COVID-19 in Hong Kong: Policies and community actions mitigate the effects of age structure and population density

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Abstract

Despite the various socio-demographic vulnerabilities of Hong Kong to the COVID-19 pandemic, the city has successfully managed four waves of local outbreaks, as shown by its comparatively low numbers of confirmed cases and deaths. In this paper, we identify and differentiate the unique characteristics of Hong Kong's COVID-19 outbreaks from those of other territories, and analyse the factors that shaped these characteristics. In particular, we examine four local demographic factors – older age structure, high population density, poor housing conditions and a large migrant population – which, according to current scientific evidence, would likely indicate that the city faces a relatively high risk of the significant spread of COVID-19. We analyse and explain how multiple policies related to border controls, social distancing, testing and tracing, partial lockdowns and housing management, as well as sustained community actions, helped to mitigate the effects of these significant disadvantages.

Keywords: COVID-19; age structure; population density; policy responses; community action; Hong Kong

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1 Introduction

This paper examines and explains the extent to which demographic insights can shed light on the nature of the spread of COVID-19 in Hong Kong, Special Administrative Region of the People's Republic of China (hereafter "Hong Kong"). Hong Kong has some of the world's most densely populated neighbourhoods, and a rapidly ageing population. Based on the current scientific evidence, these factors should indicate that Hong Kong is highly vulnerable to severe outbreaks of the virus. Nonetheless, compared to the global average, the total numbers of confirmed positive cases of COVID-19 in Hong Kong have been very low. As of 28 February 2021, there had been 11,006 positive confirmed cases of COVID-19 out of a population of approximately 7.5 million people residing in an area of 1,104 square kilometres. In addition, mortality rates from COVID-19 in Hong Kong have been low relative to global averages, in terms of both population mortality and case fatality rates. We analyse and explain how, in the face of these demographic vulnerabilities, well-targeted government policies combined with community actions helped to mitigate the serious spread of the virus in Hong Kong.

Kowloon is the most densely populated area in the city and in the world, with approximately 48,930 persons per square kilometre (United Nations, Department of Economic and Social Affairs, Population Division, 2019). The "housing problem" – i.e., a lack of affordable homes of reasonable quality and size – is a critical and, at times, seemingly intractable, social and policy issue in Hong Kong. By some estimates, the ratio of house prices to median wages in Hong Kong is by far the highest in the world (Cox, 2021). Hong Kong also has an ageing population, with people in the 65 and older age group comprising about one-fifth (19.1%) of the city's total population in 2020. In addition, Hong Kong has one of the highest life expectancies in the world, at 82.9 years for males and 88.0 years for females (Census and Statistics Department, 2021).

Despite these potential vulnerabilities, Hong Kong appeared to have the first wave of the virus "under control" by late April 2020, less than three months after the first case was reported on 23 January 2020. From April to mid-July 2020, the rate of the spread of the virus was low, with the number of daily recorded positive cases of COVID-19 ranging from zero to 30 (Figure 1). In mid-July, the third wave of the pandemic began in Hong Kong. By late August 2020, the pandemic had again been brought "under control", with the number of cases declining to fewer than 20 per day. A prolonged fourth wave began in November 2020, and continued until late February 2021, when the local spread of COVID-19 appeared to have returned to low levels, with the number of new cases again falling to fewer than 20 per day.

Our research paper published in May 2020 highlighted the unique age structure of positive COVID-19 cases in the first and second waves of the outbreak in Hong Kong (Cruz et al., 2020). Despite Hong Kong's rapidly ageing population, the cases in the city were initially concentrated among the younger age groups, with the highest incidence of cases reported in the 15–24 age group. Our analysis of detailed case and travel history data highlighted the large proportions of imported cases in Hong Kong's first and second waves, and emphasised the contributions of return

Figure 1:
Number of daily confirmed cases by transmission type and waves and seven-day averages, Hong Kong (*n* = 11,006, 23 January 2020 to 28 February 2021)
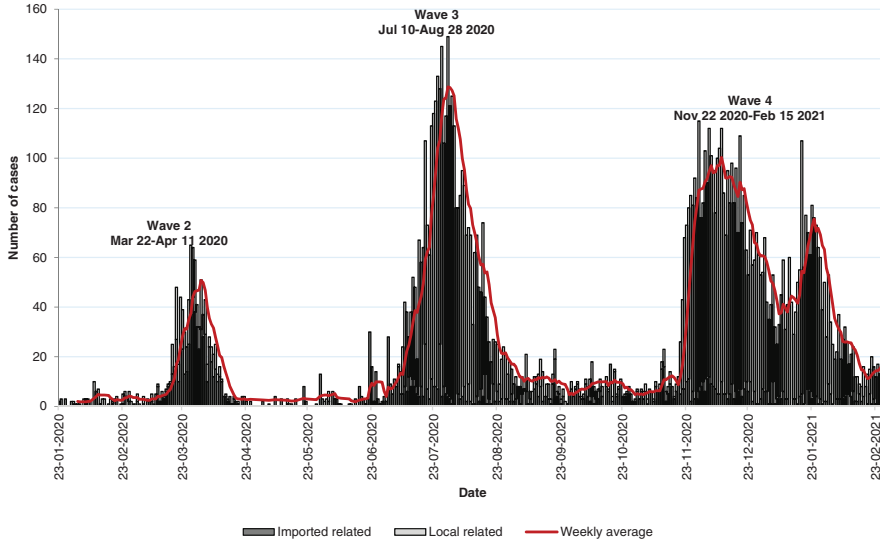
Data source: Hong Kong Center for Health Protection, Department of Health.

Note: The seven-day averages are the authors' own calculations.

migration to the spread of COVID-19, with large numbers of students and working-age citizens returning from emerging pandemic hotspot countries overseas. In this paper, we update those findings by compiling detailed case data in order to assess the shifts in demographic characteristics in the subsequent waves.

The paper is organised as follows. First, we explain the data and methods we used to conduct our analyses. Second, we present the characteristics of Hong Kong's COVID-19 outbreaks, and analyse the influence of socio-demographic factors on Hong Kong's vulnerability to the spread of the virus. We then examine and explain how local policy responses and social norms have shaped Hong Kong's unique experience of the pandemic. In particular, we discuss the contributions of border controls, quarantine requirements, social distancing measures, testing and tracing regimes, housing management, partial lockdowns, the efficient health care system, nursing home management and community actions.

2 Data and methods

Data on positive COVID-19 cases were drawn from the Centre for Health Protection (CHP) of the Hong Kong Department of Health. We reviewed the daily confirmed cases and the transmission types (local, local-related or imported-related), as well

as the trend of the cumulative cases by age group from 23 January 2020 to 28 February 2021. Then, we calculated the seven-day averages of confirmed cases, which became our basis for defining the COVID-19 waves in Hong Kong. We defined these waves using a weekly average cut-off of 20 cases; i.e., a wave begins in the first week in which the average number of weekly cases is above 20, and ends in the week in which the average number of weekly cases falls below 20. Using this classification, we defined three waves of the pandemic, as shown in Figure 1. Wave 2 is from 22 March to 11 April 2020 (n = 683), Wave 3 is from 10 July to 28 August 2020 (n = 3,403) and Wave 4 is from 22 November 2020 to 15 February 2021 (n = 5,228). The officially defined "first wave" was excluded from our discussion because of the relatively small number of confirmed COVID-19 cases (fewer than 10 cases) that were reported during this period.

For each wave, we assessed the age and the sex distribution of the confirmed cases, and the mortality status of these cases. We calculated and analysed the overall case fatality rate (CFR) and broke it down by age and sex. The data on the geographical location of all known confirmed cases were drawn from the Centre for Health Protection Geodata dashboard. We also gathered data on the policy measures implemented in Hong Kong from government websites. For our comparative demographic analyses, we utilised the population estimate for the end of 2020 from the Hong Kong Census and Statistics Department.

3 Characteristics of Hong Kong's COVID-19 outbreaks

3.1 The shifting age profile of COVID-19 cases

Looking at Figure 2, we can see that there were major changes in the age structure of the cumulative confirmed cases in Hong Kong during our research period. Among the seven age groups, we observed the most drastic changes for the 15–24 and 65 and older age groups. Over time, the older population (aged 65+) replaced the younger population (aged 15–24) as the age group in Hong Kong with the highest proportion of total confirmed cases. By the end of the second wave (11 April 2020), the 15–24 age group accounted for 27.47% of the 1,001 cumulative confirmed cases; whereas the 65 and older age group accounted for just 7.69% of the total cases. However, by the end of the fourth wave (15 February 2021), the proportion of the 10,789 cumulative confirmed cases that were in the 15–24 age group had dropped to 10.35%, while the proportion that were in the 65 and older age group had risen to 17.78%.

We grouped the COVID-19 confirmed cases by waves, and in Figure 3 we present three comparable pyramids. Despite Hong Kong's rapidly ageing population, the confirmed COVID-19 cases in Wave 2 were initially concentrated among the younger age groups, with the largest incidence of cases reported in the 15–24 age group. Thus, we observed that during the first and second waves of COVID-19 in
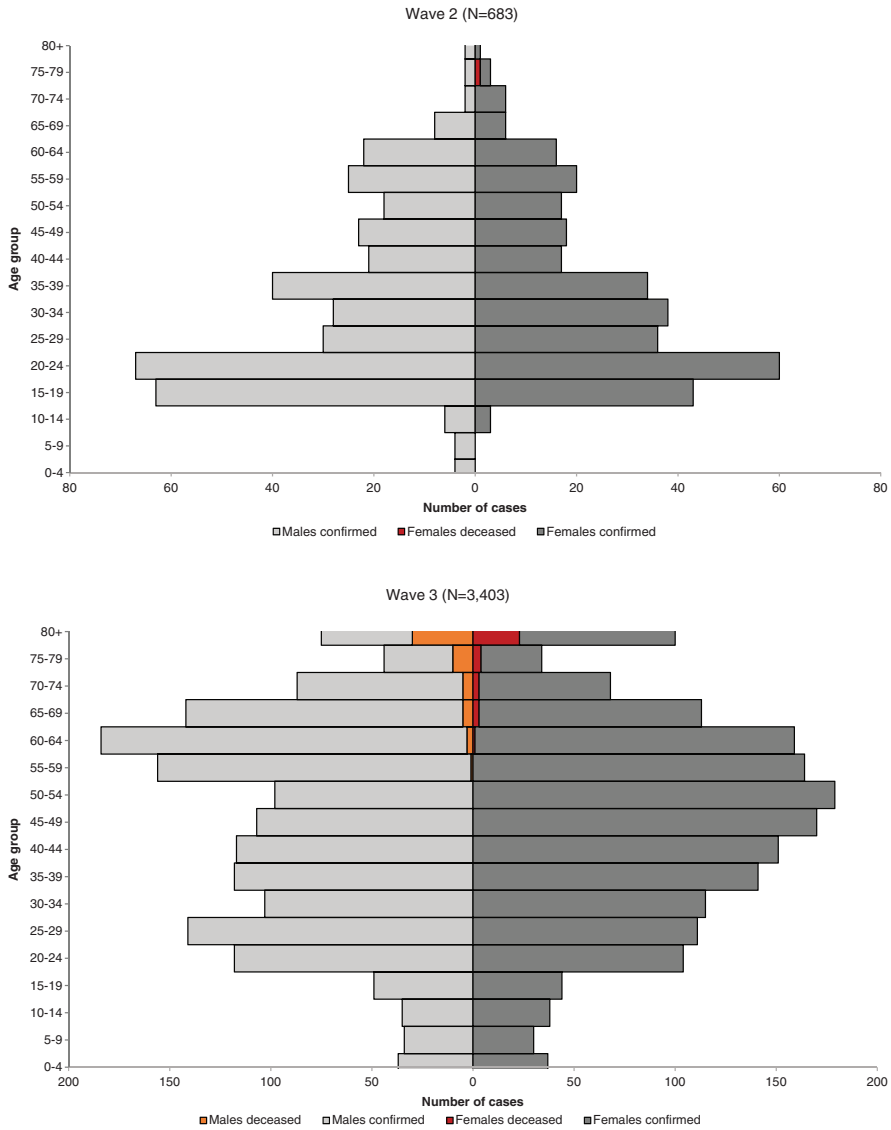
Figure 2:
Number of cumulative confirmed cases by age groups, Hong Kong (*n* = 11,006, 23 January 2020 to 28 February 2021)
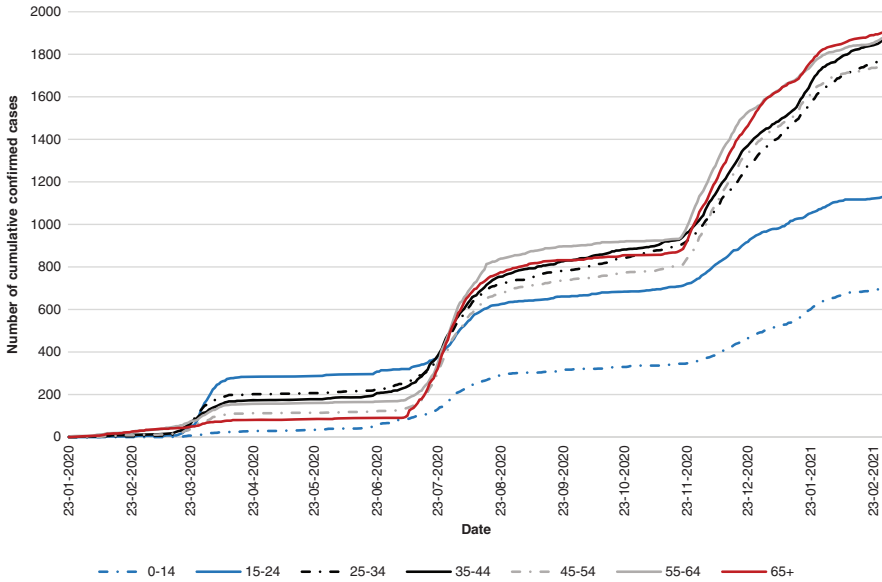
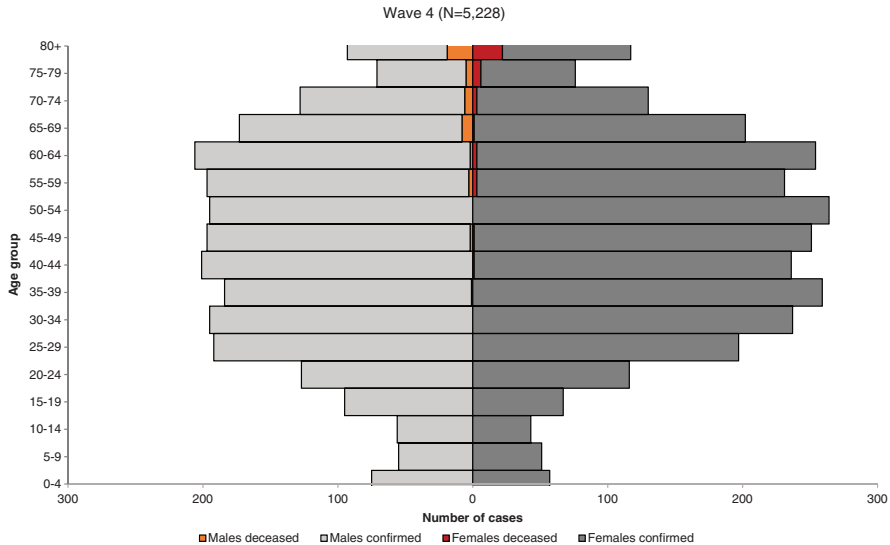**Data source:** Hong Kong Center for Health Protection, Department of Health.

Hong Kong, the confirmed cases had a very different age distribution than that of the city's ageing population, with the highest number of cases occurring in the 15–24 age group, and the majority (63.8%) of positive cases occurring in the 15–44 age group (Cruz et al., 2020). By contrast, less than a tenth (4.39%) of the cases occurred in the 65 and older age group. This age distribution of confirmed cases of COVID-19 was clearly very different from the general age profile of COVID-19 cases in other countries during this period, where infections were concentrated among people in the older age groups (Dowd et al., 2020). However, in the third wave pyramid (Figure 3, Wave 3), the age profile of COVID-19 cases in Hong Kong had shifted dramatically. For example, the share of cases that occurred in the 15–24 age group decreased from 34% in Wave 2 to 9.3% in Wave 3, representing the largest drop in the percentage of confirmed cases among the age groups. Conversely, the share of cases that occurred in the 55–64 and 65+ age groups increased substantially, from 12.2% and 4.4%, respectively, in Wave 2 to 19.5% for both groups in Wave 3. In November 2020, the fourth and more protracted wave of the COVID-19 pandemic began in Hong Kong (Figure 3, Wave 4). In line with the pattern observed in the third wave, the cases in this wave were concentrated among the older age groups, with the highest shares of cases being reported among people in the 55–64 (17.0%) and

Figure 3:
Age and sex distribution of confirmed COVID-19 cases, Waves 2–4, Hong Kong

Wave 2 (N=683)

Wave 3 (N=3,403)

Continued

Figure 3:
Continued

Wave 4 (N=5,228)

the 65+ (18.9%) age groups. In stark contrast to the second wave, in the fourth wave the share of cases that occurred in the 15–24 age group was very low, at just 7.80%.

3.2 Low COVID-19 mortality and case fatality rates in Hong Kong

Despite the shifting age profile of the confirmed cases, COVID-19 mortality in Hong Kong has remained low relative to the levels in other countries, at 2.7 deaths per 100,000 population. According to recent estimates, the three countries with the highest COVID-19 mortality rates are San Marino, Czechia and Belgium, with 237, 236 and 199 deaths per 100,000 population, respectively; while Cambodia has the lowest COVID-19 mortality rate, at 0.03 deaths per 100,000 (Johns Hopkins University and Medicine, 2021). Among the territories in East Asia, Hong Kong ranks third after Japan (seven deaths per 100,000 population) and South Korea (three deaths per 100,000 population). China, Mongolia and Taiwan Province of China (hereafter "Taiwan") have even lower COVID-19 crude mortality rates (below one death per 100,000 population) (Johns Hopkins University and Medicine, 2021).

In line with this trend of low but increasing mortality rates, the overall COVID-19 case fatality rate (CFR) in Hong Kong was 0.15% during the first two waves, and had increased to 2.6% in Wave 3. In the protracted Wave 4, the CFR was 1.6% as of 28 February 2021. Although comparisons of the CFR are challenging due to significant

Table 1:
Case fatality rate (%) by gender and age groups, Hong Kong (23 January 2020 to 28 February 2021)

Age group	Males		Females		Both sexes	
	%	*n*	*%*	*n*	*%*	*n*
0–54	1.0	3,446	0.4	3,782	0.7	7,228
55–59	1.1	450	0.6	469	0.9	919
60–64	1.1	470	1.0	487	1.0	957
65–69	3.6	363	1.1	359	2.4	722
70–74	6.0	252	3.0	232	4.5	484
75–79	12.9	147	12.0	125	12.5	272
80+	30.2	189	20.9	235	25	424
ALL	2.2	5,317	1.5	5,689	1.8	11,006

Data source: Hong Kong Center for Health Protection, Department of Health.

Note: Calculations performed by authors.

differences between countries in the testing and reporting of confirmed COVID-19 cases and deaths, Hong Kong's total CFR from 23 January 2021 to 28 February 2021 has been estimated at 1.8% (Table 1), which is lower than the levels in many other global territories. The countries with the highest CFRs are Yemen (22%), Mexico (9%), Syria (7%), Sudan (6%) and Egypt (6%); while Singapore has the lowest reported CFR, at less than 0.1% (Johns Hopkins University and Medicine, 2021). Hong Kong's overall COVID-19 CFR of 1.8% is comparable to the CFR estimates of its East Asian neighbours that also have ageing populations, like Japan (1.9%), South Korea (1.7%) and Taiwan (1.0%) (Johns Hopkins University and Medicine, 2021).

4 Factors shaping the Hong Kong COVID-19 experience

4.1 Socio-demographic risk factors and vulnerabilities

Recent research has highlighted that certain socio-demographic conditions may facilitate the rapid spread of COVID-19 infections and deaths, such as a high proportion of older people in the population, high levels of institutional residence and intergenerational co-residence (extended family living together in a household), high population density, poor housing conditions and management, and a high number of foreign domestic workers.

Scholars have established a positive relationship between old-age population structures and COVID-19 mortality *between* territories; that is, the older the

population, the higher the COVID-19 mortality rate (Farzanegan, 2020). Another study that examined 56 European areas highlighted the relationship between ageing and COVID-19 mortality, reporting a positive relationship between the median age and the case fatality rate (i.e., the case fatality rates increase as the median age increases) (Wang et al., 2020). As we noted above, during the first two waves of the COVID-19 pandemic in Hong Kong, only around 10% of the 683 confirmed cases occurred in the 60+ age group, and there was only one death during this period. Hong Kong's very low mortality rate in the first and second waves is largely attributable to the infection being concentrated in the younger population (Cruz et al., 2020). However, during Waves 3 and 4, infection rates among older age groups increased, accounting for about 30% of the total number of confirmed cases. The number of deaths also increased, with nearly all deaths occurring in the older age groups. The shift in Hong Kong in the age profile of COVID-19 infections and deaths away from the younger population and towards the older population follows the observed global pattern, which highlights the vulnerability of older people to the virus. In addition, research has shown that *within* territories, the general pattern of COVID-19 death rates is that they increase with age, and that men have a higher risk than women of dying from COVID-19 (Chamie, 2021; Hoffmann and Wolf, 2021; Undurraga et al., 2021). This pattern was also evident during Waves 3 and 4 of the Hong Kong pandemic, as the CFR increased with age, and there were more COVID-19-related deaths among older men than older women (see Table 1).

In addition to the share of older people in the population, a second factor that may have increased Hong Kong's level of vulnerability to COVID-19 mortality is the prevalence of older people living in residential care facilities. As an ageing society in which about 18% of the population are over the age of 65 (Wong and Yeung, 2019), care homes have increasingly become a residential option for older people in Hong Kong. According to the statistics released by Hong Kong's Elderly Commission in 2009, around 7% of older people aged 65 and older were living in residential facilities, compared to 2–3% in other Asian regions and 3–4% in some western societies (e.g., Canada and the US) (Elderly Commission of Hong Kong, 2009). By 2016, the proportion of older people in Hong Kong who were living in residential facilities had risen to 8.5% (Research Office of the Hong Kong Legislative Council Secretariat, 2017). Researchers have established the extreme vulnerability of nursing homes and other residential facilities around the world to the spread of COVID-19 and to high mortality from the virus. For example, it has been shown that a substantial proportion of COVID-19 deaths in the US have been among care home residents (Wagner, 2020).

Moreover, it has been observed that "intergenerational interactions, co-residence, and commuting may have accelerated the outbreak in Italy through social networks that increased the proximity of elderly to initial cases" (Dowd et al., 2020, 1). This also describes a potential COVID-19 transmission chain in Hong Kong, as co-residence is common in the city (Ko, 2012), with around half of older people living with their adult children (Tong et al., 2019). This prevalence of co-residence is much higher than it is in North America and Europe, where, apart from an exceptionally

high prevalence of 61% in Albania, the proportion of older people who live with their family ranges from 6% in the Netherlands to 36% in Romania (United Nations, Department of Economic and Social Affairs, Population Division, 2017). Hong Kong's extremely high population density and efficient transport systems also make it easy for older adults and their adult children or grandchildren to remain in regular contact. In addition, during all waves of the pandemic, there have been no legal restrictions on gatherings in private residences. An analysis of confirmed cases in Hong Kong that were transmitted through local infections during the first and second waves showed that 54.4% of cases were transmitted through households, 33.1% of cases were transmitted through social settings outside the home and 11.9% of cases were transmitted through work settings (Adam et al., 2020). However, these results may be biased somewhat by the fact that the tracing of case contacts is significantly easier among families than it is among strangers in social settings.

Another socio-demographic factor that is critical to Hong Kong's vulnerability to the spread of COVID-19 is the very high level of population density. Multiple studies have found connections between population density and the spread of COVID-19 in Iran (Ahmadi et al., 2020), Turkey (Coşkun et al., 2021) and Japan (Kodera et al., 2020). Hong Kong certainly faces a high risk of COVID-19 transmission because of its extremely high population density and poor housing conditions in certain districts. Due to the limited availability of residential land in the territory, many residents live in extremely small and cramped apartments, and the conditions are especially concerning for low-income residents. In 2016, an estimated 209,700 people in Hong Kong were living in subdivided flats (Census and Statistics Department, 2016), which are sometimes referred to as "coffin houses" because of their tiny size and very cramped conditions (Wong, 2018). In 2016, there were 27,100 such apartments divided into an average of 3.4 subdivided units, with each subdivided unit housing an average of 2.3 persons (Census and Statistics Department, 2016). The median floor space per resident was just 5.3 square metres. These flats are characterised by poor hygiene and sanitation, environmental concerns (Lai et al., 2017) and safety problems (Leung and Cheuk, 2016). The districts with the highest numbers of subdivided flats are Yau Tsim Mong, Sham Shui Po and Kowloon City, all of which are located in the Kowloon region. Hong Kong also has a number of so-called "three-nil buildings", which have no apparent owner, and are not overseen by a property management corporation or a resident organization. Because they lack effective management, these buildings tend to be poorly maintained and dilapidated, particularly since many of them are old buildings (Hong Kong Government, 2019). In 2019, there were 5,300 of these buildings, primarily located in districts of the Kowloon region (Hong Kong Government, 2019). In areas with this extreme building density – which is generally associated with lower wind and air ventilation – and high building heights, a higher incidence of COVID-19 cases has been observed (Kwok et al., 2021). Thus, poor housing conditions and inadequate building management exacerbate the impact of high population density in Hong Kong, which, in turn, means that more people in the city are vulnerable to COVID-19 infections.

Another demographic vulnerability in Hong Kong is the proportion of low-wage migrant workers in the population, as the experiences of other territories indicate that people in this demographic group are at significantly higher risk of catching COVID-19 due to their often cramped housing conditions. Moreover, migrant workers tend to be employed in occupations that require physical labour, and that do not provide opportunities for "teleworking", or working from home. During the second wave of the pandemic in Singapore, for example, more than half of the purpose-built and factory-converted dormitories for guest workers were affected by COVID-19 outbreaks (Humanitarian Organisation for Migration Economics, 2020). It has been estimated that around 80% of all cases during the second wave in Singapore were linked to these dormitories (Humanitarian Organisation for Migration Economics, 2020). Hong Kong is also home to a large population of migrant "guest workers" who may be vulnerable to spread of the virus. Most of these workers are classified as "Foreign Domestic Workers" (FDWs), and are required to live in their employer's home. In 2019, there were almost 400,000 migrant domestic workers in Hong Kong, making up more than 10% of the city's labour force (Labour and Welfare Bureau, 2019). The overwhelming majority of these migrant workers are women from Southeast Asia. These workers run a particularly high risk of catching COVID-19 because their jobs entail intra-household and, often, inter-household relations.

4.2 Protective factors: Policy responses and community actions

Two notable shifts occurred in the profile of confirmed COVID-19 cases in Hong Kong from wave to wave: i.e., a shift in the age profile of cases from younger to older ages, and a shift from imported to local transmission. In our previous analysis, we attributed a large proportion of the positive cases to members of the student-age and working-age populations returning to Hong Kong from COVID-19 hotspots in the initial stages of the pandemic. We showed that most of the confirmed cases in the first and second waves were imported, and we highlighted the important role of members of the Hong Kong diaspora, and particularly of the large overseas student population, who had returned to Hong Kong from COVID-19 hotspot areas overseas (Cruz et al., 2020). An analysis of detailed travel history data tracked by the CHP revealed that of the COVID-19 cases involving an individual with an overseas travel history, nearly half (47.4%) were imported from the United Kingdom (UK), 9.1% were imported from the United States (US), and 3.9% each were imported from Qatar, Canada and Switzerland (Cruz et al., 2020). In addition, our research found that a very high proportion of the confirmed cases in the 15–24 age group (90%) and the 25–34 age group (43%) could be classified as "imported-related" (i.e., cases that were imported from overseas or could be directly linked to an imported case). However, throughout the third and fourth waves, strict border controls designed to prevent or greatly discourage overseas travel vastly reduced travel in and out

of Hong Kong. In line with these reductions in travel, a minority of cases in the third and fourth waves were imported. Thus, during these waves, the pandemic was driven by the local spread of COVID-19. The results of our analysis indicate that a significantly lower proportion of cases in the third and fourth waves were imported, with such cases accounting for 35.8% of the total confirmed cases during the third wave, and just 7.6% of the total confirmed cases during the fourth wave (see Figure 1).

It is, however, of critical importance that government-mandated border controls changed over time and helped to mitigate the increase in imported and related cases in Hong Kong. From 25 March 2020 onwards, all non-residents were barred from entering the territory except for nationals of Macau Special Administrative Region of the People's Republic of China (hereafter "Macau"), Taiwan or Mainland China. By the end of March 2020, new 14-day home quarantine requirements were put in place for all people arriving in the city, regardless of whether they were residents. As a result of these requirements, passenger traffic decreased sharply. The longer-term effect of these policies was to dampen inbound travel for the rest of 2020, which undoubtedly contributed to the significantly lower proportion of imported cases in later waves. According to the data we retrieved from the Hong Kong Immigration Department, the number of people arriving in the city remained at around 25,000 per day before dropping significantly at the end of March 2020 to below 2,000. Government-mandated border controls as well as aggressive test-and-trace and quarantine regulations contributed to the decline in COVID-19 cases during the month of April 2020 (Cowling et al., 2020). During the third wave, strict border controls remained in place, and travel quarantine requirements became even more stringent. For example, although residents were initially permitted to quarantine at home, they were issued a tracking bracelet connected to the Global Positioning System (GPS), and were tested for COVID-19 before and during the quarantine period.

In addition, on 25 July 2020, the government introduced a list of "high-risk" territories. Travellers from these locations were subject to stricter quarantine requirements, including rules mandating that they have a negative test before travelling and spend the quarantine period in a government-designated hotel (Hong Kong Government, 2020b). These restrictions contributed to the significantly lower numbers of imported confirmed cases in the third wave than in the second wave, during which the cases were concentrated among younger age groups.

As the fourth wave of COVID-19 in Hong Kong – which was linked to transport staff – started prior to the holiday season in December 2020, the border control and quarantine regulations were further tightened to protect Hong Kong from international transmission. In November 2020, the government introduced new travel restrictions and expanded the 14-day hotel quarantine requirement to cover travellers who entered Hong Kong from any destination except Taiwan, Macau and Mainland China. The UK, the US, France and Germany were added to the list of high-risk countries, which already included many countries in Asia, such as Indonesia, the Philippines, India, Nepal and Pakistan. Under these newly imposed

restrictions, travellers also had to secure a negative COVID-19 test 72 hours before arriving in Hong Kong. On 25 December 2020, the length of the mandatory hotel quarantine was extended to 21 days for travellers arriving from all regions except Taiwan, Macau and Mainland China. At that time, this was the longest travel quarantine period in the world. In addition, all travel was banned from the UK and South Africa, including for Hong Kong residents. According to the travel data retrieved from the Hong Kong Immigration Department, the numbers of inbound and outbound travellers remained very low from December 2020 to February 2021, and thus over the Christmas and Lunar New Year holidays, which are usually the busiest travel period for Hong Kong. During this period, the daily average number of arrivals was lower than 2,000, and the daily average number of departures was around 2,500. Hong Kong has a large overseas population of secondary school- and university-age students, especially in the UK and the US, and a large share of Hong Kong residents are also nationals of the UK, the US and Canada. These populations are believed to have triggered the second wave outbreak in Hong Kong (Cruz et al., 2020). In addition, Hong Kong is home to large populations of nationals from the Philippines, Indonesia, India, Nepal and Pakistan (Cruz et al., 2020). Given that all of these countries imposed even stricter travel regulations from November 2020 onwards, it is likely that these restrictions strongly discouraged travel, leading to significantly lower numbers of imported cases in the fourth wave than in the two earlier waves.

In addition to border control measures designed to limit the number of imported cases, another set of critical policy tools used by the Hong Kong government were social distancing measures aimed at mitigating local transmission. These social distancing regulations were generally implemented when needed, and were adapted to the local pandemic conditions. These measures included reductions in the opening hours of restaurants; restrictions on the sizes of public gatherings; and closures of schools, universities, entertainment venues, recreational facilities, outdoor spaces and certain types of businesses, such as gyms, bars, nightclubs, beauty salons, massage parlours, sports and exercise facilities, beaches and playgrounds. Although these measures clearly had deleterious effects on local businesses, social activities and social interactions, the evidence suggests that from a public health perspective, they were effective in containing the spread of COVID-19. For example, research indicates that during the second wave of the pandemic in Hong Kong, a combination of adherence to social distancing and mask-wearing regulations, remote working and school closures led to a reduction in seasonal influenza incidence of around 44.0% (Cowling et al., 2020).

A third set of key government policies designed to reduce local transmission chains were testing and tracing measures. Under these rules, anyone who had come into contact with a confirmed case was pre-emptively placed in a government isolation centre for 14 days and tested regularly. It has been shown that these very thorough contact tracing processes and strict quarantine requirements were highly effective in interrupting chains of transmission during the first and second waves

(Adam et al., 2020), and may have played a role in mitigating the local spread of the virus.

Although the city's high population density and poor housing conditions in many communities posed risks for Hong Kong during the pandemic, the government attempted to compensate for these disadvantages by deploying various policy measures, most notably measures related to housing and building management, as well as community-level lockdowns. The Housing Authority (HA) implemented a number of public health measures after the start of the pandemic, such as the intensification of daily cleaning and disinfection in public areas, including of escalators, elevators, passages and drainage facilities. Whenever a COVID-19 case was confirmed by the Department of Health, the HA arranged for the thorough cleaning and disinfection of the affected buildings, and conducted comprehensive inspections of any units that shared sewerage and pipes with the unit in which the confirmed case was detected. The authority also distributed and collected voluntary testing bottles from residents, and collected environmental samples from affected public facilities (Hong Kong Housing Authority, 2020). During the fourth wave, the government imposed numerous partial lockdowns – i.e., compulsory testing orders – of certain residential blocks. These lockdowns were, for example, implemented in response to concerns about a number of community clusters that emerged in several districts in Kowloon (Jordan, Yau Ma Tei, and Sham Shui Po) with population densities of more than 48,930 persons per square kilometre. The first of these partial lockdowns centred on several housing blocks in Jordan, a district in which high proportions of the residents have lower socio-economic status and are members of ethnic minority groups. On 23 January 2021, more than 3,000 government staff – including 1,600 so-called "disciplinary workers" – locked down an area of around 70 buildings in Jordan, Kowloon, and conducted more than 7,000 COVID-19 tests (Hong Kong Government, 2021a). Numerous other community-level lockdowns have since been implemented in residential blocks spread around the city that were suspected of having clusters of COVID-19 cases. Given that these small COVID-19 outbreaks across various parts of the city were indeed brought under control, it is clear that these policy actions helped to stem the spread of the virus in the most cramped housing blocks.

The relatively low mortality and case fatality rates due to COVID-19 in Hong Kong are remarkable given the territory's large older population and the high proportion of its residents living in residential care homes, as studies have shown that there is a strong relationship between having an older population age structure and high COVID-19 mortality (Hoffmann and Wolf, 2020, 2021). As the results of our previous analysis suggested, one key, yet often overlooked factor in these relatively low mortality rates is the distribution of confirmed cases during the first few months of the COVID-19 pandemic, which were concentrated among the younger age groups in Hong Kong (Cruz et al., 2020) However, by the third and fourth waves of the pandemic in Hong Kong, the CFR in the city was clearly exhibiting the expected pattern: i.e., it was increasing with age, and was especially high among older men. Nonetheless, the CFR in Hong Kong remained lower

than the rates in most other territories. A second important set of factors in the relatively low mortality and case fatality rates in Hong Kong are, most likely, the city's effective health care system and its coordinated management of residential facilities from the start of the pandemic. Based on the lessons the city learned during the 2003 outbreak of severe acute respiratory syndrome (SARS), the Hong Kong Department of Health directed all residential care homes at the start of the COVID-19 pandemic to assign a staff member to manage infection control and implement preventive measures. These staff members were expected to implement measures such as the limitation/suspension of family visits, the restriction of the movement of residents outside the facility, social distancing, and the wearing of face masks (Chow, 2021; Woo, 2020). Meanwhile, the Hong Kong government also issued guidelines to support residential care homes in preventing infection (Centre for Health Protection, 2020), and offered other forms of support, including the provision of personal protective equipment (PPE) and infection protection services (Hong Kong Government, 2020c), as well as the transition to online care support for individuals who would ordinarily visit day care centres (Xinghui et al., 2020). Research has shown that the implementation of stringent COVID-19 guidelines and prevention measures has been highly effective in preventing the spread of infection (McMichael et al., 2020). Thus, it is likely that the strict preventive measures implemented in Hong Kong care homes from the beginning of the pandemic may have created fewer opportunities for sustained local spread within the older population. In addition, some studies have linked the low mortality and case fatality rates in Hong Kong to the city's strong overall health care system and testing and quarantine regimes (Farzanegan, 2020; Lui et al., 2020). Farzanegan found that the risk of death from COVID-19 has been lower in ageing societies with at least 3.5 hospital beds per 1,000 population (Farzanegan, 2020). Our results appear to support this finding, as based on our estimates of the numbers of beds in public and private hospitals as of May 2019 (Hong Kong Department of Health, 2019) and of the population as of the end of December 2020 (Census and Statistics Department, 2021), the current hospital bed capacity in Hong Kong is approximately 4.5 hospital beds per 1,000 population.

Moreover, even though migrant workers have been identified in other regions as a high-risk population during the coronavirus pandemic, the spread of COVID-19 among migrant workers in Hong Kong has been extremely low. It is likely that government policies in conjunction with community actions among groups of migrant workers have greatly reduced the transmission of COVID-19 in Hong Kong. In terms of government policies since the second wave of the pandemic, the government has advised local employers of FDWs to discourage employees from socialising in public places during periods of social distancing, and has mandated that such gatherings can be broken up by the police, and that the participants can be fined. It is also likely that travel policies and flexible contract and immigration arrangements for FDWs played a very important role in reducing the spread of the virus among this population. To discourage migrant workers from travelling between Hong Kong and their home countries, the government offered to extend the visas of those individuals

whose visas were about to expire. In August 2020, the Philippines and Indonesia, the biggest migrant sending countries, were added to the list of high-risk countries, and a two-week hotel quarantine for travellers from these countries was put in place. Employers of FDWs travelling from these countries were required to sign an agreement to pay for a hotel stay and testing for each employee (Hong Kong Government, 2021b). In line with the general tightening of travel restrictions, from December 2020 onwards, FDWs travelling to work in Hong Kong were required to stay in a government-designated hotel for 21 days. In addition to these efforts by the government, community actions among groups of migrant workers may have also contributed the low rates of infection among this group. These actions included mask-wearing, social distancing and taking advantage of the free COVID-19 testing that was made available to FDWs (Hong Kong Government, 2020a).

As well as the policies implemented by the government, community actions appeared to be remarkably successful in preventing the rapid spread of COVID-19, particularly in the initial stages of the pandemic. Citizens of Hong Kong were on high alert as early as in January 2020, when the Chinese government officially reported a cluster of cases of pneumonia in Wuhan, Hubei Province. For example, the general public overwhelmingly started wearing masks at the beginning of the local COVID-19 pandemic (Cheng et al., 2020), despite a lack of government advice to do so. Mask-wearing was already a common practice in Hong Kong, as it had been used to control the community transmission of SARS in 2003, and then the pandemic influenza A-H1N1 in 2009. It is also believed that these experiences contributed substantially to the community's high levels of compliance with many other non-pharmaceutical measures, including social distancing, border controls and quarantine requirements (Cheng et al., 2020). For example, evidence from three cross-sectional, representative telephone surveys during the first and second waves indicates that the vast majority of the population engaged in the rapid uptake of behaviours aimed at preventing the spread of COVID-19. By mid-February, around 20 days after the first case was announced, 97.5% of residents reported using face masks, 92.5% reported washing their hands more often, 90.2% said they were avoiding going to crowded places and 89.3% reported that they had disinfected their home in response to the pandemic (Cowling et al., 2020). Although the proportion of people who said they were avoiding public places had dropped slightly by mid-March, rates of face mask-wearing and hand-washing remained extremely high (Cowling et al., 2020).

5 Conclusion

Research has suggested that places that have an ageing population structure, high population density and cramped living conditions, and a high proportion of migrants in the population are at high risk of experiencing the rapid spread of COVID-19 and high mortality rates from the virus (Goldstein and Lee, 2020; Humanitarian Organisation for Migration Economics, 2020). However, despite fitting all these

criteria, the COVID-19 infection rates in Hong Kong have been much lower than those in many global territories, and the mortality rates in the city have been correspondingly low. The collective efforts by the government, the private sector and the public through targeted policies and community actions may have helped Hong Kong overcome its aforementioned significant socio-demographic vulnerabilities to COVID-19. Our analysis has highlighted the importance of travel histories and border restrictions in explaining the shift in the age structure of cases across waves. Border closures, travel bans and quarantine requirements significantly deterred inbound and outbound travel, resulting in lower numbers of imported cases in later waves, which had previously been clustered in the younger age groups. We highlighted the effectiveness of social distancing, testing and tracing, housing management and partial lockdowns in mitigating the local transmission of the COVID-19 virus. In seeking to explain the low COVID-19 mortality rates in Hong Kong despite the city's ageing population, we noted the role of the age profile of cases, but also emphasised the importance of the city's efficient health care system and nursing home management. The combination of all of these efforts proved effective in slowing down or even stopping the spread of infections in Hong Kong.

Furthermore, public health experts see hope in the rollout of safe COVID-19 vaccines around the world (Kasai, 2021). In Hong Kong, the vaccination rollout started at the end of February 2021, and as of 10 August 2021, 51.9% and 40.0% of the total population had been vaccinated with the first and the second dose, respectively (Hong Kong Government, 2021c). However, relative to many other countries, "vaccine hesitancy" is high and the general acceptance of vaccines is low in Hong Kong (Yu et al., 2021). To address this slow uptake, medical experts have recommended that all relevant actors help through "intensive education, provision of more evidence-based information, and public health interventions" (Chan et al., 2021).

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