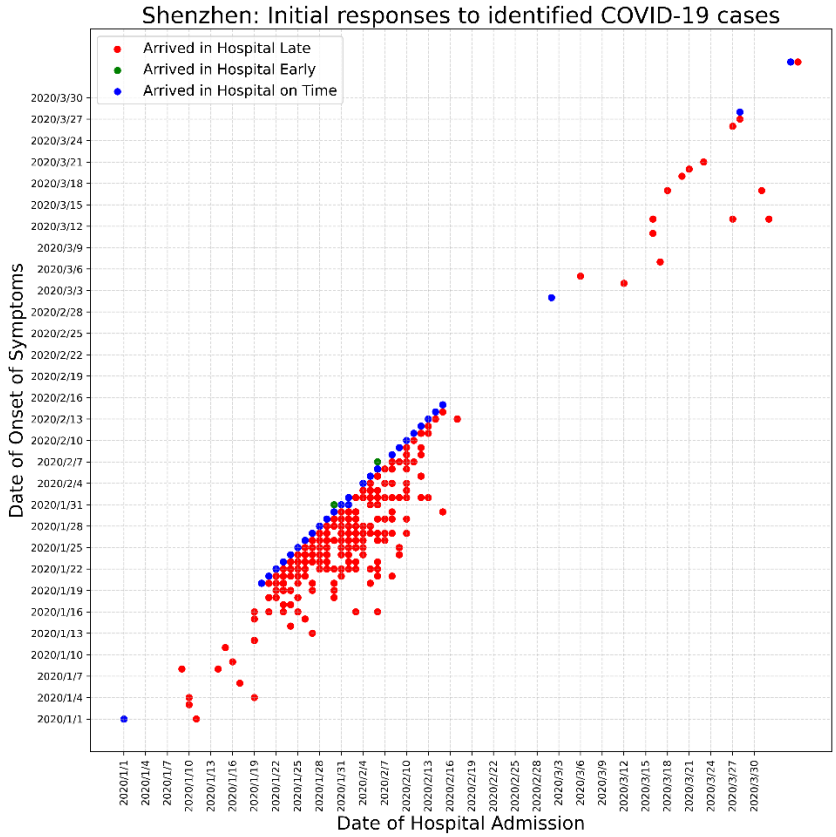


Fig.2 Shenzhen First Response of the Pandemic (Based on Hospital Admission date and Onset Date) Source: https://opendata.sz.gov.cn/

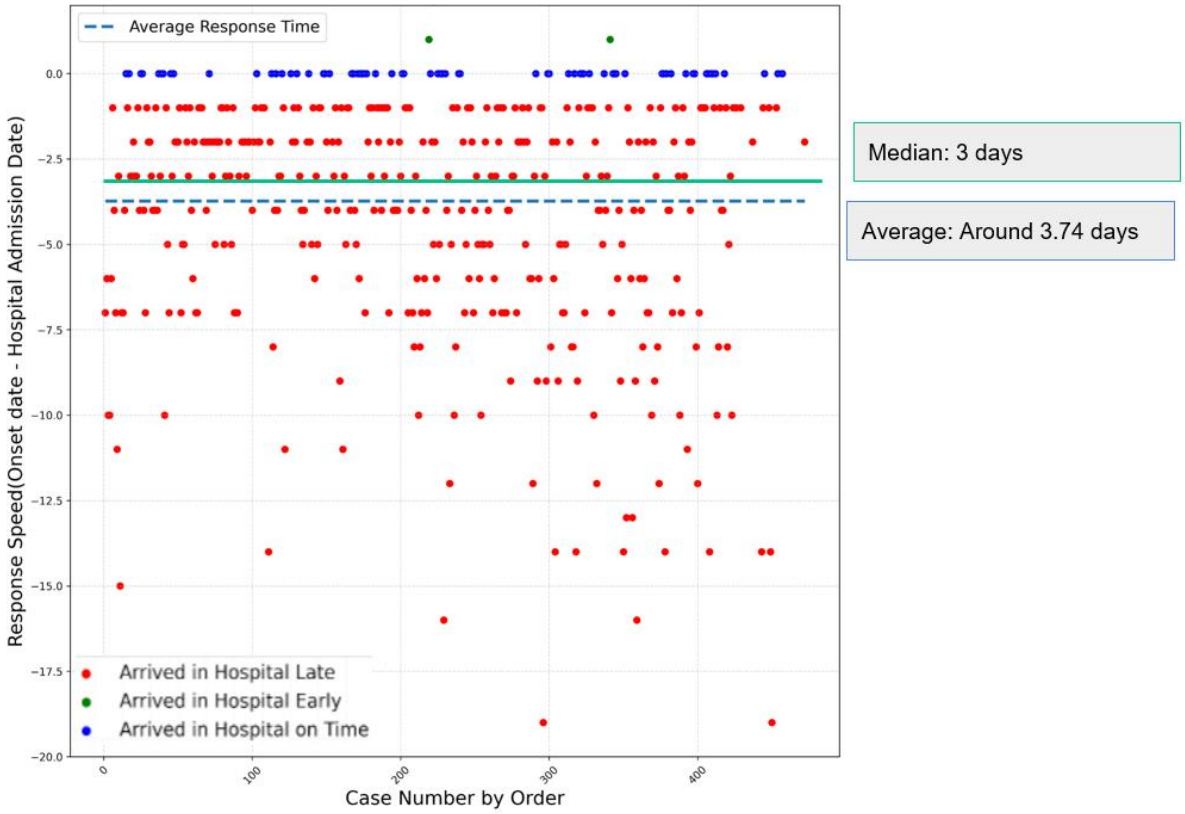


Fig.3 Shenzhen First Response of the Pandemic (In response days) Source: https://opendata.sz.gov.cn/

For question two, on the King County side, we can see that as CTA was introduced on Nov 20, 2020, the basic trends and curve were not much affected by the introduction of the CTA, it may be due to that its download and usage are completely voluntary, meaning that users of the app cannot get notifications from who got infected but were not using the app. However, due to the biological nature of the mutations, the virus is becoming less deadly. On the other hand, as the virus became more contagious, the number of cases went up exponentially and became the dominant strain in a relatively short period of time (fig.4).

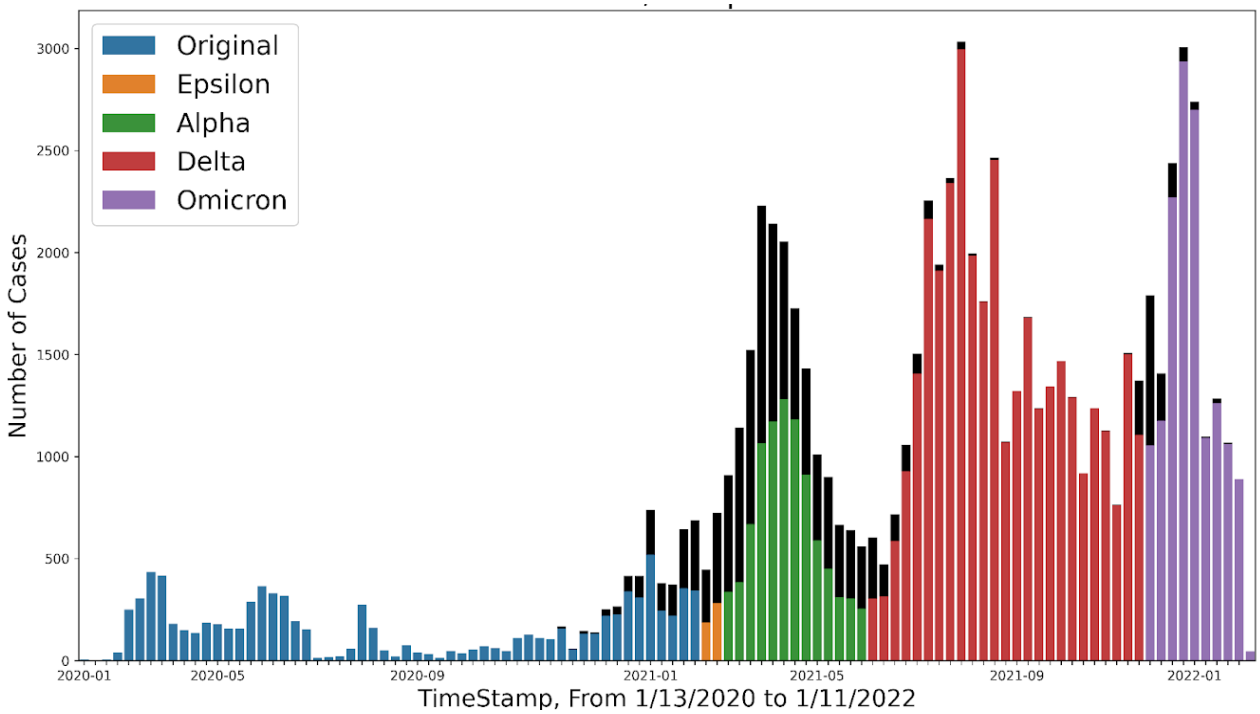


Fig.4 Seattle's Covid Dominant Strain, Compared to Total Cases. Source: https://kingcounty.gov/depts/health/covid-19/data/summary-dashboard.aspx

Comparing the number of cases and deaths (Fig.5), we can see that even though the cases number went up, the death rate dropped down significantly. However, the number of deaths due to the new mutation (Omicron) is still around the same as the previous mutations due to the large number of infections. Overall, we do not see an obvious effect of CTA in the King County Area regarding the overall cases and death number reductions.

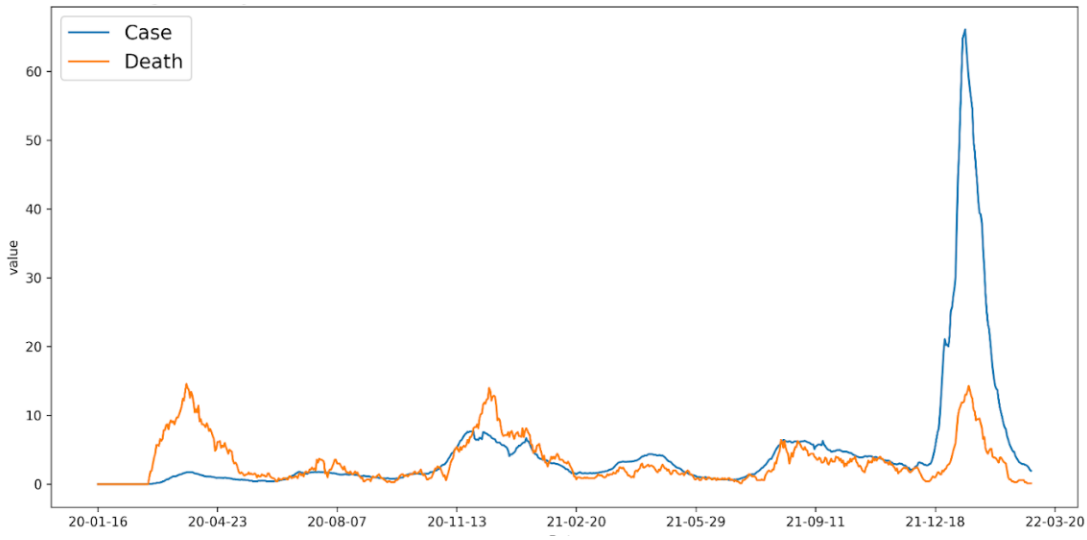


Fig.5 King County Covid Cases (Divided by 100), Compared to Death. Source: https://kingcounty.gov/depts/health/covid-19/data/summary-dashboard.aspx

What's more, we can see that COVID patients' occupancy of hospitals normal units (Black bars) and ICU (Red Bars) in Fig.6 also do not show a decreasing or constant trend after the WA Notify is introduced. Instead, the trend of occupancy largely aligns with the Covid curve shown above.

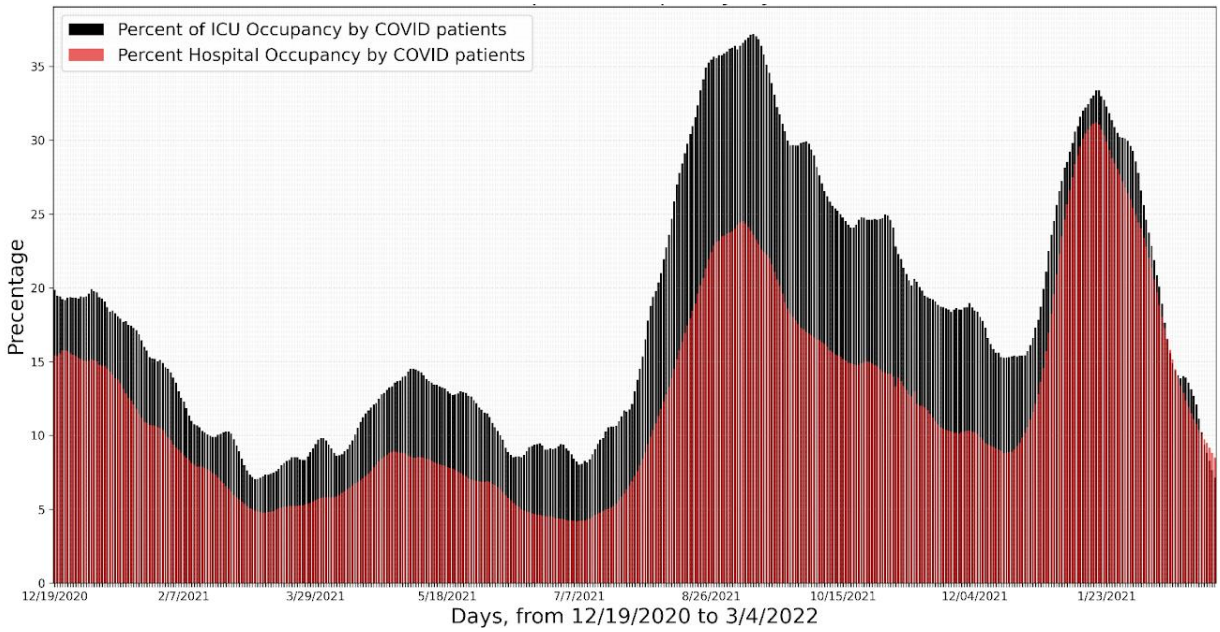


Fig.6 King County's Percentage of ICH/ Hospital Occupancy by COVID Patients. Source: https://doh.wa.gov/emergencies/covid-19/data-dashboard

Based on the data gathered, we can estimate that the CTA used in King County does not have a significant or noticeable effect on Covid Control.

In Shenzhen, due to the clear record of the number of people under quarantine and the number of patients in hospital due to Covid, we can see the detailed change over time. We see that at the beginning of the pandemic, the ratio of number of people in quarantine to people under treatment is lower, while after the Health Code is introduced, the quarantine to treatment ratio has increased, portending a possibility that the Health Code may be impactful in increasing the quarantine/ treatment ratio. However, the "Zero Tolerance" policy also played an important part of boosting the number of people under quarantine.

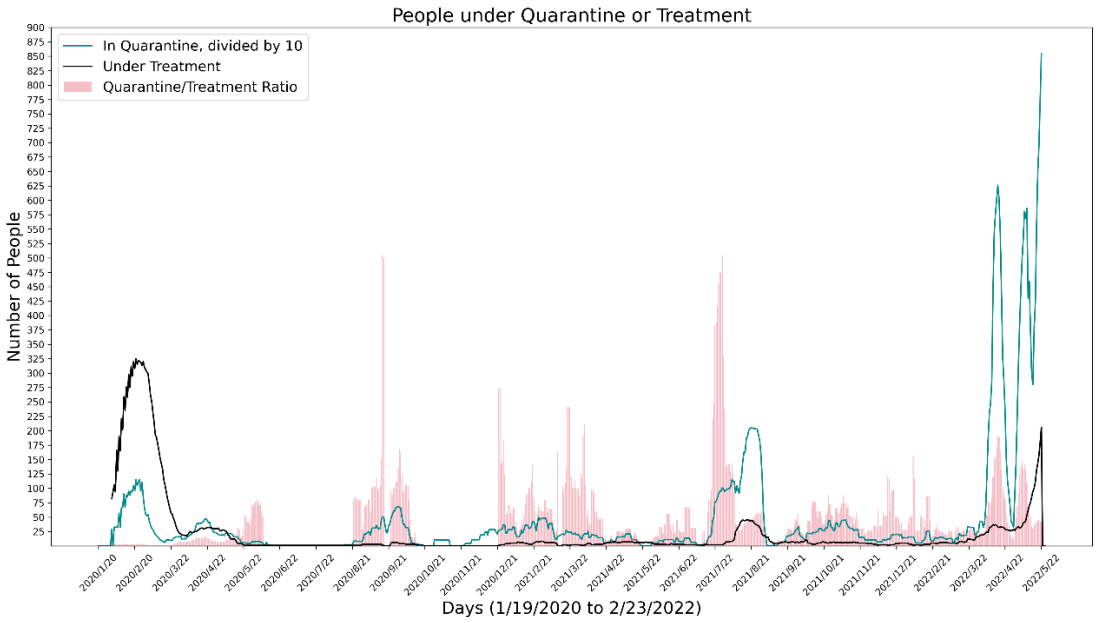


Fig.7 Shenzhen's Number of People Under Quarantine, or Treatment, and the Quarantine/Treatment Ratio

For part three, King County shows a serious health inequality during the Pandemic. The Figure below (Fig.8) shows that the southwestern side of King County is having the highest Covid positive rates and Hospitalization rates, meaning that the residents there not only end up in hospitals more due to Covid, but they also have the highest infection rate over the whole King County. Combined with the studies of the income inequality and racial distribution from the past, we may form a positive relationship between the lower income communities with higher infection rates and Hospitalization rate from Covid Pandemic.

At the same time, the communities living in the areas are mostly minorities including Hispanics, Asians, and Blacks, showing a trend of geographical and health discriminations. Fig.9 shows Covid positive rates by different Ethnicities and Cities. It indicates that the Hispanic and Black people have a higher rate of getting Covid compared to Asian and White people. By scrutinizing the cities, Algona has extremely high positive rates for all the residents, but the White population still has the lowest positive rates compared to the other

races. On the other hand, cities like Seattle show more discrepancies in the positive rates, with Asian and White populations having low positive rates while the Hispanic and Black population have comparatively high positive rates.

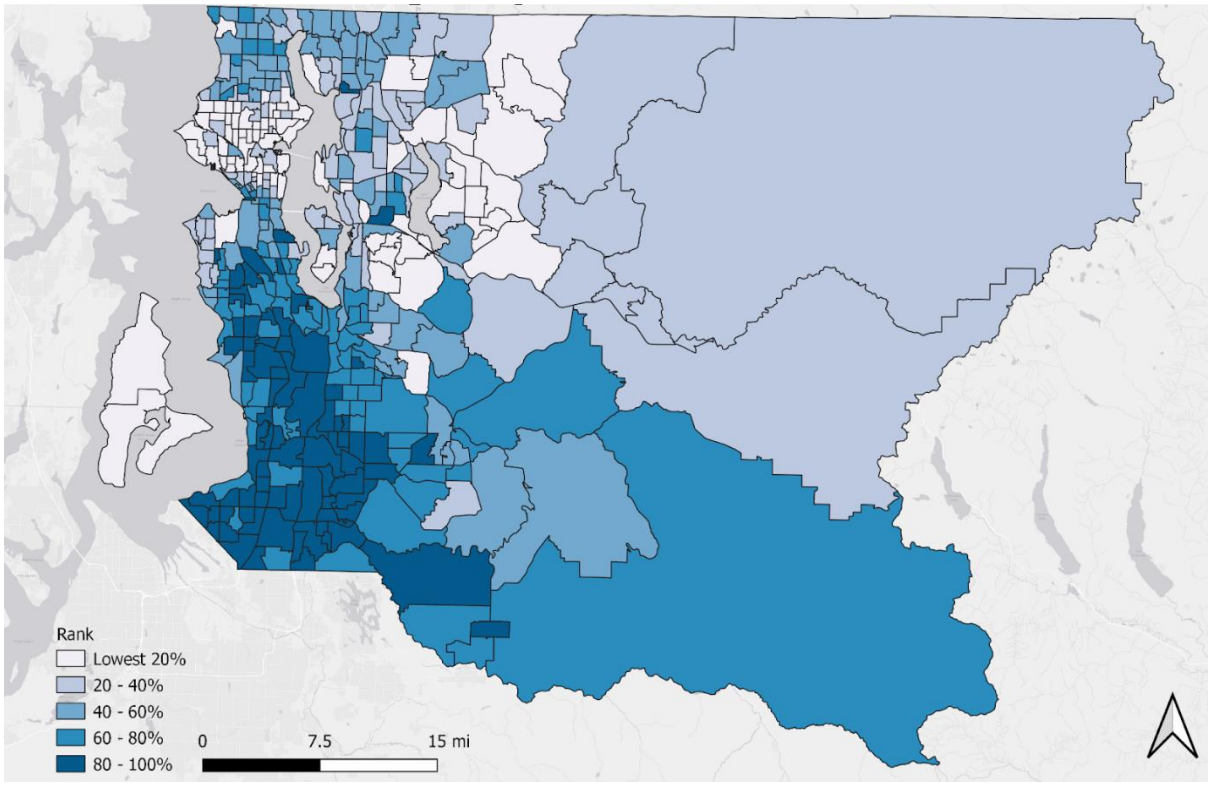


Fig.8 Hospitalization Rate of Covid Patients Times Covid Positive Rate In King County, Based on Census Tracks.
Source: https://kingcounty.gov/depts/health/covid-19/data/summary-dashboard.aspx

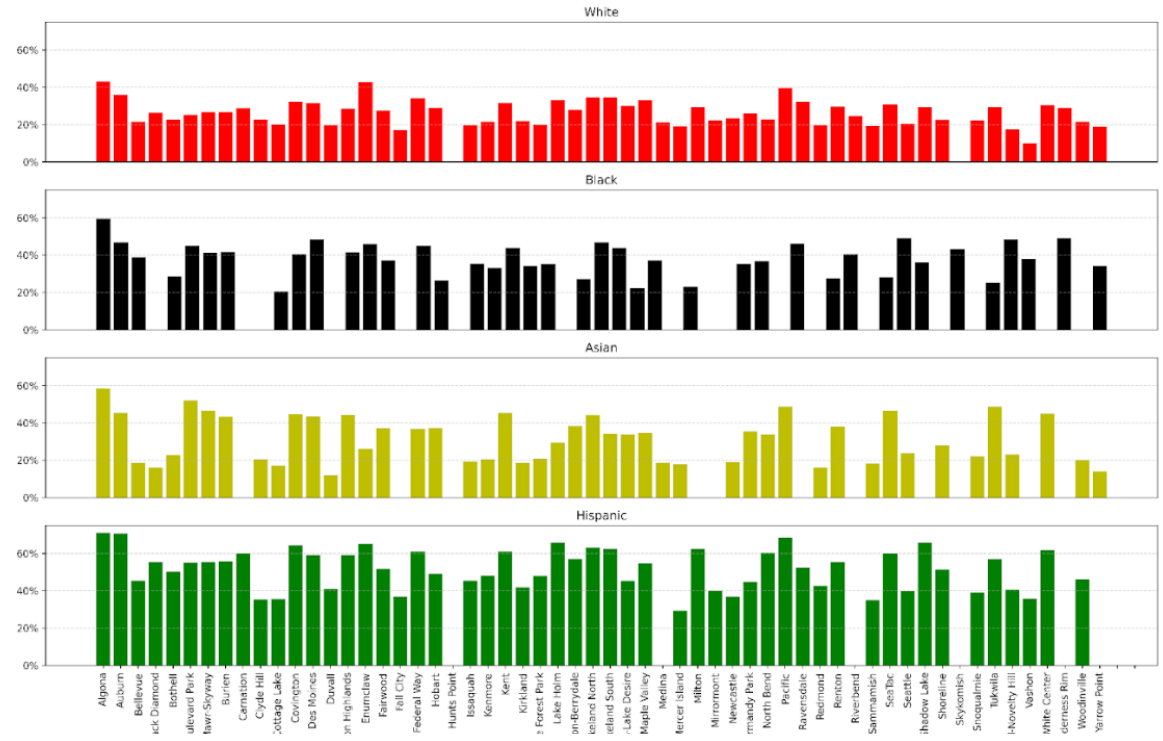


Fig.9 Positive Rate Based on Ethnicity and City in King County (Accumulated Cases), until Feb 28, 2022. Source: https://kingcounty.gov/depts/health/covid-19/data/summary-dashboard.aspx

Beyond inequality between different races and minorities, the Covid pandemic has also shown to have serious damage both on the population of King County as well as the employed population. Fig.10 shows Seattle's number of residents has been steadily growing until the Covid pandemic; the population dropped down by around 25k in 2021, compared to 2020. What's more, the Covid pandemic led to an unprecedented drop in the number of residents employed, causing at least a job loss of 200k, which could be the reason for the population decrease. Even though there is no data for King County's GDP, we can surmise from the number of people employed, which did not fully recover by the end of 2021, that the economic recovery is possibly slower than Shenzhen.

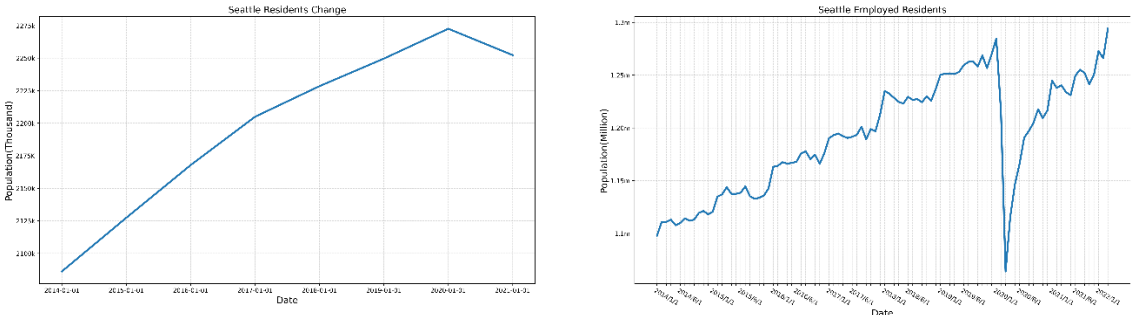


Fig.10 Seattle's Change of Number of Residents and Employed Residents Overtime. Source: https://kingcounty.gov/depts/health/covid-19/data/summary-dashboard.aspx

On the side of Shenzhen, even though there is evidence pointing out that migrant population, or Non-Registered Population (the non-Hukou population, or people with a suburban household registration type), may be affected by the pandemic, we can see that the overall trend of population growth was not affected by the pandemic. The migrant population (Non-registered Population) was also growing(Fig.10); the growing rate of the non-registered population is even higher than the previous year (2018-2019). The overall population, and the Registered Population were also growing steadily as well. The increasing amount of the Non-Registered Population partially points out that Shenzhen was safe during the time and the migrants were enabled to sustain themselves.

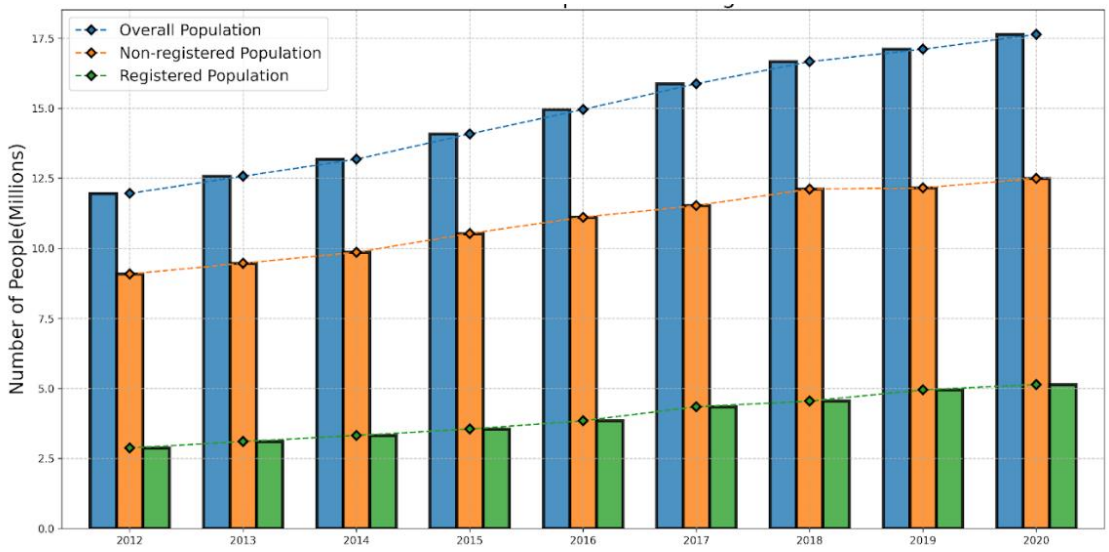


Fig.10 Change of Population in Shenzhen, based on Year. Source: https://opendata.sz.gov.cn/

Regarding the overall economy of Shenzhen, the Covid did put a dent on the economic growth rate of the first month of 2020. The GDP growth rate dropped to around -5% for the first quarter of 2020, and then slowly recovered. By the first quarter of 2021, we can see that the growth rate of the GDP has boosted to more than 15%, meaning that the Covid was fully under control and the economy is bouncing back. Combining Figure 10 and 11, we can see that while Covid did have some impactful damage to Shenzhen, but the economic recovered quickly and the migrants were able to sustain.

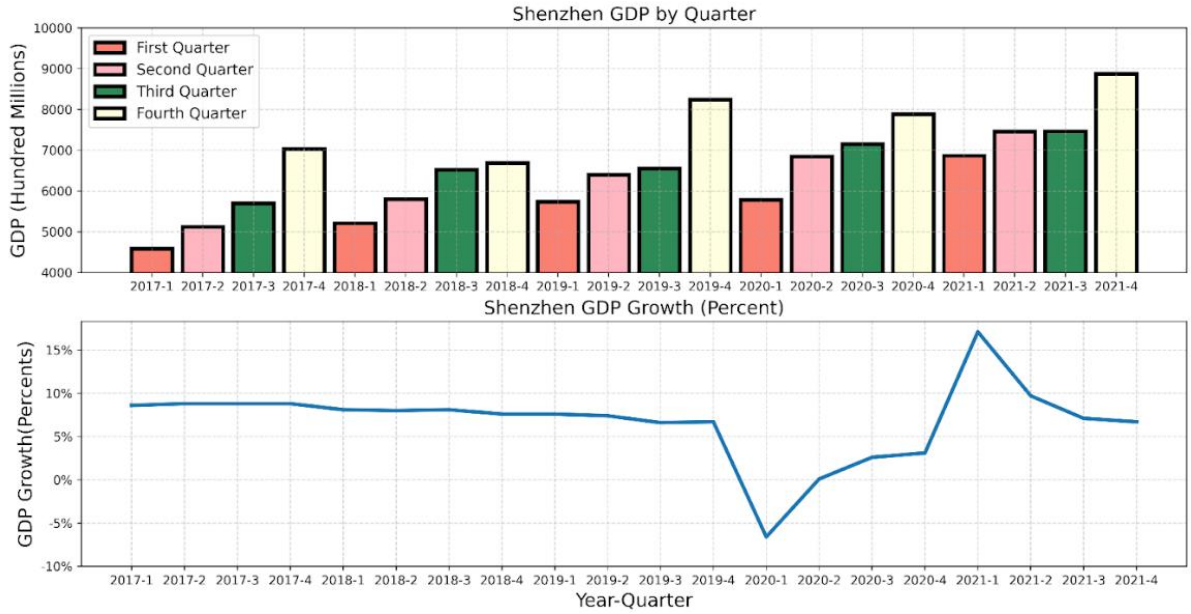


Fig.11 Change of GDP in Shenzhen and its Growth Rate, based on Quarter. Source: https://opendata.sz.gov.cn/

## Conclusion

On the government's policies and response speed, we can see that there is a clear trend that the Shenzhen Government has rules that are stricter compared to the King County government. As a result, the pandemic was quickly under control in Shenzhen but was still spreading in King County. However, as the virus mutates and vaccination rates increase, whether to keep the strict rules has become a contentious issue, and, indeed, keeping conducting the 'zero tolerance' policy is showing a diminishing marginal return.

On the CTA mechanism, the Chinese Health Code, as a small program runs on WeChat, employs GPS, and categorizes people in three different levels, green, red, and yellow; The Health Code is mostly based on WeChat, which does not give users anonymity, and the exclusivity of the Health Code can cause accessibility inconveniences, especially under the context that it's forced to be used by every resident. On the other hand, WA Notify uses Bluetooth technology and most of the user information is anonymous. However, the anonymity of the application brings to the low response speed of applications since users must report themselves so that the application can notify other potential close contacts. What's more, the WA Notify has a comparatively low usage rate (around 70%), making the contact tracking hard and less effective in Covid control.

On the effectiveness of CTA, the available data shows that Shenzhen's usage of CTA may be a factor of the large increase in the number of people under quarantine. But it also helps the government to quickly respond to potential close contacts. For King County, the available data do not show that the CTA has been an effective tool in reducing the number of cases or deaths.

To sum up the third part, the effect that CTA and Covid have on the society, we can see that there is an obvious inequality when it comes to the victims of the Covid pandemic in King County, the minorities are a lot more vulnerable than the White. Among the minorities, Hispanics are the most vulnerable minorities. What's more, the Covid pandemic has led to significant jobs lost, which was not fully recovered until the next year. On the Shenzhen side, due to the lack of statistics and the nature of homogeneity of the city, the possible inequalities may exist on different income levels. However, on a border view of the whole society, the

migration population did not decrease, instead it increased slightly compared to the previous year. What's more, even the economy of Shenzhen was heavily damaged at the first quarter of 2020 but quickly recovered and showed a strong bounce back at the first quarter of 2021.

Comparing the two regions, one can argue that when the pandemic first hit, Shenzhen did a better job in Covid control regarding the population numbers and migrants' self-sustainability, as well as the economic recovery speed. However, we see that while WA Notify, due to its anonymity and voluntary nature, did not show a significant effect on Covid control, Shenzhen's Health Code did show influence on Covid control mostly in the number of people in quarantine, leading to the question that whether this effect has more benefits than its drawbacks. In a broader view, we can portend that the WA Notify was developed more for users that care about their personal health, while the Health Code aims to facilitate the 'Zero Tolerance' Covid policies carried out by the Chinese Government, which once again shows the strong correlation between the government's policies and the purpose of CTAs.

In a boarder view, in a country level, it's obvious that China did a good job in Covid Control in the past due to the strict "Zero Tolerance" policy and the current "Dynamic Covid zero" policy, but now as the virus is getting more contagious yet less lethal, we see more Covid leakages and outbreaks in Chinese cities such as Shenzhen and Shanghai. Sticking to the 'Zero Tolerance' policy starts to show diminishing benefits as the cost of tracking every case adds up quickly. While on the other side, the U.S. focuses more on reducing the harm of Covid and recovering the economy, which did not work well at first based on the charts above. But as the virus gets less lethal, it's becoming more beneficial. However, because the mutation of Covid will not stop and the side effects of Covid are still unclear (Lopez-Leon et

al., 2021), precautions can never be wrong, and decisions should be made based on the priorities of the country's people and government.

To give some suggestions, according to the Weekly epidemiological update on COVID-19 - 12 April 2022 by WHO, "the global public health risk remains very high" and, despite the reduction in severity, there are higher numbers of hospitalizations due to the increasing cases with Omicron, putting further pressure on healthcare systems, and in some countries, there are similar or higher numbers of deaths when compared to previous peaks. For now, bearing the uncertainty of the side effects of Covid and its possible mutations, a layered or staged approach to relaxation is recommended by the WHO. A complete relaxation in Public Health and Social Measures (PHSM) can lead to the erosion of public trust and PHSM may not be easily re-implemented should the future need arise (WHO, 2022). In a layered or staged approach to relaxation can possibly maximize the power of CTAs as it can be used a tool for the government to quickly establish stricter PHSM, like the case in Shenzhen, and for residents for their personal health as the case in King County.

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