Original Research

Mitigation policies, community mobility, and COVID-19 case counts in Australia, Japan, Hong Kong, and Singapore

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ARTICLE INFO

ABSTRACT

Objectives: The objective of the study was to characterize the timing and trends of select mitigation policies, changes in community mobility, and coronavirus disease 2019 (COVID-19) epidemiology in Australia, Japan, Hong Kong, and Singapore.
Study design: Prospective abstraction of publicly available mitigation policies obtained from media reports and government websites.
Methods: Data analyzed include seven kinds of mitigation policies (mass gathering restrictions, international travel restrictions, passenger screening, traveler isolation/quarantine, school closures, business closures, and domestic movement restrictions) implemented between January 1 and April 26, 2020, changes in selected measures of community mobility assessed by Google Community Mobility Reports data, and COVID-19 epidemiology in Australia, Japan, Hong Kong, and Singapore.
Results: During the study period, community mobility decreased in Australia, Japan, and Singapore; there was little change in Hong Kong. The largest declines in mobility were seen in places that enforced mitigation policies. Across settings, transit-associated mobility declined the most and workplace-associated mobility the least. Singapore experienced an increase in cases despite the presence of stay-at-home orders, as migrant workers living in dormitories faced challenges to safely quarantine.
Conclusions: Public policies may have different impacts on mobility and transmission of severe acute respiratory coronavirus-2 transmission. When enacting mitigation policies, decision makers should consider the possible impact of enforcement measures, the influence on transmission of factors other than movement restrictions, and the differential impact of mitigation policies on subpopulations.

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Introduction

The rapid spread of SARS-CoV-2, the virus that causes coronavirus disease 2019 (COVID-19), left countries with little recourse but to adopt layered policies over time to mitigate the virus' impact while researchers investigated therapeutics and vaccines. In the absence of medical interventions, a range of nonpharmaceutical interventions (NPIs) have been used, including international travel restrictions, traveler screening at ports of entry, border closures, domestic movement restrictions, school and business closures, physical distancing, and hand hygiene.[1,2] Public policies

implemented to support these and other mitigation measures aimed to prevent importation of the virus, limit mobility, and decrease opportunities for virus transmission. The use of international travel restrictions and wholesale limitations on domestic movement is unprecedented and either not mentioned in guidance or presented as an extreme policy option to be taken with great consideration.[3,4]

Countries have taken myriad approaches to the use of NPIs to address the threat of COVID-19. With little data about SARS-CoV-2, policy makers responded as they might to pandemic influenza.[5] Although international travel-related restrictions have been shown to delay but not prevent the spread of influenza once seeded in a country, many countries imposed and maintained travel restrictions despite having local transmission of SARS-CoV-2.[6–8] Other countries have taken few, if any, steps to mitigate the spread of the virus.[9,10] In an effort to limit mobility and eventually

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social mixing and disease exposure, many countries closed schools and non-essential businesses.[11,12] Particularly in countries with community transmission, these policies were often followed by stay-at-home orders to limit exposure even further.[13] Such a layered approach in the application of mitigation policies draws on lessons learned from the 1918 influenza pandemic, as well as the severe acute respiratory syndrome outbreak and H1N1 pandemic.[14–16]

The effect of NPIs in the context of COVID-19 is still being investigated. Studies have shown that mitigation policies can slow the spread of COVID-19, although the extent of the effect differs by setting.[17,18] For example, mobility has been shown to decline in some settings after implementation of mitigation policies. In addition, each policy may come with a human cost and a cost to the economy, now and in the future. It is estimated that global gross domestic product will contract by 5.2% in 2020, and it may take time to recover lost jobs and time in school.[19,20] School closures and stay-at-home orders may further inflict a cost on children and adults through increased interpersonal violence and decreased access to food.[21–23] Governments are weighing their ability to stem disease transmission with their implications for the economy.[19,20,24]

More information is needed to describe the effectiveness of mitigation policies in diverse settings. To this end, we characterized the timing and trends of select mitigation policies, changes in community mobility, and COVID-19 epidemiology in Australia, Japan, Hong Kong, and Singapore. These locations were among the first in the world to report COVID-19 cases, are close in proximity, used different policy approaches, and all saw their epidemic peak during the study period.

Methods

Seven kinds of policy measures to support SARS-CoV-2 mitigation—mass gathering restrictions, international travel restrictions, passenger screening, traveler isolation/quarantine, school closures, business closures, and domestic movement restrictions—implemented by government authorities between January 1 and April 26, 2020, were abstracted from media reports and government and United Nations websites. These data were examined in conjunction with daily new case counts. Daily new case counts starting from January 22, 2020, were extracted from the COVID-19 dashboard maintained by the Center for Systems Science and Engineering at the Johns Hopkins University.[25] A three-day moving average of the daily case count was calculated to account for changes in testing and reporting. Mobility data beginning February 15, 2020, were obtained from Google's Community Mobility Reports; these provide country- and territory-level information on the percentage change in visits to or time spent in six location types compared with each country's baseline or median level of activity on that day of the week from January 3 to February 6, 2020.[26] The baseline period was determined by Google Community Mobility Reports and cannot be modified by users. Visits to and time spent in locations were tracked among smartphone users who turned on their phone's location history setting.[26] Three mobility measures were selected for analysis: visits to retail and recreation, transit stations, and workplaces. Other measures—parks, residential, and groceries and pharmacies—were not included as we would expect visits to parks to increase as other venues closed, as well as more time spent in residential areas. Because groceries and pharmacies provide essential services, these were also excluded.

Four countries or territories were identified for analysis to reflect different mitigation strategies and epidemics: Australia, Japan, Hong Kong, and Singapore. These locations were chosen due to the relatively early date of their first detected COVID-19 case and because differences in mitigation policy responses and the ensuing

epidemiologic patterns may inform application of these policies elsewhere. In addition, as neighbors in the East Asia Pacific Region, governments and residents may be influenced by events unfolding in their neighbors.

To visually represent the effects that mitigation measures might have on community mobility and on the incidence of COVID-19 mitigation over time, mobility, and COVID-19 epidemiology (MME), graphics were developed for each country.[27]

The protocol was reviewed according to the Centers for Disease Control and Prevention's (CDC) human research protection procedures and was determined not to be research.

Results

Australia, Japan, Hong Kong, and Singapore all reported their first COVID-19 cases in January 2020.[25] By April 26, 2020, the end of the study period, Australia reported 6714 cases and 83 deaths, with the number of cases reported per day peaking at 500 on March 28.[28] Japan reported 13,441 cases and 372 deaths. Its epidemic peaked on April 17, with 1161 cases reported.[28] Hong Kong reported 1037 cases and four deaths, with the epidemic peaking with 80 cases reported on March 29.[28] Singapore reported 13,624 cases and 12 deaths, with the number of cases reported per day peaking at 1426 on April 20.[28]

Australia enacted its first non-travel–related mitigation policy, a ban on gatherings of more than 500 people, on March 15, 2020, approximately two weeks after identification of its first case (Fig. 1). A succession of other policies over the next two weeks reduced the size of permitted gatherings, banned entry of non-residents, extended the summer school holiday, and recommended that the elderly, chronically ill, and indigenous people remain at home (Table 1). On April 5, the states of New South Wales, Queensland, Victoria, and Tasmania, which together account for 80% of Australia's population and 83% of national COVID-19 cases on that date, instituted mandatory stay-at-home orders.[29,30] The largest declines in the targeted mobility outcomes occurred on April 10, a national holiday, and ranged from 76% to 82% below baseline. Australia's mitigation policies were generally requirements rather than recommendations and included penalties for non-compliance. The rapid application of increasingly restrictive mitigation policies was followed by a gradual decline in mobility, with the largest change occurring in public transit-associated mobility (median 45% decrease).

Japan implemented its first international travel restriction on January 21, 2020 (Fig. 2). Mass gatherings were restricted on February 25, but a limit on the size of the gathering was not set (Table 1). On February 27, Prime Minister Shinzo Abe asked primary and secondary schools to close starting March 2; a stay-at-home request was made on March 26 for residents of Tokyo and was extended nationally on April 16. These policies were non-mandatory requests. Community mobility in Japan began declining in late February, then remained stable for one month before beginning a slow and consistent decline around the time of Tokyo's requested stay-at-home order. The largest declines in the targeted mobility outcomes occurred on April 18 and ranged from 26% to 60% below baseline. Although Japan experienced a decrease in daily cases, relative to the implementation of mitigation policies the decline occurred later than Australia's.

In Hong Kong, a policy instituted on January 29, 2020, called for non-essential civil servants to work from home and sports, cultural, and leisure facilities to close (Fig. 3). Primary and secondary schools were closed on February 3. After daily case counts had remained below 15 for more than one month, civil servants returned to their offices on March 2, followed by the reopening of sports, cultural, and leisure facilities (Table 1). Mobility remained below baseline
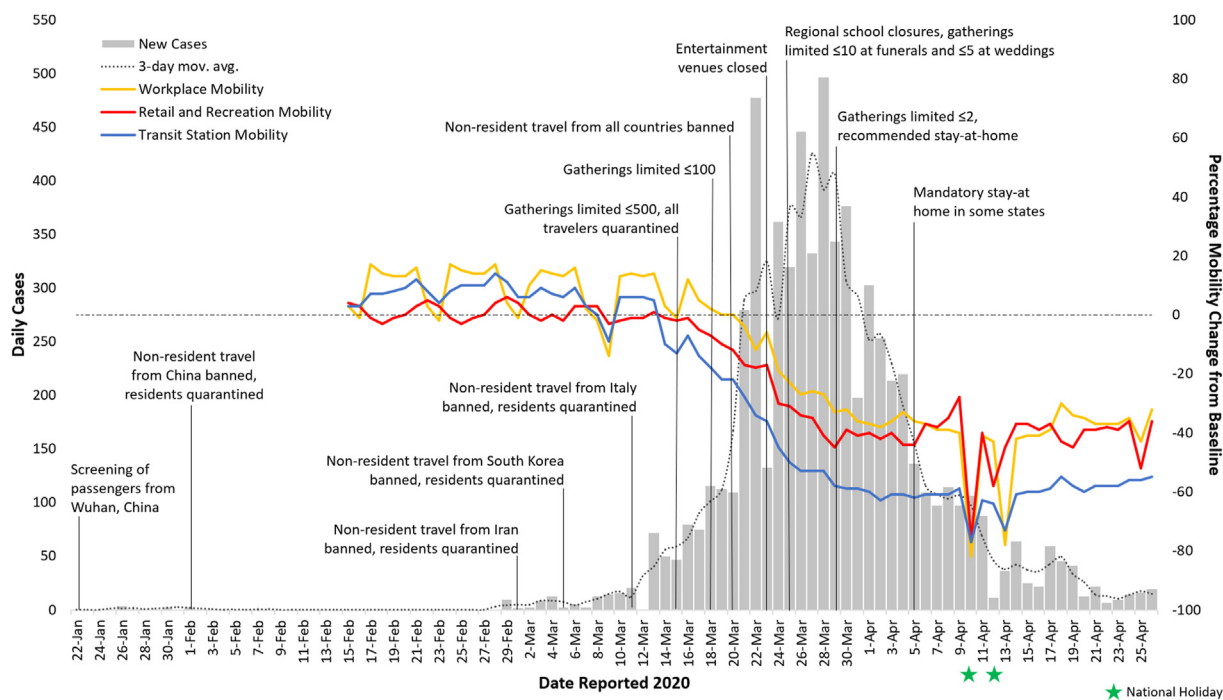
Fig. 1. Coronavirus disease 2019 (COVID-19) mitigation, mobility, and epidemiology in Australia, January 21–April 26, 2020.

and relatively stable, declining to a low of 26–60% below baseline, as case counts increased and mitigation policies were reapplied. The number of daily cases peaked on March 29, the same day that gatherings of more than four people were banned. Bars were closed five days later. Daily case counts declined to less than 10 per day by mid-April.

Singapore restricted mass gatherings of more than 250 people on March 13, 2020. On March 26, the ban was applied to gatherings of >10 people, and some businesses were closed (Fig. 4). The enactment of these policies was followed by declines in mobility outcomes from 10% to 40% below baseline. During the week of April 7, gatherings of any size were banned, non-essential businesses were closed, schools and universities were closed, and a national stay-at-home order was issued (Table 1). Mobility outcomes fell sharply by 63–83% below baseline. However, Singapore experienced an increase in daily cases with a peak of 1426 cases on April 20. Many of these cases were in migrant workers living in dormitories housing upward of 20 people per room.[31]

Discussion

Our findings reveal that mitigation policies were followed by decreases in the mobility outcomes of interest. Across settings, transit-associated mobility declined the most and workplace-associated mobility the least. Between January 1 and April 26, 2020, Australia, Japan, Hong Kong, and Singapore took varied approaches to implementing similar policies to mitigate the spread of COVID-19. Policies were implemented at different times, including after the peak in daily cases, and in Hong Kong, some policies were lifted and reapplied in responses to fluctuations in daily reported cases. The later epidemic peaks in Japan and Singapore, approximately three weeks after the peaks in Australia and Hong Kong, may reflect the consequences of different mitigation strategies.

Changes in mobility and case counts after the implementation of mitigation policies were uneven, possibly reflecting differences in

enforcement, differential ability of specific subpopulations to adhere to the policies, and the impact of changes in practices by individuals, business, and civic organizations in response to media coverage and personal risk assessment. For example, greater reductions in mobility in Australia compared with Japan might reflect the differential enactment and enforcement of policies in these two countries, with Australia enacting mandatory restrictions, while Japan made recommendations. Singapore's experience of business closures and stay-at-home orders highlights that mitigation policies may not be equally effective for all groups within a population. Memories of the 2003 severe acute respiratory syndrome outbreak may have aroused people in Hong Kong and Singapore to take preemptive measures and limit mobility before the implementation of mitigation policies.

Mitigation policies can be enhanced through careful consideration to avoid inadvertently increasing risk of SARS-CoV-2 transmission among subpopulations. They can also be tailored for subpopulations, and resources can be provided to enhance the ability of subpopulations to adhere to policies.[32] Migrants may similarly benefit from special policies to protect them from COVID-19 and increase their access to health services during the pandemic.[33]

Our findings suggest an association between the implementation of select mitigation policies and subsequent changes in relevant mobility outcomes. These findings are limited by our inability to attribute changes in mobility to a single mitigation policy. Furthermore, mobility measures may not fully reflect changes, for example, in physical distancing, that impact the degree of contact between people. Further research is necessary to assess the association between mobility and SARS-CoV-2 transmission and to determine the types and degree of changes in mobility needed to achieve a certain level of reduction in SARS-CoV-2 transmission. The application of other mitigation policies, including personal measures such as increased handwashing and the wearing of masks, or engineering controls, such as barriers between cashiers and customers or the use of markers on the ground to indicate

Table 1
Public policies to support mitigation of SARS-CoV-2 transmission and dates of implementation—Australia, Japan, Hong Kong, and Singapore, January 21–April 26, 2020.

Mitigation policy	Australia	Japan[a]	Hong Kong	Singapore
Screening of passengers from Wuhan, China	January 22	January 21	January 3	January 3
Travel ban for non-residents	February 1: traveling from China	February 1: traveling from Hubei Province	January 27: traveling from Hubei Province	February 1: traveling from China
	March 1: traveling from Iran	March 9: traveling from China or South Korea	February 25: traveling from South Korea	March 4: traveling from South Korea, Iran, northern Italy
	March 5: traveling from South Korea March 11: traveling from Italy March 20: traveling from all countries	March 19: traveling from all high-risk countries	March 25: traveling from all countries	March 15: traveling from Italy, France, Spain, Germany
Traveler quarantine/isolation for 14 days upon arrival	February 1: traveling from China	March 9: traveling from China or South Korea	February 8: traveling from China	January 22: traveling from China
	March 1: traveling from Iran	March 14: traveling from all high-risk countries	February 25: traveling from South Korea	
	March 5: traveling from South Korea March 11: traveling from Italy		March 1: traveling from Italy or Iran March 14: traveling from France, Germany, Japan, Italy	March 4: traveling from South Korea, Iran, northern Italy
	March 15: traveling from all countries		March 19: traveling from all countries	March 15: traveling from Italy, France, Spain, Germany March 16: traveling from member countries of the Association of Southeast Asian Nations, Japan, Switzerland, United Kingdom April 9: traveling from all countries
Size limitations on gatherings	March 15: limiting to ≤500 March 18: limiting to ≤100 March 25: limiting to ≤10 at funerals, ≤5 at weddings March 29: limiting to ≤2	February 25: public gatherings	January 25: public gatherings March 29: limiting to ≤4	February 8: public gatherings March 13: limiting to ≤250 March 26: limiting to ≤10 April 7: complete restriction on mass gatherings
Non-essential business closures	March 23: entertainment venues closed	March 10: entertainment venues closed April 8[b]: all non-essential businesses	January 29: entertainment venues and non-essential government workers **March 2: civil servants return to work**[c] **March 11: reopening of entertainment venues** March 23: entertainment venues closed April 3: bars closed	March 26: entertainment venues closed April 7: all non-essential businesses
School closures	March 25[b]	March 2	February 3	April 8
Stay-at-home order	March 29: recommendation (stronger recommendation also issued for elderly, chronically ill, and indigenous populations) April 5[b]: mandatory	March 26[b]: recommendation for Tokyo April 16: recommendation	NR	April 9: recommendation

NR = none reported.
[a] Japan's limits on mass gatherings, business closures, and stay-at-home orders are recommendations, not mandatory orders.
[b] Regional.
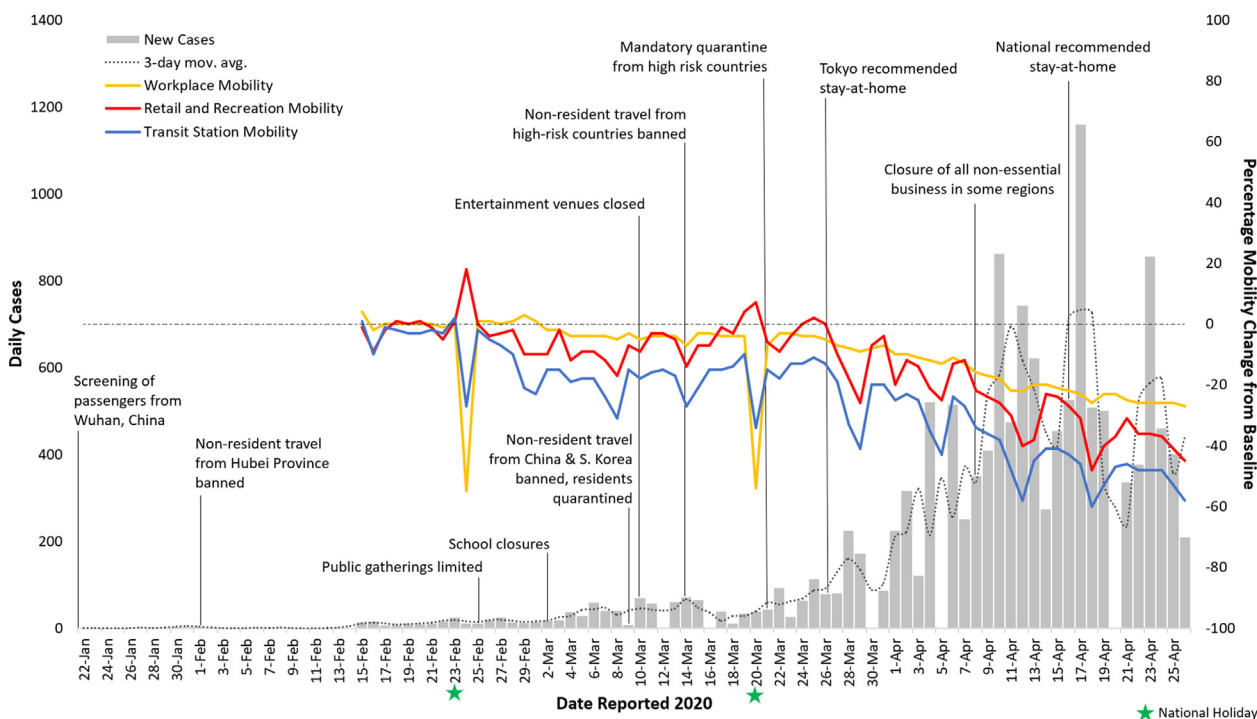[c] Bold font signifies the lifting of policies.

Fig. 2. Coronavirus disease 2019 (COVID-19) mitigation, mobility, and epidemiology in Japan, January 21–April 26, 2020.
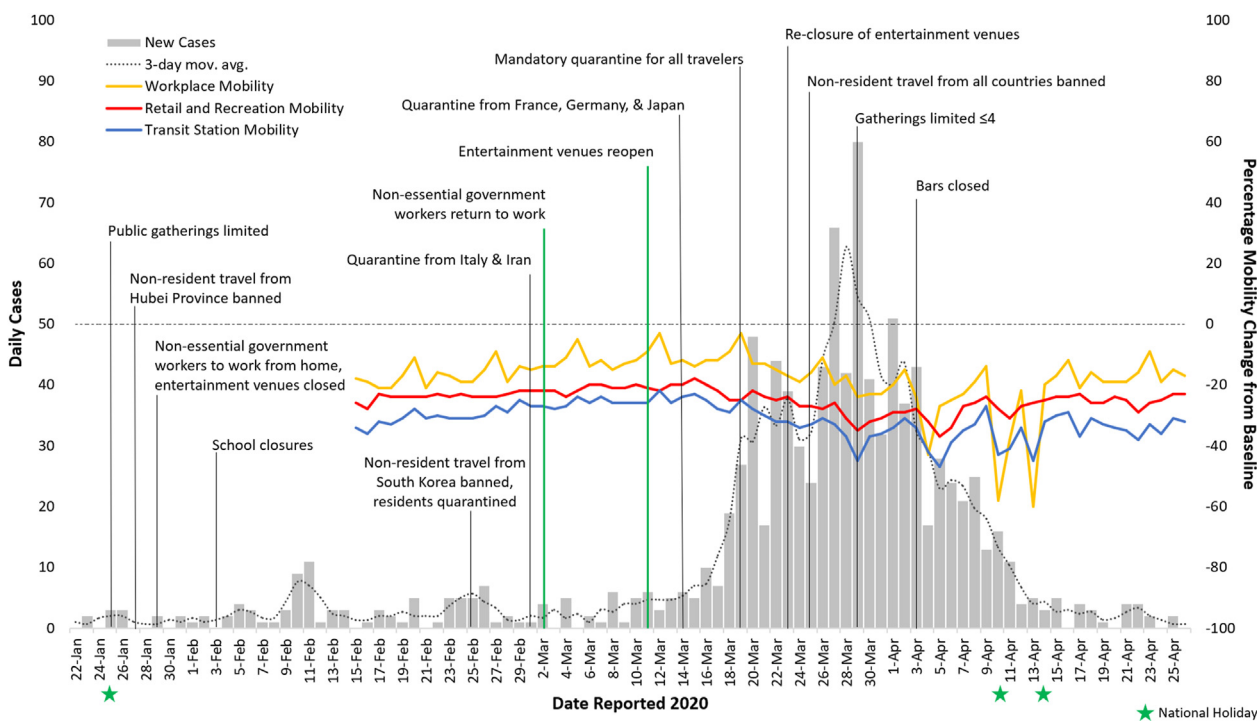

Fig. 3. Coronavirus disease 2019 (COVID-19) mitigation, mobility, and epidemiology in Hong Kong, January 21–April 26, 2020. *Green bars indicate lifted policies

where people in a queue should stand, may further modify the effect of mobility by making interactions safer.

Our analysis is also limited by restricting it to locations that experienced a peak in the epidemic and by our use of national mobility data and case counts which may obscure subnational variations. Potential variation in the implementation of

subnational policies that may have influenced mobility patterns similarly limits a complete assessment of the role of mitigation policies on mobility. Although mobile phone use is high in Australia, Japan, Hong Kong, and Singapore, it is not universal, and specific subpopulations may not be accurately reflected in Google Community Mobility data. Younger and better educated persons in
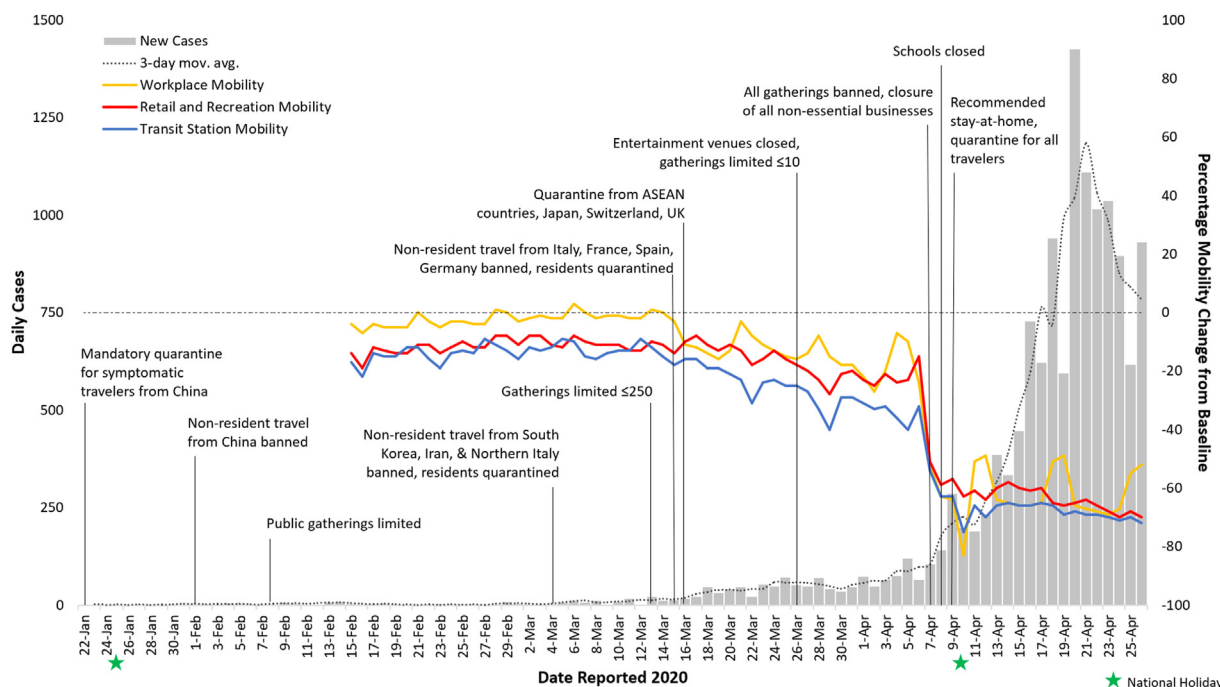
Fig. 4. Coronavirus disease 2019 (COVID-19) mitigation, mobility, and epidemiology in Singapore, January 21—April 26, 2020.

Australia and Japan are most likely to own a smartphone.[34] The same is likely true in Hong Kong and Singapore where mobile phone penetration is more than 100%.[35,36] Moreover, the number of people and geographic distribution of people represented by these data is unknown. Data from media sources may inadvertently include errors.

In Hong Kong, non-essential government workers were told to work from home beginning January 29. Entertainment venues were closed the same day, and on February 3, schools were closed. Any changes in mobility resulting from these policies and occurring through February 6 would have been part of the baseline. As such, it is possible that Hong Kong experienced a greater change in mobility than we have reported due to Google's baseline period.

Changes in mobility may differ by locality based on the number of cases reported. In addition, comparison of mitigation and mobility to trends in case counts did not account for the effects of case isolation, contact tracing, and quarantine of contacts. Finally, there are many reasons that case counts may be incomplete, including related to testing policies and testing capacity.

Our findings highlight seven kinds of mitigation policies governments may enact and the trajectories that epidemics may take. Monitoring mitigation, mobility, and epidemiology graphs (Figs. 1—4) may help inform countries considering applying or lifting mitigation policies to address COVID-19.[37] MME graphs can provide users with a sense of how mitigation policies are affecting the COVID-19 pandemic. This can inform decision makers as they apply or reapply mitigation policies as part of the response to the COVID-19 pandemic. However, implementation of mitigation policies, changes in community mobility, and daily COVID-19 case counts varied; differences may be explained in part by differences in enforcement, changes in prevention practices that are not related to imposed restrictions, and differential ability to adhere to policies by different subpopulations. Policy makers can consider these factors, as well as the time delay between policy enactment, mobility and other behavior change, and changes in daily case counts when considering policy actions.

Author statements

Ethical approval

The CDC determined that this project did not require ethical approval.

Competing interests

None declared.

Disclaimer

The findings and conclusions of this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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