**Github Materials and Methods**

**Survey data**

In each weekly survey from 5 May 2020 to 15 February 2021, we contacted either 500 or 1000 local residents through random digit dialing of landlines and mobile telephones, using age, gender, education, and employment information to weight the response frequencies to the adult population in Hong Kong [(1)](https://paperpile.com/c/bTMcET/VIcTS). Details about the surveyed questions are summarized in **Github** [**Table S1**](#sta_data) and shown in **Github** [**Figure S2**](#sif_survey). The survey enables us to estimate (1) the percentage of participants perceived the risk of infection; and (2) the percentage of participants engaged in physical distancing policies.

**Epidemic data**

We collect the daily reported cases by reporting date in Hong Kong from COVID-19 Dashboard by the Center for Systems Science and Engineering at Johns Hopkins University [(2)](https://paperpile.com/c/bTMcET/WBJVh) and the real-time effective reproductive number for local cases and the daily symptomatic cases by onset date in Hong Kong from the real-time dashboard in School of Public Health, The University of Hong Kong [(3)](https://paperpile.com/c/bTMcET/ynB5B), shown in **Github** [**Figure S2**](#sif_survey).

**Mobility data**

To estimate the dynamic of people traveling in the COVID-19 pandemic, we obtained the daily mobility data from the Google community mobility reports in Hong Kong [(4)](https://paperpile.com/c/bTMcET/LdGR2). Based on visitors’ daily numbers to specific categories of location (e.g. grocery stores; parks; train stations), Google compares it to baseline period (the 5-week period from January 3 to February 6, 2020) before the pandemic outbreak and reports six mobility categories to indicate how the numbers of visitors in Hong Kong to places, as shown in **Github** [**Figure S1**](#sif_mobility).

We also compared the self-reported behavioural changes in our survey data with changes in population movements. Considering the large user base of Google’s products and the real-time data of Google’s Community Mobility Reports [(4)](https://paperpile.com/c/bTMcET/LdGR2), we performed a stepwise regression analysis to examine the correlation between each surveyed indicator of protective behaviours and Google’s daily mobility movement trends. We found that Google’s mobility indexes were highly correlated with our surveyed self-reported protective behaviours (**Github** [**Figure S5**](#sif_step).and **Github** [**Table S3**](#sta_mobility)). For example, the mobility of retail and grocery can explain up to 87% for the variability in avoiding social gathering (**Github** [**Table S3**](#sta_mobility)). Therefore, with the aid of Google’s mobility data, our weekly surveys of population behavioural changes can be interpolated into the daily resolution.

**Epidemic model**

We simulate the transmission of COVID-19 using a compartmental model, in which the health status of each individual can be susceptible (S), exposed (E), asymptomatic (A), presymptomatic (P), symptomatic (Y), or recovery/death (R) at any time (**Github** [**Figure S3**](#sif_model)). Details about the parameterization are summarized in **Github** [**Table S4**](#sta_para).

Chart, histogram

Description automatically generated

**Github** [**Figure S1**](#sifig_mobility)**.** **Google mobility data** [(4)](https://paperpile.com/c/bTMcET/LdGR2) **for each of the six location categories.** The daily mobility index of Google measures the ratio between the number of individuals visiting a specific category of locations each day from 10 March 2020 to 9 February 2021 and the daily average of populations visiting the same category of locations during the pre-pandemic baseline period from January 3 to February 6, 2020. Six location categories include (1) retail and recreation, (2) grocery and pharmacy stores, (3) parks, (4) transit stations, (5) workplaces, and (6) residential areas

A screenshot of a video game

Description automatically generated with medium confidence

**Github** [**Figure S2**](#sifig_survey)**. Overview of survey and epidemic data.** Weekly proportions of protective behaviour and risk perception from weekly cross-sectional telephone surveys, daily reported cases on average in a week by reporting date, and real-time reproduction number on average in a week (**Github** [**Table S1**](#sta_data)).

Graphical user interface, application

Description automatically generated

**Github** [**Figure S3**](#sifig_model). **Epidemiological model of COVID-19 transmission in Hong Kong.** Upon infection, susceptible individuals (S) progress to being exposed (E). A fraction of cases become asymptomatic infectious (A) with lower infectiousness before recovering (R); the remaining cases progress to presymptomatic (P), where they are moderately infectious but not yet symptomatic, followed by symptomatic infectious (Y) and then either recover or die (R).

Graphical user interface

Description automatically generated

**Github** [**Figure S4**](#sifig_linear)**.** **Linear regression of surveyed indicators using data from 40 surveys from May 5, 2020 to February 8, 2021.** We estimated the coefficients using linear regression for each surveyed indicator per 100 daily reported cases. We only summarized those with adjusted R2 larger than 0.3. The number on each arrow indicates the coefficient of significant linear regression of the two lined factors across the 40 surveys.

Graphical user interface, text, application

Description automatically generated

**Github** [**Figure S5**](#sifig_step). **Stepwise regression of Google mobility measures and protective behaviour proportions with information on coefficients in Github** [**Table S2**](#sta_coefficients)**.** We examine the correlation between each type of surveyed protective behaviours and six daily mobility movement trends of Google by a stepwise regression analysis to add or remove predictors with the criterion of p-value for F test. Lines denote those selected mobility indexes for each behaviour.

**Github** [**Table S1**](#stabl_data)**. Data sources towards COVID-19 of risk perceptions, behavioural responses, transmission, public reports, and Google mobility in Hong Kong.**

| **Factors** | **Indicators** | **Scale** | **Sources** |
| --- | --- | --- | --- |
|
| Protective behaviour | In the past 7 days, did you take the following measure to prevent yourself from contracting SARS-CoV-2? | | |
| Avoid going to crowded places (%) | weekly | Survey |
| Stay at home as much as possible (%) | weekly | Survey |
| Avoid using public transportation (%) | weekly | Survey |
| Avoid social gathering (%) | weekly | Survey |
| Risk perception | Susceptibility to COVID-19 (%): Perceived susceptibility to COVID-19 (“How likely do you think it is that you will contract COVID-19 over the  next one month?“ -- likely/ very likely/ certain rather than never) | weekly | Survey |
| Worry about being infected (%): Worry about being infected with COVID-19 (moderately/ very much worried/ extremely worried) | weekly | Survey |
| Transmission | Real-time reproduction number | daily | [(3)](https://paperpile.com/c/bTMcET/ynB5B) |
| Daily number of reported symptomatic case by onset date | daily |
| Public reports | Daily number of reported cases on average in a week by reporting date | weekly | [(2)](https://paperpile.com/c/bTMcET/WBJVh) |
| Google mobility | Retail: the percentage change in the number of visitors to places of retail and recreation relative to pre-pandemic baseline (the median number of visitors for the 5-week period from January 3 to February 6, 2020) | daily | [(4)](https://paperpile.com/c/bTMcET/LdGR2) |
| Grocery: the number change of visitors to grocery and pharmacy stores has changed compared to baseline days (the median value for the 5-week period from January 3 to February 6, 2020) | daily | [(4)](https://paperpile.com/c/bTMcET/LdGR2) |
| Parks: the number change of visitors to parks and outdoor spaces has changed compared to baseline days (the median value for the 5-week period from January 3 to February 6, 2020) | daily | [(4)](https://paperpile.com/c/bTMcET/LdGR2) |
| Transit: the number change of visitors to transit stations has changed compared to baseline days (the median value for the 5-week period from January 3 to February 6, 2020) | daily | [(4)](https://paperpile.com/c/bTMcET/LdGR2) |
| Work: the number change of visitors to workplaces has changed compared to baseline days (the median value for the 5-week period from January 3 to February 6, 2020) | daily | [(4)](https://paperpile.com/c/bTMcET/LdGR2) |
| Resident: the percentage change in average duration spent at places of residence relative to pre-pandemic baseline (the median duration for the 5-week period from January 3 to February 6, 2020) | daily | [(4)](https://paperpile.com/c/bTMcET/LdGR2) |

**Github** [**Table S2**](#stabl_coefficients). Protective behaviours and risk perception in the surveys, associated with the reproduction number

|  | | Third wave | | | Fourth wave | | | Median decreased in the fourth wave |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Median | 95% CrI lower | 95% CrI upper | Median | 95% CrI lower | 95% CrI upper |
| Protective behaviour | Avoid going to crowded places (%) | 89.65 | 80.30 | 92.40 | 87.50 | 83.90 | 90.20 | 2.15 |
| Stay at home as much as possible (%) | 83.35 | 71.80 | 89.40 | 81.90 | 77.50 | 86.20 | 1.45 |
| Avoid using public transportation (%) | 74.45 | 62.20 | 80.70 | 69.00 | 64.50 | 72.50 | 5.45 |
| Avoid social gathering (%) | 91.50 | 76.60 | 95.70 | 90.00 | 87.10 | 93.30 | 1.50 |
| Risk perception | Susceptibility to COVID-19 (%) | 22.25 | 16.70 | 25.70 | 15.10 | 13.90 | 21.60 | 7.15 |
| Worry about being infected (%) | 56.25 | 43.80 | 66.90 | 48.60 | 45.30 | 53.20 | 7.65 |
| Transmission | Reproduction number | 0.67 | 0.45 | 2.30 | 0.84 | 0.57 | 1.39 | -0.17 |
| Public reports | Reported daily cases on average | 56.57 | 17.00 | 127.57 | 62.00 | 25.86 | 94.43 | -5.43 |

**Github** [**Table S3**](#stabl_mobility)**. Stepwise regression of protective behaviours and Google mobility movement trends across different categories of places.** We examine the correlation between each type of surveyed protective behaviours and six daily mobility movement trends of Google by a stepwise regression analysis to add or remove predictors with the criterion of p-value for F test.

| Protective behaviours | Coefficient of Google mobility movement trends | | | | | | R2 adjusted |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Retail | Grocery | Parks | Transit | Work | Resident |
| Avoid going to crowded places | -0.44 | 0.13 |  |  |  |  | 0.79 |
| Stay at home as much as possible | -0.55 | 0.19 |  |  |  | 0.74 | 0.88 |
| Avoid using public transportation |  | 0.41 | -0.49 |  | -0.58 |  | 0.71 |
| Avoid social gathering | -0.76 | 0.22 |  |  |  |  | 0.87 |

**Github** [**Table S4**](#stabl_para)**. Epidemiological parameters for the SARS-CoV-2 infection model.**

| **Parameters** | **Values** |
| --- | --- |
| : daily number of reported symptomatic cases at day by onset date | [(3)](https://paperpile.com/c/bTMcET/ynB5B) |
| : population size of Hong Kong | 7.5 million [(5)](https://paperpile.com/c/bTMcET/HzGFO) |
| : transmission rate |  |
| : percentage of people avoiding gathering | Estimated by Google mobility data (**Github** [**Table S3**](#sta_mobility)) |
| : coefficient of protective-behaviour forcing at day | Calibrated to local cases reported at day and assumed with the range between -1 and 0.1 |
| : baseline of transmission rate at day | assumed as 0.5 |
| Initial number in exposed, asymptomatic, pre-symptomatic, symptomatic states | The number of the local symptomatic cases reported at start in the studded wave: 6 for the third wave and 5 for the fourth wave |
| : transition rate out of exposed state | 1/3 [(6)](https://paperpile.com/c/bTMcET/sFGaG) |
| : recovery rate of symptomatic individuals | 1/4 [(7, 8)](https://paperpile.com/c/bTMcET/EWePT+YUyKN) |
| : recovery rate of asymptomatic individuals | 1/9 |
| : transition rate from the pre-symptomatic to symptomatic stage | 1/2 [(6)](https://paperpile.com/c/bTMcET/sFGaG) |
| : relative infectiousness of pre-symptomatic cases | 1.57 [(7, 8)](https://paperpile.com/c/bTMcET/YUyKN+EWePT) |
| : relative infectiousness of asymptomatic cases | 0.5 [(9)](https://paperpile.com/c/bTMcET/pFSFu) |
| : proportion of infections that are symptomatic | 75% [(8, 10)](https://paperpile.com/c/bTMcET/TWmtH+YUyKN) |

**References**

1. [B. J. Cowling, *et al.*, Impact assessment of non-pharmaceutical interventions against coronavirus disease 2019 and influenza in Hong Kong: an observational study. *The Lancet Public Health* **5**, e279–e288 (2020).](http://paperpile.com/b/bTMcET/VIcTS)

2. [E. Dong, H. Du, L. Gardner, An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect. Dis.* **20**, 533–534 (2020).](http://paperpile.com/b/bTMcET/WBJVh)

3. [School of Public Health, The University of Hong Kong, Real-time dashboard. *School of Public Health, The University of Hong Kong* (March 11, 2021).](http://paperpile.com/b/bTMcET/ynB5B)

4. [Google, COVID-19 Community Mobility Reports (March 15, 2021).](http://paperpile.com/b/bTMcET/LdGR2)

5. [Census and Statistics Department, Hong Kong Special Administrative Region, Press Release (18 Feb 2021) :Year-end population for 2020 (2021) (March 15, 2021).](http://paperpile.com/b/bTMcET/HzGFO)

6. [J. A. Backer, D. Klinkenberg, J. Wallinga, Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20-28 January 2020. *Euro Surveill.* **25**, 2000062 (2020).](http://paperpile.com/b/bTMcET/sFGaG)

7. [X. He, *et al.*, Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nat. Med.* **26**, 672–675 (2020).](http://paperpile.com/b/bTMcET/EWePT)

8. [A. Aleta, *et al.*, Modelling the impact of testing, contact tracing and household quarantine on second waves of COVID-19. *Nat Hum Behav* **4**, 964–971 (2020).](http://paperpile.com/b/bTMcET/YUyKN)

9. [D. McEvoy, *et al.*, Relative infectiousness of asymptomatic SARS-CoV-2 infected persons compared with symptomatic individuals: a rapid scoping review. *BMJ Open* **11**, e042354 (2021).](http://paperpile.com/b/bTMcET/pFSFu)

10. [H. Nishiura, *et al.*, Estimation of the asymptomatic ratio of novel coronavirus infections (COVID-19). *Int. J. Infect. Dis.* **94**, 154–155 (2020).](http://paperpile.com/b/bTMcET/TWmtH)