Knowledge, attitudes, and practice towards COVID-19 among multi-ethnic elderly Asian residents in Singapore: a mixed methods study

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Singapore Med J 2021, 1–42
https://doi.org/10.11622/smedj.2021152
Published ahead of print: 11 October 2021

More information, including how to cite online first accepted articles, can be found at: http://www.smj.org.sg/accepted-articles
ABSTRACT

Introduction: We investigated knowledge, attitudes, and practice (KAP) about COVID-19 and related preventive measures in Singaporeans aged ≥ 60 years.

Methods: This was a population-based, cross-sectional, mixed-methods study (13 May 2020–9 June 2020) of participants aged ≥60 years. Self-reported KAP about ten COVID-19 symptoms and six government-endorsed preventive measures were evaluated. Multivariable regression models identified sociodemographic and health-related factors associated with knowledge, attitudes and practices in our sample. Associations between knowledge/attitude scores, and practice categories were determined using logistic regression. 78 participants were interviewed qualitatively about practice of additional preventive measures and data were analysed thematically.

Results: Mean awareness score of the symptoms was 7.2/10. Fever (93.0%) and diarrhoea (33.5%) were the most- and least-known symptoms, respectively. Most knew all six preventive measures (90.4%), perceived them as effective (78.7%), and practiced ‘wear a mask’ (97.2%). Indians, Malays, and those in smaller housing had poorer mean knowledge of COVID-19 symptoms scores. Older participants had poorer attitudes towards preventive measures. Compared to Chinese, Indians had lower odds of practicing 3/6 recommendations. A one-point increase in knowledge of and attitudes towards preventive measures score had higher odds of always practicing 3/6 and 2/6 measures, respectively. Qualitative interviews revealed use of other preventive measures, e.g. maintaining a healthy lifestyle.

Conclusions: Elderly Singaporeans displayed high levels of KAP about COVID-19 and related preventive measures, with a positive association between levels of knowledge/attitude, and practice. However, important ethnic and socioeconomic disparities were evident, suggesting key vulnerabilities remain, requiring immediate attention.

Keywords: Knowledge; Attitude; Practice; COVID-19; Elderly
INTRODUCTION

Older adults and those with comorbidities are most vulnerable to serious health complications and death when infected with the coronavirus disease 2019 (COVID-19). Many countries have had evolving public health messages (e.g., mask wearing, hand washing, safe distancing), with some countries having stronger government enforced measures, particularly in Asia.

Since Singapore’s first confirmed COVID-19 case in January 2020, the government has endorsed several unprecedented measures in response to the outbreak, including safe physical distancing, hand washing, travel restrictions, school closures, suspension of all non-essential services, suspension of social and other activities that cannot be conducted through telecommuting, banning public gatherings, and wearing of masks when outside. In contrast to many other countries, some of these measures are compulsory, closely monitored, and enforced, with significant legal consequences if not adhered to.

However, for the successful containment of any virus, long term adherence to associated preventive measures is essential and is largely influenced by the knowledge, attitudes, and practice (KAP) of the population towards the disease and government-endorsed preventive measures. Presence of knowledge deficits among older individuals has been shown to lead to reduced capacity to make appropriate health decisions, and problematic health-seeking behaviours. Furthermore, poor health literacy contributes to health disparities associated with race/ethnicity and socioeconomic status (SES), thus increasing the risk of inadequate access to critical information for many vulnerable populations. For example, in older adults aged ≥ 60 years with chronic illnesses living in Chicago, one third could not identify COVID-19 symptoms or proper preventive measures, although most perceived the threat of COVID-19 to be serious. However, these findings may not be generalisable to Asian populations due to differences in outbreak management adopted by government, political,
economic, and healthcare systems, and cultural differences in people’s perceptions of illness and disease coping mechanisms.\(^{(11)}\)

To date, most studies investigating COVID-19 related KAP in Asian populations have targeted younger individuals via web-based surveys with few data on vulnerable populations such as older adults, those of low SES,\(^{(12)}\) and those with significant co-morbidities such as hypertension, diabetes and cardiovascular disease.\(^{(13)}\) Such information is imperative to identify potentially risky behaviours relating to disease management and to inform tailored health education programs targeting high-risk segments of the population.

In this study, we addressed these knowledge gaps. Using a mixed-methods approach, we (a) investigated the KAP about COVID-19 and related preventive measures among multi-ethnic elderly residents in Singapore recruited from the ongoing PopulatION HEalth and Eye Disease PRofile of Elderly Singaporean (PIONEER) study; (b) identified sociodemographic and health-related factors associated with levels of KAP; and (c) explored the association between knowledge/attitudes and practice of the preventive measures.

**METHODS**

Participants of this PIONEER-COVID-19 sub-study were recruited from the ongoing population-based PIONEER study.\(^{(14)}\) The PIONEER-COVID-19 sub-study procedures were approved by the SingHealth Centralised Institutional Review Board (CIRB, #2020/2350) and its protocol adheres to the principles of the Declaration of Helsinki. All participants included in the sub-study had provided prior consent to be contacted for future research opportunities.

Participants who passed the six-item Cognitive Impairment Test (6CIT)\(^{(15)}\) during their previous PIONEER assessment were invited to participate in the COVID-19 sub-study via telephone by a trained clinical research coordinator (CRC). Individuals identified with severe cognitive or hearing impairment during the recruitment call that precluded their ability to
complete the telephone interviews were excluded. The 6CIT was repeated on participants who completed their PIONEER assessment > 6 months before the current COVID-19 sub-study. For eligible individuals, the CRCs explained the study in the participant’s preferred language (English, Mandarin, Malay or Tamil) and obtained verbal consent. Participants were deemed ‘not contactable’ after four unsuccessful telephone calls conducted on different days/times.

The PIONEER-COVID-19 sub-study employed a mixed-methods approach, including both quantitative surveys (conducted in four languages) and qualitative semi-structured interviews (conducted in English or Mandarin). Respondents for the interviews were selected purposively to ensure an even spread of age, gender and ethnicity, and were contacted within two weeks of the quantitative survey. Data were collected until thematic saturation was reached. All assessments were conducted via telephone, as it was not feasible to conduct household visits during the outbreak period.

Participants’ responses were recorded using Qualtrics web-based software, taking on average 25 minutes to complete. A total of 1100 PIONEER participants (679 Chinese, 305 Indians, 115 Malays and one Eurasian) were contacted for the COVID-19 sub-study. Of these, 186 declined (64.5% - not interested, 17.2% - no time/ long survey, 13.4% - caregivers did not approve and 4.8% - other reasons), 123 were ineligible, and 121 were not responsive/uncontactable. Most of the participants who were deemed ineligible either failed the 6 item cognitive impairment test (n = 57, 46.3%) or were hearing impaired (n = 35, 28.5%), thus making it impossible for them to complete the questionnaires. Others (n = 31) were excluded due to one of the following reasons - did not speak English, Mandarin, Malay or Tamil but conversant in other languages (e.g., Hainanese, Hakka, Hindi, Telugu, Malayalam, Punjabi, Gujarati) unfamiliar to PIONEER’s clinical research coordinators (8.9%); deceased (7.3%); did not reside in Singapore (4.9%); resided in nursing homes (2.4%); or were bed-
ridden (1.6%). In total, 670 eligible participants (78.3% response rate) agreed to participate. Data were collected between 13th May 2020 and 9th June 2020.

Knowledge of COVID-19 symptoms was assessed using ten items adapted from the World Health Organization Tool for Behavioural Insights on COVID-19.(17) Knowledge of six government-endorsed preventive measures was assessed by asking participants if they had been told to adhere to these measures (see Supplementary Table S1). Three measures were monitored and enforced: 1. wearing a face mask when going out: ‘wear a mask’; 2. staying at least 1-2 meters away from other people: ‘safe distance’; and 3. not visiting relatives or friends: ‘not visiting’. Three measures were recommended as best practice: 4. washing hands with soap and water for at least 30 seconds: ‘wash hands’, 5. stay at home and go out only if needed (e.g., food, necessities, exercise): ‘stay home’; and 6. seek immediate medical attention when sick: ‘seek medical attention’. Responses were recorded as yes, no/unsure. Correct and incorrect/unsure responses were assigned 1 and 0 points, respectively. An aggregate score was calculated for both knowledge scales, with higher scores indicating better knowledge about COVID-19 symptoms and preventive measures.

Participants’ perceptions of effectiveness of the six preventive measures were assessed with the question “Will (item) keep you or others safe from COVID-19” (Supplementary Table S1). Yes, no, and unsure responses were scored as per the knowledge items, with a higher total score denoting better attitudes towards COVID-19 related preventive measures. Based on expert panel feedback and discussion with patients during pre-testing, we included three items on other preventive practices not endorsed by the government. These items asked participants if they believed that praying, using traditional medicines, and wearing gloves every time they left home would keep themselves or others safe from COVID-19 (yes, no, unsure). Perception of susceptibility towards COVID-19 was assessed by asking participants about their chances of getting COVID-19 in the next three months (very unlikely, unlikely, likely, very likely).
Participants were asked how often they practiced the six preventive measures in the past 7 days (all the time, most of the time, some of the time, never, or not applicable; Supplementary Table S1). Participant responses for all six items were coded dichotomously for analyses as ‘always’ (all the time) and ‘sometimes/never’ (most of the time, some of the time, never) practice categories.

A subset (n=78; mean age 73.0 years, SD:7.6; female 51%; Chinese 46%) of the 670 participants was approached to complete semi-structured interviews. Respondents answered open-ended questions on how severe they believed their symptoms would be if they contracted COVID-19 and what measures apart from government-endorsed ones they had adopted to protect themselves from contracting COVID-19. Responses were audio-recorded, transcribed professionally, and independently coded using thematic analysis by two researchers.

Participants’ demographics (age, sex, ethnicity), SES (educational attainment, employment status, housing type, monthly household income), living arrangement, language spoken, place of residence in Singapore, and self-reported medical conditions were extracted from participants’ prior PIONEER assessments.

Descriptive statistics (mean and SD, counts and percentages) were calculated for all patient characteristics and survey responses. Frequencies of correct knowledge answers, and attitudes and practice responses were described. We compared knowledge and attitude scores between categories of sociodemographic and health-related factors using Analysis of Variance and Tukey’s test for pairwise combinations. Linear regression was used to identify factors independently associated with knowledge and attitude scores. Variables were selected for multivariable models if crude and/or age-gender-adjusted associations were observed. Chi-squared statistics and logistic regression were used to determine associations between sociodemographic and health-related factors and practice categories (always/sometimes or never). We used Student’s t-test and logistic regression to assess associations between
knowledge and attitude scores with practice categories. Regression coefficients (β) or odds ratios (ORs) and their 95% confidence intervals (CIs) were reported. All analyses were performed using Stata/SE, version 15 (StataCorp, College Station, Texas).

RESULTS

Of the 670 participants, three who tested positive for COVID-19 and seven who did not complete the KAP survey were excluded (Supplementary Table S2), leaving 660 for the final analysis. Of the 660 participants (mean age [SD] 73.9 years [7.7], female 53.0%; Supplementary Table S3), most were Chinese (62.6%), followed by Indian (27.1%), Malay (9.8%), and Eurasian (0.5%). Most respondents had secondary or above education (64.1%), were living in 3-5 room public or private housing (92.6%) and were not living alone (85.6%). Of those who were not living alone, 60.9% lived with at least one younger family member i.e., son, daughter, son-in-law, daughter-in-law, grandson, or granddaughter.

On average, respondents correctly identified 7.2/10 COVID-19 symptoms. Fever (93.0%), shortness of breath (92.3%), cough (91.4%), and sore throat (85.6%) were the most well-known symptoms; runny or stuffy nose (73.7%), fatigue (71.8%), lost sense of smell (65.4%) and muscle or body aches (60.5%) were moderately well-known; and headache (56.8%) and diarrhoea (33.5%) were the least well-known. Participants who were older, male, Malay, with lower education, living in 1-2 rooms public housing, separated, divorced or widowed, Tamil-speaking, current smokers, and had cardiovascular disease were more likely to have poorer symptoms-related knowledge scores (all P<0.05; Table 1). Multiple linear regression analyses showed that older age (per year increase, β: -0.03, 95% CI -0.06 to -0.00; P=0.031), Malay and Indian ethnicities (vs. Chinese, β: -1.05, CI -1.75 to -0.35, P=0.004; and β: -0.44, CI -0.88 to -0.01, P=0.047, respectively), primary or lower education (vs. secondary or above education β: -1.30, CI -1.72 to -0.89, P<0.001) and 1-2 room public housing (vs. 3-5
room public/private housing $\beta$: -1.07, CI -1.86 to -0.28, P=0.008) were associated with lower scores (Table 2).

Most participants (90.4%) were aware of the six preventive measures, with a mean knowledge score of 5.8/6 (SD: 0.5) (Table 3). Male respondents, Indians, those living in 1-2 room public housing, Tamil speakers and those born in India had poorer knowledge of the preventive measures (all P<0.05; Table 1). Multiple linear regression analyses showed that Malay and Indian ethnicities (vs. Chinese, $\beta$: -0.16, CI -0.32 to -0.00, P=0.049; and $\beta$: -0.22, CI -0.32 to -0.11, P<0.001, respectively), and 1-2 rooms public housing (vs. 3-5 room public/private $\beta$: -0.21, CI -0.36 to -0.05, P=0.009) were associated with lower knowledge scores (Table 2).

Most participants (78.7%) agreed that all six preventive measures were effective, with a mean attitude score of 5.6/6 (SD: 0.9) (Table 3). While there were no factors associated with attitude scores in univariable analyses (Supplementary Table S4), multiple linear regression showed that individuals who were older (per year increase, $\beta$: -0.02, CI -0.04 to -0.01, P=0.001) had lower attitude scores (Table 4).

Our quantitative survey found some participants believed praying (53.2%), wearing gloves when going out (45.1%) and using traditional medicines (30.2%) would keep themselves or others safe from COVID-19. The qualitative interviews revealed that other measures, such as regular physical activity, intake of supplements, consuming only home-cooked food and healthy eating, were also perceived as protective.

“I take vitamin C every morning... I exercise now. This was something I wasn’t doing before... I do use Vicks vapour rub. It doesn’t allow me to sneeze or to have liquid coming out from sneezing and things like that...” (Interview 55)
Most participants (80.6%) felt they were unlikely to get COVID-19 in the next three months, although participants aged ≥80 years, Mandarin speakers, and those with primary or lower education perceived themselves as more susceptible (all P<0.05; Supplementary Table S4). In multiple linear regression analyses, Mandarin (β: 0.28, CI 0.13 to 0.44, P<0.001; Table 4) and ‘other’ language (β: 0.21, CI 0.04 to 0.39, P=0.018) speaking participants reported greater perceived susceptibility compared to English speakers.

Qualitative interviews supported the survey findings, with most participants reporting low perceived susceptibility. However, the views of Tamil- and Malay-speaking participants were not explored. Nevertheless, when prompted to ‘imagine a scenario where they contracted COVID-19’, more than half (56.1%) anticipated severe symptoms requiring intensive treatment or leading to death, due to their age and overall poor health status.

“If I were to catch COVID, that would be the end for me. For one thing, I’ve got many health issues… I think COVID-19 won’t kill me but my other issues will.” (Interview 77)

Most participants reported always practicing enforced preventive measures such as ‘wear a mask’ (97.2%), ‘not visiting’ (89.8%), and ‘safe distance’ (82%). However, only 61.8% and 49.1% always practiced ‘wash hands’ and ‘seek medical attention’ (Table 3) recommendations, respectively.

Practice of these preventive measures varied significantly according to socio-demographic and health-related factors (Supplementary Table S5). For example, in multiple logistic regression analysis, compared to Chinese, Indians had lower odds of always practicing ‘wash hands’ (OR: 0.66, CI 0.45 to 0.96, P=0.032; Table 5), ‘safe distance’ (OR: 0.44, CI 0.28 to 0.71, P=0.001), and ‘not visiting’ (OR: 0.46, CI 0.21 to 0.99, P=0.046) measures. Participants residing in the West of Singapore (OR: 0.52, CI 0.30 to 0.90), P=0.019) had lower
odds of always practicing ‘stay home’. Females (OR: 3.30, CI 1.05 to 10.43], P=0.042) had higher odds of always wearing a mask when going out.

Better knowledge of COVID-19 symptoms and preventive measures and better attitude scores were observed in participants who reported always practicing government-endorsed preventive measures, compared with only sometimes or never (all P<0.05; Supplementary Table S6). In multivariable regression models (Table 6), a one-point increase in knowledge of preventive measures was associated with 1.41 (CI 1.01 to 1.97, P=0.041), 1.48 (CI 1.03 to 2.12, P=0.034) and 12.93 (CI 6.19 to 27.03, P<0.001) times higher odds of always practicing ‘wash hands’, ‘safe distance’ and ‘not visiting’, respectively. In addition, a one-point increase in attitudes towards preventive measures was associated with 1.37 (CI 1.08 to 1.72, P=0.008) and 2.62 (CI 1.85 to 3.69, P<0.001) higher odds of always practicing ‘safe distance’ and ‘not visiting’, respectively.

**DISCUSSION**

In our multi-ethnic elderly Singaporean population, most were aware of common symptoms of COVID-19 but less so about rarer symptoms. Although nearly 4 in 5 participants believed they were unlikely to get the disease, their perceived prognosis was poor if they did contract it due to advanced age and comorbidities. Knowledge of, attitudes about, and practice of government-endorsed preventive measures was high, particularly the enforced measures. However, older age, ethnicity (particularly Indian and Malay), and low SES were associated with poorer KAP, suggesting key vulnerabilities remain. Importantly, knowledge and attitudes did not differ by presence of comorbidities such as diabetes, hypertension and cardiovascular disease. Better knowledge of and attitudes towards preventive measures were associated with increased likelihood of practicing 3/5 and 2/5 measures, respectively, suggesting that targeted
communication strategies to improve knowledge and attitudes about COVID-19 prevention may positively affect behaviour in elderly Singaporeans.

Although participants were largely aware of common symptoms of COVID-19, only one-third were aware of diarrhoea. This is important as diarrhoea is reported by 10% of patients with COVID-19\(^{(19)}\) and those with diarrhoea tend to take longer to seek medical care than those with common symptoms, leading to delayed diagnosis and more severe symptoms at presentation.\(^{(20)}\) Continual public education about new and less common symptoms of COVID-19 is needed to enable earlier identification and quarantine, faster time to treatment, and lower community exposure community.

While perceived susceptibility to COVID-19 was low in our population, the consequences of catching the disease were believed to be severe due to frailty and comorbidity. Interestingly, Mandarin and ‘other’ language speakers felt that they were more likely to contract COVID-19 than English-speakers. Importantly, several studies have reported that perception of susceptibility is a useful predictor of adoption of preventive measures,\(^{(21,22)}\) suggesting that Mandarin and ‘other’ language speakers may be more likely to adhere to preventive measures. Indeed, we found that Mandarin and ‘other’ language speakers were more likely to always practice ‘staying home’, albeit this result was not statistically significant. These findings may reflect lingering fear resonating from the Severe Acute Respiratory Syndrome (SARS) epidemic in 2003, which affected China and Hong Kong more than India and Malaysia.\(^{(23)}\) Follow-up qualitative inquiries are needed to properly understand these findings and unearth potentially harmful fear and stigmatization among this group.\(^{(24)}\)

Our finding that awareness of government-endorsed preventive measures was very high contrasts with elderly populations elsewhere.\(^{(25)}\) This may be due to use of media platforms (e.g., MediaCorp television [TV] and radio) that are closely aligned with Singapore’s state-government policies through which intense mass media public health campaigns have
successfully engaged the public in containing similar health crises.\footnote{26} In addition, a majority of participants live with younger family members (e.g. son, daughter, daughter-in law) and therefore may have more access to or be provided with information on COVID-19 related preventive measures by these family members. Importantly, older age was associated with lower knowledge of symptoms, which is similar to findings during the SARS epidemic in Singapore in 2003\footnote{27} and the current COVID-19 outbreak in Chicago, USA.\footnote{10} This could be because older adults have reduced cognitive capacity to understand complex health information and acquire new information,\footnote{8} especially during quickly evolving pandemic situations. A recent press release showed that older Singaporeans relied more on official media sources (TV and radio) for information regarding COVID-19 over alternative forms of media.\footnote{28} As such, health authorities should work closely with TV and radio channels to effectively and quickly disseminate new health information in all local languages. Our finding that Malays and Indians had lower knowledge of symptoms and preventive measures is consistent with ethnic disparities related to COVID-19 related knowledge identified elsewhere.\footnote{10,29} Importantly, our findings were independent of SES, which is often considered a proxy for ethnicity,\footnote{30} suggesting that minority ethnic groups may be underserved in the Singapore government’s messaging. Our finding that those with lower SES were more likely to have lower knowledge of COVID-19 in our study supports existing literature on health literacy gaps among these groups.\footnote{29,31,32} Overall, health authorities may need to improve communication about COVID-19 to the very old, minority ethnic groups, and those with lower SES to ensure optimal disease management in these vulnerable segments of society, especially during lockdown periods.

We found positive attitudes towards government-endorsed COVID-19 preventive measures, similar to the SARS epidemic, where Singaporeans indicated high confidence with government handling of the situation.\footnote{33} Interestingly, more than a third believed that praying would keep themselves or others safe from COVID-19, similar to beliefs observed among older
adults with chronic illnesses such as musculoskeletal conditions, circulatory problems, and cancer. While praying is associated with positive health-related behaviours, preventive service use and satisfaction with care, it is also important that faith-related activities do not replace practice of evidence-based, government-endorsed preventive measures.

Practice of government-endorsed measures was high, particularly the enforced measures. This may be in response to the COVID-19 (Temporary Measures) Act and related punitive controls e.g. fines, that were instituted by the government to control the spread of COVID-19. However, there were important between-subgroup disparities in practice. For example, females were three times more likely to adhere to ‘wear a mask’ than males, which is consistent with gender differences in patterns of practice elsewhere, and underscores less risk-taking behaviours among women. We also found that Indians were less likely than Chinese to practice ‘wash hands’, ‘stay at home’ and ‘not visiting’. Although the reasons underlying this finding are unclear, the US National survey also demonstrated less adherence to COVID-19 related behaviours among African American respondents compared to their white counterparts. Further qualitative research is required to explain this phenomenon. Our study also showed that respondents residing in the West of Singapore were less likely to always practice ‘stay home’. The General Household Survey 2015 showed that this region is predominantly occupied by ethnic minorities, highlighting the need for innovative strategies to advance health education among culturally diverse populations with limited English proficiency through local community centres. Our finding that better knowledge/attitudes was associated with higher odds of practicing preventive measures is similar to related studies, suggesting that improving knowledge/attitudes via targeted educational/behavioural campaigns may have a measurable impact on suppression of this aggressive virus. Targeted educational or behavioural campaigns could be used to identify and address modifiable barriers (e.g., visiting friends or family during a lockdown in order to
avoid feeling lonely\(^{(17)}\) to practicing COVID-19 related preventive measures in the groups prone to be less adherent to regulations. These initiatives could be delivered via individual-level interventions coupled with effective organizational measures and community-based interventions. Furthermore, health authorities should aim at swift dissemination of public health information via national media platforms in languages (e.g. Tamil, Malay) familiar to the minority groups or by increasing the exposure to cue-to-action (e.g. posters in all local languages) in commonly visited public areas (e.g. void decks, shops, elevators). Health authorities could also liaise with leaders/prominent members of a group\(^{(41)}\) (e.g. entertainment or sport celebrities)/employers to disseminate information on preventive measures.

This study had several notable strengths. To the best of our knowledge, this is the first study in Asia to exclusively examine KAP about COVID-19 among individuals aged > 60 years, a vulnerable and difficult cohort to access, especially during a pandemic. Our high response is also a strength combined with the generalizability of our findings, being a sub-study of a population based study. Another strength is our use of WHO recommended questionnaires to assess knowledge of symptoms, and our adaptation of KAP questions to the local context. In addition, the questionnaires were translated to four local languages ensuring data were collected from the multi-ethnic population. The study also has some limitations. First, to reduce respondent burden and increase response rate our survey was relatively brief; as such, our findings are limited to basic measures of KAP. Similarly, while our qualitative study allowed an in-depth exploration of issues and supplemented our survey findings, the proportion of the participants who completed in-depth qualitative interviews (11.8%) was relatively small suggesting that our results must be interpreted with caution. Second, our study was conducted nearly four months after the first COVID-19 case was reported, over a 4-week period. As the pandemic continues to evolve and new measures are frequently announced, participants’ KAP may have already changed. Follow-up waves of the survey will be required to capture data on
new behaviours. Third, as our measurement of practice of preventive measures was self-reported, it may lack accuracy due to social desirability and recall bias. However, limiting recall to just a four-month period may mitigate the effects of recall bias. Fourth, our findings may not be generalizable to other vulnerable populations in Singapore, such as migrant workers residing in dormitories, who are at higher risk than local residents and are more likely to have poorer KAP about COVID-19. Finally, our study was cross-sectional and cannot assess the causal association between knowledge, attitudes and practices; future longitudinal studies are needed to confirm our findings.

In conclusion, our study of KAP about COVID-19 and preventive measures provides a rare snapshot of how multi-ethnic elderly Asian residents understood and responded to this unprecedented time in Singapore. Overall, most elderly Singaporeans had good knowledge of common symptoms of COVID-19; and were aware of, optimistic about, and practiced government-endorsed preventive measures. Good knowledge and attitudes about the preventive measures were associated with increased self-reported practice of measures. Nevertheless, we found profound gaps in KAP among older adults, ethnic minorities and those of low SES, requiring attention. General and unified health educational campaigns may not be good enough, with targeted and culturally appropriate messaging needed to educate all Singaporeans adequately about the disease and emphasize the importance of adhering to preventive measures to mitigate the chances of future outbreaks.

ACKNOWLEDGMENTS

We thank the PIONEER-COVID-19 data collection team for their important contribution to the study implementation: Abdul Farook; Ang Poh Hoon; Aricia Ho Xin Yi; Belicia Lim Jia Yi; Boh Hui Hui; FatimahZuhra bte Yacob Marica; Joshua Lim Hua Siong; Kodi Goh Jia Ling; Leow Zhun Hong; Neo Wee Teck; Nurul Huda Binte Ramli; Olga Aprianti Lee;
Raihanah Binte Rosli; Roger Lim Ching Khiang; Tan Wei Lin; Teo Hui Ting; Theophila Ang Jin Lin. This independent research was supported by the Singapore National Medical Research Council (NMRC #JRNMRR140601). The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

REFERENCES

1. Leung C. Clinical features of deaths in the novel coronavirus epidemic in China. Rev Med Virol 2020; 30:e2103.

2. Yang J, Zheng Y, Gou X, et al. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. Int J Infect Dis 2020; 94:91-5.

3. De Deyn MLZQ, Ng QX, Loke W, Yeo WS. A tale of two cities: a comparison of Hong Kong and Singapore’s early strategies for the coronavirus disease 2019 (COVID-19). J Infect 2020; 81:e51-2.

4. Wang CJ, Ng CY, Brook RH. Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive testing. JAMA 2020; 323:1341-2.

5. Confirmed Imported Case of Novel Coronavirus Infection in Singapore; Multi-Ministry Taskforce Ramps up Precautionary Measures. Available at: https://www.moh.gov.sg/news-highlights/details/confirmed-imported-case-of-novel-coronavirus-infection-in-singapore-multi-ministry-taskforce-ramps-up-precautionary-measures. Accessed June 29, 2020.

6. Singapore Statutes Online. COVID-19 (temporary measures) Act 2020. Available at: https://sso.agc.gov.sg/Act/COVID19TMA2020. Accessed August 27, 2020.

7. Vijaya K, Chan SP, Low YY, et al. Public knowledge, attitude, behaviour and response to the SARS outbreak in Singapore. Int J Health Promot Educ 2004; 42:78-82.
8. Wolf MS, Gazmararian JA, Baker DW. Health literacy and functional health status among older adults. Arch Intern Med 2005; 165:1946-52.

9. Bennett IM, Chen J, Soroui JS, White S. The contribution of health literacy to disparities in self-rated health status and preventive health behaviors in older adults. Ann Fam Med 2009; 7:204-11.

10. Wolf MS, Serper M, Opsasnick L, et al. Awareness, attitudes, and actions related to COVID-19 among adults with chronic conditions at the onset of the U.S. outbreak: a cross-sectional survey. Ann Intern Med 2020; 173:100-9.

11. Hale T, Angrist N, Kira B, et al. Variation in government responses to COVID-19 BSG Working Paper Series. BSG-WP-2020/032. Version 6.0. Available at: https://www.bsg.ox.ac.uk/research/publications/variation-government-responses-covid-19. Accessed September 6, 2020.

12. Zhong BL, Luo W, Li HM, et al. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. Int J Biol Sci 2020; 16:1745-52.

13. Yan AF, Sun X, Zheng J, et al. Perceived risk, behavior changes and health-related outcomes during COVID-19 pandemic: findings among adults with and without diabetes in China. Diabetes Res Clin Pract 2020; 167:108350.

14. Gupta P, Man REK, Fenwick EK, et al. Rationale and methodology of the PopulatION HEalth and Eye Disease PRofile in Elderly Singaporeans Study [PIONEER]. Aging Dis 2020; 11:1444-58.

15. Upadhyaya AK, Rajagopal M, Gale TM. The Six Item Cognitive Impairment Test (6-CIT) as a screening test for dementia: comparison with Mini-Mental State Examination (MMSE). Curr Aging Sci 2010; 3:138-42.
16. Snow J, Mann M, Page T. Qualtrics Survey Software: Handbook for Research Professionals. Qualtrics Labs, Inc. 2012.

17. Coroiu A, Moran C, Campbell T, Geller AC. Barriers and facilitators of adherence to social distancing recommendations during COVID-19 among a large international sample of adults. PLoS One 2020; 15:e0239795.

18. What you can and cannot do during the circuit breaker period. In: the official government of the Republic of Singapore [online]. Available at: https://www.gov.sg/article/what-you-can-and-cannot-do-during-the-circuit-breaker-period. Accessed July 21, 2020.

19. D’Amico F, Baumgart DC, Danese S, Peyrin-Biroulet L. Diarrhea during COVID-19 infection: pathogenesis, epidemiology, prevention, and management. Clin Gastroenterol Hepatol 2020; 18:1663-72.

20. Han C, Duan C, Zhang S, et al. Digestive symptoms in COVID-19 patients with mild disease severity: clinical presentation, stool viral RNA testing, and outcomes. Am J Gastroenterol 2020; 115:916-23.

21. Jose R, Narendran M, Bindu A, et al. Public perception and preparedness for the pandemic COVID-19: a health belief model approach. Clin Epidemiol Glob Health 2021; 9:41-6.

22. Lau JTF, Yang X, Pang E, et al. SARS-related perceptions in Hong Kong. Emerg Infect Dis 2005; 11:417-24.

23. Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003. Available at: https://www.who.int/publications/m/item/summary-of-probable-sars-cases-with-onset-of-illness-from-1-november-2002-to-31-july-2003. Accessed October 6, 2021.

24. Person B, Sy F, Holton K, et al. Fear and stigma: the epidemic within the SARS outbreak. Emerg Infect Dis 2004; 10:358-63.
25. de Lima Filho BF, Bessa NPOS, Fernandes ACT, et al. Knowledge levels among elderly people with diabetes mellitus concerning COVID-19: an educational intervention via a teleservice. Acta Diabetol 2021; 58:19-24.

26. Ho SS. The knowledge gap hypothesis in Singapore: the roles of socioeconomic status, mass media, and interpersonal discussion on public knowledge of the H1N1 flu pandemic. Mass Commun Soc 2012; 15:695-717.

27. Seng SL, Lim PS, Ng MY, Wong HB, Emmanuel SC. A study on SARS awareness and health-seeking behaviour - findings from a sampled population attending National Healthcare Group Polyclinics. Ann Acad Med Singap. 2004 Sep;33(5):623-9. PMID: 15531959.

28. Financial burdens and well-being of Singapore’s older adults significantly impacted by COVID-19. Available at: Financial burdens and well-being of Singapore’s older adults significantly impacted by COVID-19 | SMU Newsroom. Accessed September 6, 2020.

29. Alsan M, Stantcheva S, Yang D, Cutler D. Disparities in coronavirus 2019 reported incidence, knowledge, and behavior among US adults. JAMA Netw Open 2020; 3:e2012403.

30. Schulman KA, Rubenstein LE, Chesley FD, Eisenberg JM. The roles of race and socioeconomic factors in health services research. Health Serv Res 1995; 30(1 Pt 2):179-95.

31. McCaffery KJ, Dodd RH, Cvejic E, et al. Health literacy and disparities in COVID-19-related knowledge, attitudes, beliefs and behaviours in Australia. Public Health Res Pract 2020; 30:30342012.

32. Seng SL, Lim PS, Ng MY, Wong HB, Emmanuel SC. A study on SARS awareness and health-seeking behaviour - findings from a sampled population attending National Healthcare Group Polyclinics. Ann Acad Med Singap 2004; 33:623-9.
33. Quah SR, Lee HP. Crisis prevention and management during SARS outbreak, Singapore. Emerg Infect Dis 2004; 10:364-8.

34. O’Connor PJ, Pronk NP, Tan A, Whitebird RR. Characteristics of adults who use prayer as an alternative therapy. Am J Health Promot 2005; 19:369-75.

35. Tang CSK, Wong CY. Factors influencing the wearing of facemasks to prevent the severe acute respiratory syndrome among adult Chinese in Hong Kong. Prev Med 2004; 39:1187-93.

36. Pawlowski B, Atwal R, Dunbar RIM. Sex differences in everyday risk-taking behavior in humans. Evol Psychol 2008; 6:29-42.

37. Resident population by subzone, ethnic group and sex. In: data.gov.sg [online]. Available at: https://data.gov.sg/dataset/resident-population-by-planning-area-subzone-ethnic-group-and-sex-2015?view_id=8955d2b2-9209-4b39-adf1-4035933a24b0&resource_id=08f521ae-c3c2-4e55-b69b-55c5d7671329. Accessed September 17, 2020.

38. Andrulis DP, Brach C. Integrating literacy, culture, and language to improve health care quality for diverse populations. Am J Health Behav 2007; 31 Suppl 1(Suppl 1):S122-33.

39. Clements JM. Knowledge and behaviors toward COVID-19 among US residents during the early days of the pandemic: cross-sectional online questionnaire. JMIR Public Health Surveill 2020; 6:e19161.

40. Rubin GJ, Amlôt R, Page L, Wessely S. Public perceptions, anxiety, and behaviour change in relation to the swine flu outbreak: cross sectional telephone survey. BMJ 2009; 339:b2651.

41. Bicchieri C, Dimant E, Gaechter S, Nosenzo D. Social proximity and the erosion of norm compliance. October 5, 2021. Available at SSRN: http://dx.doi.org/10.2139/ssrn.3355028. Access April 21, 2021.
| Table 1. Knowledge of COVID-19 symptoms and related government-endorsed preventive measures scores across sample characteristics (n=660) in univariable analyses |
|---------------------------------------------------------------|
| **Symptoms** | **Preventive measures** |  |
| | n (%) | mean ± SD | P value | n (%) | mean ± SD | P value |  |
| **Age group** | | | | | | | |
| 60 - 64 | 96 (14.6) | 7.73 ± 1.74 | 0.001(a) | 96 (14.7) | 5.90 ± 0.45 | 0.136 |  |
| 65 - 69 | 142 (21.6) | 7.36 ± 2.31 |  | 142 (21.8) | 5.88 ± 0.44 |  |  |
| 70 - 74 | 158 (24.0) | 7.39 ± 2.23 |  | 157 (24.1) | 5.75 ± 0.65 |  |  |
| 75 - 79 | 101 (15.4) | 7.35 ± 2.42 |  | 101 (15.5) | 5.87 ± 0.46 |  |  |
| 80 and above | 160 (24.4) | 6.56 ± 2.82 |  | 155 (23.8) | 5.82 ± 0.53 |  |  |
| **Gender** | | | | | | | |
| Male | 308 (47.0) | 6.98 ± 2.59 | 0.014 | 304 (46.8) | 5.79 ± 0.59 | 0.016 |  |
| Female | 347 (53.0) | 7.44 ± 2.20 |  | 345 (53.2) | 5.88 ± 0.44 |  |  |
| **Ethnicity** | | | | | | | |
| Chinese | 407 (62.6) | 7.48 ± 2.27 | 0.004(b) | 406 (63.0) | 5.92 ± 0.36 | <0.001(c) |  |
| Malay | 64 (9.8) | 6.52 ± 2.58 |  | 63 (9.8) | 5.70 ± 0.71 |  |  |
| Indian | 176 (27.1) | 6.91 ± 2.54 |  | 173 (26.9) | 5.69 ± 0.69 |  |  |
| Others | 3 (0.5) | 7.67 ± 1.53 |  | 2 (0.3) | 6.00 ± 0.00 |  |  |
| **Education level** | | | | | | | |
| Primary or lower | 222 (35.9) | 6.47 ± 2.73 | <0.001 | 219 (35.7) | 5.86 ± 0.47 | 0.484 |  |
| Secondary or above | 397 (64.1) | 7.70 ± 2.03 |  | 395 (64.3) | 5.83 ± 0.54 |  |  |
| **Housing type** | | | | | | | |
| 1-2 rooms public housing | 46 (7.4) | 5.89 ± 3.05 | <0.001 | 45 (7.3) | 5.64 ± 0.71 | 0.009 |  |
| 3-5 rooms public or private housing | 573 (92.6) | 7.37 ± 2.29 |  | 569 (92.7) | 5.85 ± 0.50 |  |  |
| **Income** | | | | | | | |
| <$2000 | 212 (55.1) | 7.10 ± 2.64 | 0.212 | 209 (54.7) | 5.81 ± 0.55 | 0.515 |  |
| $2000 and above | 173 (44.9) | 7.41 ± 2.05 |  | 173 (45.3) | 5.77 ± 0.61 |  |  |
| Occupation                     | No. (Per cent) | Mean ± SD  | P-value (x) | No. (Per cent) | Mean ± SD  | P-value (y) |
|-------------------------------|----------------|------------|-----------|----------------|------------|------------|
| Unemployed, housewife or retired | 370 (67.0)     | 7.18 ± 2.39 | 0.695     | 366 (66.8)     | 5.86 ± 0.49 | 0.140      |
| White-collar, admin or clerical | 54 (9.8)       | 7.59 ± 2.19 |           | 54 (9.9)       | 5.80 ± 0.59 |            |
| Blue-collar                   | 65 (11.8)      | 7.26 ± 2.03 |           | 65 (11.9)      | 5.91 ± 0.38 |            |
| Self-employed or others       | 63 (11.4)      | 7.25 ± 2.71 |           | 63 (11.5)      | 5.71 ± 0.71 |            |
| Marital status                |                |            |           |                |            |            |
| Single or never married       | 30 (4.8)       | 7.77 ± 2.39 | 0.023 (d) | 30 (4.9)       | 5.97 ± 0.18 | 0.383      |
| Married                       | 449 (72.5)     | 7.37 ± 2.33 |           | 445 (72.5)     | 5.83 ± 0.54 |            |
| Separated, divorced or widowed | 140 (22.6)    | 6.80 ± 2.49 |           | 139 (22.6)     | 5.83 ± 0.51 |            |
| Lives alone                   |                |            |           |                |            |            |
| No                            | 565 (92.3)     | 7.30 ± 2.36 | 0.179     | 561 (92.4)     | 5.83 ± 0.53 | 0.203      |
| Yes                           | 47 (7.7)       | 6.81 ± 2.70 |           | 46 (7.6)       | 5.93 ± 0.25 |            |
| Main language                 |                |            |           |                |            |            |
| English                       | 173 (27.9)     | 7.64 ± 2.20 | <0.001 (e) | 171 (27.9)     | 5.82 ± 0.57 | 0.001 (f)  |
| Mandarin                      | 158 (25.5)     | 7.82 ± 2.04 |           | 158 (25.7)     | 5.94 ± 0.30 |            |
| Malay                         | 65 (10.5)      | 6.68 ± 2.66 |           | 64 (10.4)      | 5.72 ± 0.68 |            |
| Tamil                         | 85 (13.7)      | 6.46 ± 2.38 |           | 84 (13.7)      | 5.68 ± 0.68 |            |
| Others                        | 138 (22.3)     | 6.92 ± 2.60 |           | 137 (22.3)     | 5.90 ± 0.41 |            |
| Place of Residence            |                |            |           |                |            |            |
| North                         | 249 (38.5)     | 7.39 ± 2.45 | 0.161     | 246 (38.4)     | 5.82 ± 0.54 | 0.547      |
| South                         | 121 (18.7)     | 6.95 ± 2.56 |           | 118 (18.4)     | 5.90 ± 0.42 |            |
| East                          | 130 (20.1)     | 7.42 ± 2.30 |           | 130 (20.3)     | 5.82 ± 0.54 |            |
| West                          | 147 (22.7)     | 6.98 ± 2.28 |           | 146 (22.8)     | 5.84 ± 0.52 |            |
| Country of birth              |                |            |           |                |            |            |
| Singapore                     | 429 (69.4)     | 7.37 ± 2.26 | 0.202     | 428 (69.8)     | 5.87 ± 0.47 | 0.002 (g)  |
| China                         | 28 (4.5)       | 7.54 ± 2.36 |           | 28 (4.6)       | 5.89 ± 0.42 |            |
| Malaysia                      | 104 (16.8)     | 7.00 ± 2.67 |           | 102 (16.6)     | 5.74 ± 0.64 |            |
| India                         | 34 (5.5)       | 7.00 ± 2.72 |           | 33 (5.4)       | 5.58 ± 0.79 |            |
| Others                        | 23 (3.7)       | 6.39 ± 2.57 |           | 22 (3.6)       | 6.00 ± 0.00 |            |
| **Smoking status** |   |   |   |   |   |   |
|--------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                    | Never            | Past             | Current          | Never            | Past             | Current          |
| Smoking status     | 453 (75.5)       | 105 (17.5)       | 42 (7.0)         | 449 (75.5)       | 104 (17.5)       | 42 (7.1)         |
|                    | 7.40 ± 2.34      | 6.87 ± 2.35      | 6.43 ± 2.74      | 5.86 ± 0.48      | 5.79 ± 0.60      | 5.83 ± 0.54      |
| Overall P-value    | 0.008(h)         | 0.309            | 0.012            | 0.067            | 0.012            | 0.048            |
| ANOVA             | 0.407            | 0.372            | 0.460            | 0.254            | 0.399            | 0.777            |
| Significant pairwise comparisons based on Tukey's test | (a) 80 and above vs. the other age categories | (b) Chinese vs. Malay | (c) Chinese vs. Indian | (d) Separated, divorced or widowed vs. Married | (e) English vs. Malay, Tamil and others; Mandarin vs. Malay, Tamil and others | (f) Mandarin vs. Malay and Tamil; Others vs. Tamil | (g) Singapore vs. India and Others vs. India | (h) Current vs. Never smoker |
| Alcohol use        | 492 (82.0)       | 42 (7.0)         | 66 (11.0)        | 487 (81.8)       | 42 (7.1)         | 66 (11.1)        |
|                    | 7.30 ± 2.38      | 7.24 ± 2.12      | 6.82 ± 2.59      | 5.86 ± 0.48      | 5.81 ± 0.59      | 5.77 ± 0.63      |
| Diabetes           | 433 (68.6)       | 198 (31.4)       | 128 (21.3)       | 430 (68.8)       | 195 (31.2)       | 126 (21.2)       |
|                    | 7.33 ± 2.32      | 6.95 ± 2.56      | 6.77 ± 2.75      | 5.86 ± 0.48      | 5.81 ± 0.57      | 5.88 ± 0.45      |
| Cardiovascular disease | 472 (78.7)       | 128 (21.3)       | 469 (78.8)       | 460 (84.7)       | 126 (21.2)       | 126 (21.2)       |
|                    | 7.37 ± 2.27      | 6.77 ± 2.75      | 5.84 ± 0.52      | 5.85 ± 0.51      | 5.88 ± 0.45      | 5.88 ± 0.45      |
| Chronic kidney disease | 464 (84.5)       | 85 (15.5)        | 460 (84.7)       | 460 (84.7)       | 83 (15.3)        | 83 (15.3)        |
|                    | 7.36 ± 2.29      | 6.81 ± 2.66      | 5.85 ± 0.51      | 5.85 ± 0.51      | 5.89 ± 0.44      | 5.89 ± 0.44      |
| Hypertension       | 94 (14.9)        | 537 (85.1)       | 92 (14.7)        | 92 (14.7)        | 533 (85.3)       | 533 (85.3)       |
|                    | 7.50 ± 2.23      | 7.16 ± 2.43      | 5.86 ± 0.48      | 5.86 ± 0.48      | 5.84 ± 0.51      | 5.84 ± 0.51      |
| Hyperlipidaemia    | 190 (32.1)       | 537 (85.1)       | 186 (31.7)       | 186 (31.7)       | 400 (68.3)       | 400 (68.3)       |
|                    | 7.21 ± 2.39      | 7.16 ± 2.43      | 5.80 ± 0.58      | 5.80 ± 0.58      | 5.88 ± 0.45      | 5.88 ± 0.45      |
| Overall P-value    | 0.782            | 0.048            | 0.012            | 0.048            | 0.048            | 0.048            |
| ANOVA             | 0.063            | 0.460            | 0.399            | 0.777            | 0.063            | 0.063            |

Overall P-value based on ANOVA. Significant pairwise comparisons based on Tukey's test
(a) 80 and above vs. the other age categories (b) Chinese vs. Malay (c) Chinese vs. Indian (d) Separated, divorced or widowed vs. Married (e) English vs. Malay, Tamil and others; Mandarin vs. Malay, Tamil and others (f) Mandarin vs. Malay and Tamil; Others vs. Tamil (g) Singapore vs. India and Others vs. India (h) Current vs. Never smoker
Table 2. Factors associated with knowledge of COVID-19 symptoms and related government-endorsed preventive measures scores in multiple linear regression analyses‡

|                         | Symptoms                              | Preventive measures                     |
|-------------------------|---------------------------------------|-----------------------------------------|
|                         | Beta (95% CI)                         | P                                       | Beta (95% CI)                         | P       |
| **Age (per year increase)** | -0.03 (-0.06 to 0.00) | 0.031                                   | -0.00 (-0.01 to 0.00) | 0.544          |
| **Gender**              |                                       |                                         |                                       |         |
| Male                    | REF                                   |                                         | Male                                   | REF     |
| Female                  | 0.35 (-0.13 to 0.82)                  | 0.151                                   | Female                                 | 0.09 (-0.00 to 0.18) | 0.051 |
| **Ethnicity**           |                                       |                                         |                                       |         |
| Chinese                 | REF                                   |                                         | Chinese                                | REF     |
| Malay                   | -1.05 (-1.75 to -0.35)                | 0.004                                   | Malay                                  | -0.16 (-0.32 to -0.00) | 0.049 |
| Indian                  | -0.44 (-0.88 to -0.01)                | 0.047                                   | Indian                                 | -0.22 (-0.32 to -0.11) | <0.001 |
| Others                  | -0.22 (-2.75 to 2.30)                 | 0.862                                   | Others                                 | 0.15 (-0.84 to 1.14) | 0.762 |
| **Education**           |                                       |                                         |                                       |         |
| Secondary or above      | REF                                   |                                         |                                        |         |
| Primary or lower        | -1.30 (-1.72 to -0.89)                | <0.001                                  | 1-2 rooms public housing               | -0.21 (-0.36 to -0.05) | 0.009 |
| **Housing**             |                                       |                                         |                                        |         |
| 3-5 rooms public or private housing | REF                              |                                         |                                        |         |
| 1-2 rooms public housing | -1.07 (-1.86 to -0.28)                | 0.008                                   |                                        |         |
| **Marital status**      |                                       |                                         |                                        |         |
| Married                 | REF                                   |                                         |                                        |         |
| Single or never married | -0.06 (-0.97 to 0.85)                 | 0.896                                   |                                        |         |
| Separated, divorced or widowed | -0.25 (-0.76 to 0.26) | 0.336                                   |                                        |         |
| **Smoking status**      |                                       |                                         |                                        |         |
| Never                   | REF                                   |                                         |                                        |         |
| Past                    | -0.17 (-0.74 to 0.41)                 | 0.565                                   |                                        |         |

‡ Significant at p < 0.05.
| Variable                  | Reference Value | Beta (95% CI) | p-Value |
|--------------------------|-----------------|---------------|---------|
| **Alcohol use**          |                 |               |         |
| Current                  | REF             | -0.41 (-1.22 to 0.40) | 0.319   |
| Past                     |                 | 0.43 (-0.35 to 1.21)  | 0.282   |
| Current                  |                 | -0.85 (-1.46 to -0.24) | 0.007   |
| Others                   |                 | 0.12 (-0.10 to 0.35)  | 0.282   |
| **Diabetes**             |                 |               |         |
| No                       | REF             | -0.01 (-0.43 to 0.41)  | 0.957   |
| Yes                      |                 | -0.42 (-0.91 to 0.07)  | 0.091   |
| **Cardiovascular disease**|               |               |         |
| No                       | REF             | -0.42 (-0.91 to 0.07)  | 0.091   |
| Yes                      |                 | -0.11 (-0.67 to 0.45)  | 0.691   |

‡Variables included were those that were significant in univariable or age/gender adjusted analyses
Table 3. Knowledge, Attitudes, and Practice (KAP) towards COVID-19 related government-endorsed preventive measures, and Perception of Susceptibility in overall sample (n=660).

| Knowledge n (%) | Attitudes n (%) | Practice n (%) |
|----------------|----------------|---------------|
| **Have you been told to (item here)?** | **Will (item here) keep you or others safe from COVID-19?** | **How often did you (item here) in the past 7 days?** |
| Yes | No | Unsure | Yes | No | Unsure | All the time | Most of the time | Some of the time | Never |
|---|---|---|---|---|---|---|---|---|---|
| 1. Wear a face mask when going out[^] | 652 (99.8) | 1 (0.2) | 632 (96.9) | 4 (0.6) | 16 (2.5) | 560 (97.2) | 14 (2.4) | 2 (0.3) | 10 refused to answer |
| 2. Stay at least 1-2 metres away from other people | 647 (99.1) | 2 (0.3) | 613 (94.0) | 16 (2.5) | 23 (3.5) | 473 (82.0) | 97 (15.8) | 7 (1.2) | 74 not applicable responses |
| 3. For K and A: Not visit relatives or friends | 644 (98.6) | 7 (1.1) | 624 (95.7) | 15 (2.3) | 13 (2.0) | 570 (89.8) | 17 (2.7) | 8 (1.3) | 40 not applicable responses |
| For P: Visit relatives or friends§ | 648 (99.2) | 5 (0.8) | 610 (93.4) | 18 (2.8) | 25 (3.8) | 402 (61.8) | 212 (32.6) | 34 (5.2) | 2 (0.3) |
| 4. Wash hands with soap and water | 648 (99.2) | 5 (0.8) | 610 (93.4) | 18 (2.8) | 25 (3.8) | 402 (61.8) | 212 (32.6) | 34 (5.2) | 2 (0.3) |
| 5. Stay at home and go out only if needed | 611 (99.7) | 1 (0.2) | 602 (98.4) | 7 (1.1) | 3 (0.5) | 495 (81.0) | 76 (12.4) | 33 (5.4) | 7 (1.1) |
| 6. Go to the doctor if you’re sick¥ | 609 (99.3) | 4 (0.7) | 584 (95.4) | 9 (1.5) | 19 (3.1) | 26 (49.1) | 1 (1.9) | 17 (3.2) | 9 (1.7) |
| Mean correct response ± SD | 5.8 ± 0.5 | 5.6 ± 0.9 | 3.7 ± 0.3 | |

SD - Standard deviation, λ10 refused to answer[^]74 not applicable responses, †73 not applicable responses ¥558 not applicable responses §15 not applicable responses
| Attitudes towards preventive measures | Perception of susceptibility |
|--------------------------------------|-----------------------------|
| **Beta (95% CI)**                    | **Beta (95% CI)**           |
| **P**                                | **P**                       |
| **Age (per year increase)**          | **Age (per year increase)** |
| **Gender**                           |                             |
| Male                                 | REF                         |
| Female                               | 0.03 (-0.17 to 0.22)        | 0.789                       |
| **Income**                           |                             |
| <$2000                               | REF                         |
| $2000 and above                      | -0.25 (-0.46 to -0.04)      | 0.021                       |
| **Education**                        |                             |
| Primary or lower                     | REF                         |
| Secondary or above                   | -0.19 (-0.32 to -0.06)      | 0.005                       |
| **Housing Type**                     |                             |
| 1-2 rooms public housing             | REF                         |
| 3-5 rooms public or private housing  |                             |
| **Main Language**                    |                             |
| English                              | REF                         |
| Mandarin                             | 0.28 (0.13 to 0.44)         | <0.001                      |
| Malay                                | 0.03 (-0.17 to 0.23)        | 0.769                       |
| Tamil                                | 0.13 (-0.06 to 0.32)        | 0.190                       |
| Others                               | 0.21 (0.04 to 0.39)         | 0.018                       |

‡Variables included were those that were significant in univariable or age/gender adjusted analyses
|                                | 1. Wear a mask OR (95% CI) | P    | 2. Safe distance OR (95% CI) | P    | 3. Not visiting OR (95% CI) | P    | 4. Wash hands OR (95% CI) | P    | 5. Stay home OR (95% CI) | P    |
|--------------------------------|-----------------------------|------|-------------------------------|------|-----------------------------|------|--------------------------|------|--------------------------|------|
| **Age (per year increase)**    | 0.98 (0.92 to 1.05)         | 0.591| 1.01 (0.98 to 1.04)           | 0.727| 1.02 (0.96 to 1.08)         | 0.534| 1.00 (0.98 to 1.03)       | 0.771| 1.02 (0.99 to 1.05)       | 0.142|
| **Gender**                     |                             |      |                               |      |                             |      |                          |      |                          |      |
| Male                           | REF                         |      | REF                           |      | REF                         |      | REF                      |      | REF                      |      |
| Female                         | 3.30 (1.05 to 10.39)        | 0.042| 1.22 (0.78 to 1.89)           | 0.379| 1.41 (0.65 to 3.04)         | 0.383| 1.33 (0.87 to 2.02)       | 0.185| 1.34 (0.86 to 2.08)       | 0.200|
| **Ethnicity**                  |                             |      |                               |      |                             |      |                          |      |                          |      |
| Chinese                        | ..                          | ..   | REF                           |      | 0.60 (0.29 to 1.25)         | 0.173| 0.56 (0.15 to 2.16)       | 0.403| 0.93 (0.48 to 1.79)       | ..   |
| Malay                          | ..                          | ..   | REF                           |      | 0.44 (0.28 to 0.71)         | 0.001| 0.46 (0.21 to 0.99)       | 0.046| 0.66 (0.45 to 0.96)       | ..   |
| Indian                         | ..                          | ..   |                               |      |                            |      |                          |      |                          |      |
| **Housing**                    |                             |      |                               |      |                             |      |                          |      |                          |      |
| 1-2 rooms public housing       | ..                          | ..   | ..                            | ..   | Ref                        | ..   | Ref                      | ..   | Ref                      | ..   |
| 3-5 rooms public or private housing | ..                        | ..   | ..                            | ..   |                            |      |                          |      |                          |      |
| **Income**                     |                             |      |                               |      |                             |      |                          |      |                          |      |
| < $2000                        | ..                          | ..   | ..                            | ..   | Ref                        | ..   | ..                       | ..   | ..                       | ..   |
| $2000 and above                | ..                          | ..   | ..                            | ..   | 0.39 (0.16 to 0.97)         | 0.044| ..                       | ..   | ..                       | ..   |
| **Occupation**                 |                             |      |                               |      |                             |      |                          |      |                          |      |
| Unemployed, housewife or retired | ..                        | ..   | ..                            | ..   | Ref                        | ..   | ..                       | ..   | ..                       | ..   |
White-collar, admin or clerical & .. & .. & .. & .. & 0.84 (0.29 to 2.46) & 0.756 & .. & .. & .. & ..
Blue-collar & .. & .. & .. & .. & 3.47 (0.82 to 14.78) & 0.092 & .. & .. & .. & ..
Self-employed or others & .. & .. & .. & .. & 0.31 (0.12 to 0.84) & 0.022 & .. & .. & .. & ..

**Main language**

| Language | Odds ratio (95% CI) | p-value |
|----------|---------------------|---------|
| English  | REF                 |         |
| Mandarin | 1.18 (0.66 to 2.11) | 0.586   |
| Malay    | 3.11 (1.03 to 9.44) | 0.045   |
| Tamil    | 0.89 (0.43 to 1.82) | 0.746   |
| Others   | 1.15 (0.62 to 2.12) | 0.650   |

**Place of residence**

| Region   | Odds ratio (95% CI) | p-value |
|----------|---------------------|---------|
| North    | REF                 |         |
| South    | 0.95 (0.52 to 1.76) | 0.879   |
| East     | 1.37 (0.70 to 2.70) | 0.359   |
| West^    | 0.52 (0.30 to 0.90) | 0.019   |

**Diabetes**

| Status | Odds ratio (95% CI) | p-value |
|--------|---------------------|---------|
| No     | REF                 |         |
| Yes    | 1.76 (1.04 to 2.99) | 0.034   |

‡Variables included were those that were significant in univariable or age/gender adjusted analyses
As more than 80% responded ‘not applicable’ to ‘6. Seek Medical Attention’, this measure was not analysed further
Table 6. Association between Knowledge and Attitudes towards COVID-19 and related government-endorsed preventive measures, and practice (always) of the measures in multiple logistic regression analyses

| Practice items (always) | 1. Wear a mask | 2. Safe distance | 3. Not visiting | 4. Wash hands | 5. Stay home |
|-------------------------|----------------|-----------------|----------------|---------------|--------------|
|                         | OR (95% CI)    | P               | OR (95% CI)    | P             | OR (95% CI)  | P             |
| Knowledge               |                |                 |                |               |              |               |
| Symptoms                |                |                 |                |               |              |               |
| Age-gender adjusted     | 1.01 (0.81 to 1.25) | 0.93 | 1.13 (1.03 to 1.24) | 0.00 | 1.04 (0.93 to 1.16) | 0.504 | 1.03 (0.96 to 1.10) | 0.45 | 1.10 (1.01 to 1.20) | 0.028 |
| Multivariable adjusted* | 1.01 (0.81 to 1.25) | 0.93 | 1.11 (1.01 to 1.22) | 0.03 | 1.03 (0.88 to 1.20) | 0.744 | 1.03 (0.95 to 1.11) | 0.47 | 1.08 (0.98 to 1.19) | 0.125 |
| Preventive Measures     |                |                 |                |               |              |               |
| Age-gender adjusted     | 1.20 (0.54 to 2.65) | 0.65 | 1.65 (1.16 to 2.34) | 0.00 | 14.11 (8.06 to 24.68) | <0.00 | 1.43 (1.05 to 1.94) | 0.02 | 1.42 (0.65 to 3.07) | 0.378 |
| Multivariable adjusted* | 1.20 (0.54 to 2.65) | 0.65 | 1.48 (1.03 to 2.12) | 0.03 | 12.93 (6.19 to 27.03) | <0.00 | 1.41 (1.01 to 1.97) | 0.04 | 1.32 (0.54 to 3.22) | 0.540 |
| Attitudes               |                |                 |                |               |              |               |
| Preventive Measures     |                |                 |                |               |              |               |
| Age-gender adjusted     | 1.48 (0.98 to 2.25) | 0.06 | 1.44 (1.15 to 1.80) | 0.00 | 2.85 (2.20 to 3.70) | <0.00 | 1.26 (1.04 to 1.51) | 0.01 | 1.14 (0.89 to 1.47) | 0.306 |
| Multivariable adjusted* | 1.48 (0.98 to 2.25) | 0.06 | 1.37 (1.08 to 1.72) | 0.00 | 2.62 (1.85 to 3.69) | <0.00 | 1.19 (0.98 to 1.45) | 0.07 | 0.98 (0.71 to 1.35) | 0.913 |
| Perception of susceptibility |                |                 |                |               |              |               |
| Age-gender adjusted     | 1.05 (0.49 to 2.25) | 0.89 | 0.92 (0.66 to 1.27) | 0.60 | 0.98 (0.66 to 1.44) | 0.906 | 0.91 (0.71 to 1.17) | 0.47 | 1.35 (0.97 to 1.89) | 0.075 |
| Multivariable adjusted* | 1.05 (0.49 to 2.25) | 0.89 | 0.89 (0.64 to 1.23) | 0.47 | 0.95 (0.58 to 1.55) | 0.846 | 0.89 (0.69 to 1.15) | 0.38 | 1.40 (0.97 to 2.01) | 0.075 |

* Adjusted for significant variables that were associated with respect to each practice in univariable analysis

As more than 80% responded ‘not applicable’ to ‘6. Seek Medical Attention’, this measure was not analysed further
## APPENDIX

**Supplementary Table S1. Questionnaire about Knowledge, Attitude, and Practices towards COVID-19 and related government-endorsed preventive measures**

The Singapore government and MOH have proposed several recommendations to reduce the spread of COVID-19 in the population. For each recommendation, please indicate your knowledge, attitude, and actions towards practicing it in the last 7 days.

| Preventive measures | Knowledge | Attitude | Practice |
|---------------------|-----------|----------|----------|
|                     | Have you been told to *(item here)*? | Will *(item here)* keep you or others safe from COVID-19? | How often did you *(item here)* in the past 7 days? |
|                     | Yes | No | Unsure | Yes | No | Unsure | All the time | Most of the time | Some of the time | Never | N.A. |
| 1 Wear a face mask when going out | 1 | 0 | 88 | 1 | 0 | 88 | 1 | 2 | 3 | 4 | 888 |
| 2 Stay at least 1-2 metres away from other people | 1 | 0 | 88 | 1 | 0 | 88 | 1 | 2 | 3 | 4 | 888 |
| 3 For Knowledge and Attitude: Not visit relatives or friends For Practice: Visit relatives or friends | 1 | 0 | 88 | 1 | 0 | 88 | 4 | 3 | 2 | 1 | 888 |
| 4 Wash hands with soap and water | 1 | 0 | 88 | 1 | 0 | 88 | 1 | 2 | 3 | 4 | - |
| 5 Stay at home and go out only if needed (e.g., food, necessities, exercise) | 1 | 0 | 88 | 1 | 0 | 88 | 1 | 2 | 3 | 4 | - |
| 6 Go to the doctor if you’re sick | 1 | 0 | 88 | 1 | 0 | 88 | 1 | 2 | 3 | 4 | 888 |
| Variable                                      | Number observed | Number missing | % missing |
|----------------------------------------------|-----------------|----------------|-----------|
| Knowledge of symptoms                        |                 |                |           |
| Overall knowledge of symptoms score          | 660             | 0              | 0.0       |
| Fever                                        | 660             | 0              | 0.0       |
| Cough                                        | 660             | 0              | 0.0       |
| Shortness of breath                          | 659             | 1              | 0.2       |
| Sore throat                                  | 659             | 1              | 0.2       |
| Runny or stuffy nose                         | 659             | 1              | 0.2       |
| Muscle or body aches                         | 659             | 1              | 0.2       |
| Headaches                                    | 659             | 1              | 0.2       |
| Fatigue (tiredness)                          | 659             | 1              | 0.2       |
| Diarrhoea                                    | 659             | 1              | 0.2       |
| Lost sense of smell                          | 659             | 1              | 0.2       |
| Knowledge of preventive measures             |                 |                |           |
| Wash hands                                   | 653             | 7              | 1.1       |
| Wear a mask                                  | 653             | 7              | 1.1       |
| Safe distance                                | 653             | 7              | 1.1       |
| Stay home                                    | 613             | 47             | 7.1       |
| Seek medical attention                       | 613             | 47             | 7.1       |
| Not visiting                                 | 653             | 7              | 1.1       |
| Overall knowledge of preventive measures score| 653             | 7              | 1.1       |
| Attitudes towards preventive measures        |                 |                |           |
| Wash hands                                   | 653             | 7              | 1.1       |
| Wear a mask                                  | 652             | 8              | 1.2       |
| Safe distance                                | 652             | 8              | 1.2       |
| Stay home                                    | 612             | 48             | 7.3       |
| Seek medical attention                       | 612             | 48             | 7.3       |
| Not visiting                                 | 652             | 8              | 1.2       |
| Overall attitudes towards preventive measures score | 653             | 7              | 1.1       |
| Perception of susceptibility                 | 584             | 76             | 11.5      |
| Practice of preventive measures          | 650 | 10 | 1.5 |
|-----------------------------------------|-----|----|-----|
| Wash hands                              | 650 | 10 | 1.5 |
| Wear a mask                             | 650 | 10 | 1.5 |
| Safe distance                           | 650 | 10 | 1.5 |
| Stay home                               | 611 | 49 | 7.4 |
| Not visiting                            | 650 | 10 | 1.5 |
| Exposures of interest                   |     |    |     |
| Age                                     | 657 | 3  | 0.5 |
| Gender                                  | 655 | 5  | 0.8 |
| Ethnicity                               | 650 | 10 | 1.5 |
| Main language                           | 619 | 41 | 6.2 |
| Education                               | 619 | 41 | 6.2 |
| Income                                  | 385 | 275| 41.7|
| Housing                                 | 619 | 41 | 6.2 |
| Smoking status                          | 600 | 60 | 9.1 |
| Alcohol use                             | 600 | 60 | 9.1 |
| Country of birth                        | 618 | 42 | 6.4 |
| Marital status                          | 619 | 41 | 6.2 |
| Occupation                              | 552 | 108| 16.4|
| Lives alone                             | 612 | 48 | 7.3 |
| Diabetes                                | 631 | 29 | 4.4 |
| Hypertension                            | 631 | 29 | 4.4 |
| Hyperlipidaemia                         | 592 | 68 | 10.3|
| Cardiovascular disease                  | 600 | 60 | 9.1 |
| Chronic kidney disease                  | 549 | 111| 16.8|
| Place of residence                      | 647 | 13 | 2.0 |
| Supplementary Table S3. Sociodemographic and health-related characteristics of the study population (N=660) |
|--------------------------------------------------|------------------|
| **Age (in years)**                               | N (%)            |
| 60 - 64                                          | 96 (14.6)        |
| 65 - 69                                          | 142 (21.6)       |
| 70 - 74                                          | 158 (24.0)       |
| 75 - 79                                          | 101 (15.4)       |
| 80 and above                                     | 160 (24.4)       |
| **Gender, female**                              | 347 (53.0)       |
| **Ethnicity**                                    |                  |
| Chinese                                          | 407 (62.6)       |
| Malay                                            | 64 (9.8)         |
| Indian                                           | 176 (27.1)       |
| Others                                           | 3 (0.5)          |
| **Education level**                             |                  |
| Primary or lower                                 | 222 (35.9)       |
| Secondary or above                               | 397 (64.1)       |
| **Housing type**                                 |                  |
| 1-2 rooms public housing                         | 46 (7.4)         |
| 3-5 rooms public or private housing              | 573 (92.6)       |
| **Income**                                       |                  |
| < $2000                                          | 212 (55.1)       |
| $2000 and above                                  | 173 (44.9)       |
| **Occupation**                                   |                  |
| Unemployed, housewife or retired                 | 370 (67.0)       |
| White-collar, admin or clerical                  | 54 (9.8)         |
| Blue-collar                                      | 65 (11.8)        |
| Self-employed or others                          | 63 (11.4)        |
| **Marital status**                               |                  |
| Single or never married                          | 30 (4.8)         |
| Married                                          | 449 (72.5)       |
| Separated, divorced or widowed                   | 140 (22.6)       |
| **Lives alone**                                  | 47 (7.7)         |
| **Main language**                                |                  |
| English                                          | 173 (27.9)       |
| Mandarin                                         | 158 (25.5)       |
| Malay                                            | 65 (10.5)        |
| Tamil                                            | 85 (13.7)        |
| Others                                           | 138 (22.3)       |
| **Place of residence**                           |                  |
| Country of birth | Count (Percentage) |
|------------------|--------------------|
| North            | 249 (38.5)         |
| South            | 121 (18.7)         |
| East             | 130 (20.1)         |
| West             | 147 (22.7)         |

| Country of birth | Count (Percentage) |
|------------------|--------------------|
| Singapore        | 429 (69.4)         |
| China            | 28 (4.5)           |
| Malaysia         | 104 (16.8)         |
| India            | 34 (5.5)           |
| Others           | 23 (3.7)           |

| Smoking status   | Count (Percentage) |
|------------------|--------------------|
| Never            | 453 (75.5)         |
| Past             | 105 (17.5)         |
| Current          | 42 (7.0)           |

| Alcohol use      | Count (Percentage) |
|------------------|--------------------|
| Never            | 492 (82.0)         |
| Past             | 42 (7.0)           |
| Current          | 66 (11.0)          |

| Diabetes (yes)   | Count (Percentage) |
|------------------|--------------------|
| 198 (31.4)       |                    |

| Cardiovascular disease (yes) | Count (Percentage) |
|------------------------------|--------------------|
| 128 (21.3)                  |                    |

| Chronic kidney disease (yes) | Count (Percentage) |
|------------------------------|--------------------|
| 85 (15.5)                   |                    |

| Hypertension (yes)          | Count (Percentage) |
|-----------------------------|--------------------|
| 537 (85.1)                  |                    |

| Hyperlipidaemia (yes)       | Count (Percentage) |
|-----------------------------|--------------------|
| 402 (67.9)                  |                    |
**Supplementary Table S4. Factors associated with attitudes towards COVID-19 related government-endorsed preventive measures, and Perception of Susceptibility scores in univariable analyses**

|                      | Attitudes towards Preventive measures | Perception of susceptibility |
|----------------------|--------------------------------------|------------------------------|
|                      | n (%)      | mean ± SD  | P value | n (%)      | mean ± SD  | P value |
| **Age group**        |            |            |         |            |            |         |
| 60 - 64              | 96 (14.7)  | 5.70 ± 0.67 | 0.252   | 91 (15.6)  | 1.70 ± 0.78 | 0.047(a) |
| 65 - 69              | 142 (21.8) | 5.73 ± 0.72 | 0.129   | 129 (22.2) | 1.62 ± 0.66 |          |
| 70 - 74              | 157 (24.1) | 5.53 ± 0.94 | 0.047   | 139 (23.9) | 1.65 ± 0.60 |          |
| 75 - 79              | 101 (15.5) | 5.52 ± 1.14 | 0.252   | 89 (15.3)  | 1.53 ± 0.62 |          |
| 80 and above         | 155 (23.8) | 5.60 ± 0.98 | 0.047   | 134 (23.0) | 1.80 ± 0.72 |          |
| **Gender**           |            |            |         |            |            |         |
| Male                 | 304 (46.8) | 5.57 ± 0.92 | 0.212   | 273 (47.1) | 1.70 ± 0.69 | 0.368   |
| Female               | 345 (53.2) | 5.66 ± 0.89 | 0.212   | 307 (52.9) | 1.64 ± 0.67 |          |
| **Ethnicity**        |            |            |         |            |            |         |
| Chinese              | 406 (63.0) | 5.67 ± 0.89 | 0.312   | 357 (62.1) | 1.70 ± 0.68 | 0.545   |
| Malay                | 63 (9.8)   | 5.49 ± 0.93 | 0.047   | 61 (10.6)  | 1.61 ± 0.61 |          |
| Indian               | 173 (26.9) | 5.55 ± 0.91 | 0.047   | 155 (27.0) | 1.63 ± 0.71 |          |
| Others               | 2 (0.3)    | 6.00 ± 0.00 | 0.047   | 2 (0.3)    | 1.50 ± 0.71 |          |
| **Education level**  |            |            |         |            |            |         |
| Primary or lower     | 219 (35.7) | 5.68 ± 0.84 | 0.257   | 191 (34.7) | 1.83 ± 0.66 | <0.001  |
| Secondary or above   | 395 (64.3) | 5.59 ± 0.93 | 0.257   | 360 (65.3) | 1.59 ± 0.68 |          |
| **Housing type**     |            |            |         |            |            |         |
| 1-2 rooms public housing | 45 (7.3)   | 5.49 ± 1.18 | 0.308   | 36 (6.5)   | 1.61 ± 0.64 | 0.594   |
| 3-5 rooms public or private housing | 569 (92.7) | 5.63 ± 0.87 | 0.308   | 515 (93.5) | 1.67 ± 0.69 |          |
| **Income**           |            |            |         |            |            |         |
| <$2000               | 209 (54.7) | 5.62 ± 0.93 | 0.225   | 183 (54.8) | 1.70 ± 0.69 | 0.567   |
| $2000 and above      | 173 (45.3) | 5.50 ± 1.00 | 0.225   | 151 (45.2) | 1.66 ± 0.70 |          |
| **Occupation**       |            |            |         |            |            |         |
### Unemployed, housewife or retired

| Category                        | N (%)  | Mean ± SE  | P-value | 95% CI  |
|---------------------------------|--------|------------|---------|---------|
| White-collar, admin or clerical | 54 (9.9) | 5.69 ± 0.80 | 1.65 ± 0.79 | 0.145 |
| Blue-collar                     | 65 (11.9) | 5.65 ± 0.78 | 1.75 ± 0.73 | 0.415 |
| Self-employed or others         | 63 (11.5) | 5.56 ± 0.80 | 1.81 ± 0.74 | 0.054 |

### Marital status

| Category                          | N (%)  | Mean ± SE  | P-value | 95% CI  |
|-----------------------------------|--------|------------|---------|---------|
| Single or never married           | 30 (4.9) | 5.90 ± 0.31 | 1.42 ± 0.64 | 0.134 |
| Married                           | 445 (72.5) | 5.61 ± 0.90 | 1.67 ± 0.68 | 0.054 |
| Separated, divorced or widowed    | 139 (22.6) | 5.59 ± 0.98 | 1.72 ± 0.70 | 0.054 |

### Lives alone

| Category | N (%)  | Mean ± SE  | P-value | 95% CI  |
|----------|--------|------------|---------|---------|
| No       | 561 (92.4) | 5.60 ± 0.92 | 1.68 ± 0.68 | 0.319 |
| Yes      | 46 (7.6) | 5.80 ± 0.54 | 1.56 ± 0.72 | 0.054 |

### Main language

| Language | N (%)  | Mean ± SE  | P-value | 95% CI  |
|----------|--------|------------|---------|---------|
| English  | 171 (27.9) | 5.56 ± 0.99 | 1.48 ± 0.63 | <0.001 |
| Mandarin | 158 (25.7) | 5.72 ± 0.85 | 1.81 ± 0.69 | 0.054 |
| Malay    | 64 (10.4) | 5.53 ± 0.85 | 1.57 ± 0.61 | 0.054 |
| Tamil    | 84 (13.7) | 5.49 ± 0.91 | 1.68 ± 0.74 | 0.054 |
| Others   | 137 (22.3) | 5.71 ± 0.83 | 1.79 ± 0.68 | 0.054 |

### Zone

| Region    | N (%)  | Mean ± SE  | P-value | 95% CI  |
|-----------|--------|------------|---------|---------|
| North     | 246 (38.4) | 5.60 ± 0.92 | 1.70 ± 0.66 | 0.352 |
| South     | 118 (18.4) | 5.79 ± 0.64 | 1.73 ± 0.69 | 0.054 |
| East      | 130 (20.3) | 5.50 ± 1.07 | 1.59 ± 0.71 | 0.054 |
| West      | 146 (22.8) | 5.60 ± 0.91 | 1.63 ± 0.70 | 0.054 |

### Country of birth

| Country      | N (%)  | Mean ± SE  | P-value | 95% CI  |
|--------------|--------|------------|---------|---------|
| Singapore    | 428 (69.8) | 5.63 ± 0.88 | 1.62 ± 0.68 | 0.077 |
| China        | 28 (4.6) | 5.71 ± 0.85 | 1.96 ± 0.55 | 0.054 |
| Malaysia     | 102 (16.6) | 5.50 ± 1.11 | 1.75 ± 0.70 | 0.054 |
| India        | 33 (5.4) | 5.64 ± 0.70 | 1.70 ± 0.75 | 0.054 |
| Others       | 22 (3.6) | 5.77 ± 0.43 | 1.83 ± 0.62 | 0.054 |

### Smoking status

| Category | N (%)  | Mean ± SE  | P-value | 95% CI  |
|----------|--------|------------|---------|---------|
| Never    | 449 (75.5) | 5.64 ± 0.87 | 1.66 ± 0.69 | 0.712 |
|                        | Past            | Current         | Overall P-value based on ANOVA |
|------------------------|-----------------|-----------------|--------------------------------|
| **Alcohol use**        |                 |                 |                                |
| Never                  | 487 (81.8)      | 438 (82.2)      | 1.000                          |
| Past                   | 42 (7.1)        | 37 (6.9)        |                                |
| Current                | 66 (11.1)       | 58 (10.9)       |                                |
| **Diabetes**           |                 |                 |                                |
| No                     | 430 (68.8)      | 379 (68.0)      | 0.362                          |
| Yes                    | 195 (31.2)      | 178 (32.0)      |                                |
| **Cardiovascular disease** |               |                 |                                |
| No                     | 469 (78.8)      | 419 (78.6)      | 0.619                          |
| Yes                    | 126 (21.2)      | 114 (21.4)      |                                |
| **Chronic kidney disease** |               |                 |                                |
| No                     | 460 (84.7)      | 415 (84.2)      | 0.112                          |
| Yes                    | 83 (15.3)       | 78 (15.8)       |                                |
| **Hypertension**       |                 |                 |                                |
| No                     | 92 (14.7)       | 84 (15.1)       | 0.822                          |
| Yes                    | 533 (85.3)      | 473 (84.9)      |                                |
| **Hyperlipidaemia**    |                 |                 |                                |
| No                     | 186 (31.7)      | 167 (31.6)      | 0.927                          |
| Yes                    | 400 (68.3)      | 362 (68.4)      |                                |

Significant pairwise comparisons based on Tukey's test

(a) 80 and above vs. 75 - 79
(b) English vs. Mandarin; English vs. Others
### Supplementary Table S5. Factors associated with always practicing COVID-19 related government-endorsed preventive measures in univariable analyses

| Age Group | 1. Wear a mask | 2. Safe distance | 3. Not visiting | 4. Wash hands | 5. Stay home |
|-----------|----------------|-----------------|----------------|--------------|-------------|
|           | Practice always (%) | P | Practice always (%) | P | Practice always (%) | P | Practice always (%) | P |
| 60 - 64   | N 92   | P 89 (96.7) | 0.568 | N 91   | P 67 (73.6) | 0.088 | N 95   | P 83 (87.4) | 0.174 | N 96   | P 53 (55.2) | 0.704 | N 91   | P 72 (79.1) | 0.503 |
| 65 - 69   | N 135  | P 133 (98.5) | 0.027 | N 134  | P 117 (87.3) | 0.609 | N 293  | P 256 (87.4) | 0.054 | N 303  | P 168 (55.4) | 0.002 | N 279  | P 221 (79.2) | 0.323 |
| 70 - 74   | N 147  | P 142 (96.6) | 0.915 | N 149  | P 122 (81.9) | 0.004 ** | N 394  | P 365 (92.6) | 0.018 ** | N 404  | P 259 (64.1) | 0.153 | N 393  | P 311 (79.1) | 0.272 |
| 75 - 79   | N 85   | P 84 (98.8) | 0.051 | N 84   | P 72 (85.7) | 0.095 | N 217  | P 204 (94.9) | 0.001 | N 217  | P 147 (67.7) | 0.014 | N 208  | P 166 (79.8) | 0.745 |
| 80 and above | N 116  | P 111 (95.7) | 0.054 | N 118  | P 94 (79.7) | 0.069 | N 296  | P 147 (93.3) | 0.047 | N 303  | P 168 (63.6) | 0.002 | N 279  | P 124 (84.9) | 0.323 |

| Gender     | 1. Wear a mask | 2. Safe distance | 3. Not visiting | 4. Wash hands | 5. Stay home |
|------------|----------------|-----------------|----------------|--------------|-------------|
| Male       | N 274  | P 262 (95.6) | 0.427 | N 274  | P 222 (81.0) | 0.001 | N 293  | P 256 (87.4) | 0.054 | N 303  | P 168 (55.4) | 0.002 | N 279  | P 221 (79.2) | 0.323 |
| Female     | N 299  | P 295 (98.7) | 0.054 | N 300  | P 248 (82.7) | 0.069 | N 338  | P 311 (92.0) | 0.054 | N 343  | P 230 (67.1) | 0.021 | N 329  | P 271 (82.4) | 0.272 |

| Ethnicity  | 1. Wear a mask | 2. Safe distance | 3. Not visiting | 4. Wash hands | 5. Stay home |
|------------|----------------|-----------------|----------------|--------------|-------------|
| Chinese    | N 361  | P 352 (97.5) | 0.051 | N 361  | P 311 (86.1) | 0.004 ** | N 394  | P 365 (92.6) | 0.018 ** | N 404  | P 259 (64.1) | 0.153 | N 393  | P 311 (79.1) | 0.272 |
| Malay      | N 51   | P 49 (96.1) | 0.915 | N 52   | P 41 (78.8) | 0.004 ** | N 62   | P 52 (83.9) | 0.018 ** | N 63   | P 39 (61.9) | 0.002 | N 54   | P 46 (85.2) | 0.272 |
| Indian     | N 155  | P 150 (96.8) | 0.054 | N 155  | P 114 (73.5) | 0.004 ** | N 168  | P 143 (85.1) | 0.018 ** | N 172  | P 95 (55.2) | 0.002 | N 154  | P 130 (84.4) | 0.272 |
| Others     | N 2    | P 2 (100.0) | 0.001 | N 2    | P 1 (50.0) | 0.001 | N 2    | P 2 (100.0) | 0.001 | N 2    | P 2 (100.0) | 0.001 | N 2    | P 1 (50.0) | 0.001 |

| Education level | 1. Wear a mask | 2. Safe distance | 3. Not visiting | 4. Wash hands | 5. Stay home |
|-----------------|----------------|-----------------|----------------|--------------|-------------|
| Primary or lower| N 185  | P 182 (98.4) | 0.051 | N 184  | P 150 (81.5) | 0.054 | N 215  | P 204 (94.9) | 0.001 | N 217  | P 147 (67.7) | 0.014 | N 208  | P 166 (79.8) | 0.745 |
| Secondary or above | N 357  | P 344 (96.4) | 0.054 | N 359  | P 292 (81.3) | 0.054 | N 384  | P 332 (86.5) | 0.001 | N 394  | P 227 (57.6) | 0.002 | N 367  | P 297 (80.9) | 0.745 |

| Housing Type | 1. Wear a mask | 2. Safe distance | 3. Not visiting | 4. Wash hands | 5. Stay home |
|--------------|----------------|-----------------|----------------|--------------|-------------|
| 1-2 rooms public housing | N 40   | P 38 (95.0) | 0.054 | N 40   | P 34 (85.0) | 0.054 | N 44   | P 36 (81.8) | 0.001 | N 44   | P 36 (81.8) | 0.004 | N 40   | P 29 (72.5) | 0.184 |
| 3-5 rooms public or private housing | N 502  | P 488 (97.2) | 0.054 | N 503  | P 408 (81.1) | 0.054 | N 555  | P 500 (90.1) | 0.001 | N 567  | P 338 (59.6) | 0.002 | N 535  | P 434 (81.1) | 0.184 |

| Income | 1. Wear a mask | 2. Safe distance | 3. Not visiting | 4. Wash hands | 5. Stay home |
|--------|----------------|-----------------|----------------|--------------|-------------|
| <$2000 | N 182  | P 179 (98.4) | 0.051 | N 183  | P 154 (84.2) | 0.356 | N 204  | P 186 (91.2) | 0.007 | N 207  | P 138 (66.7) | 0.006 | N 195  | P 154 (79.0) | 0.289 |
| $2000 and above | N 164  | P 155 (94.5) | 0.054 | N 163  | P 131 (80.4) | 0.054 | N 169  | P 138 (81.7) | 0.001 | N 173  | P 107 (58.4) | 0.006 | N 157  | P 131 (83.4) | 0.289 |

| Occupation | 1. Wear a mask | 2. Safe distance | 3. Not visiting | 4. Wash hands | 5. Stay home |
|------------|----------------|-----------------|----------------|--------------|-------------|

**Note:** P values for categorical variables are calculated using chi-square or Fisher's exact test, while those for continuous variables are calculated using t-test.
### Smoking status

| Smoking status                        | Yes | No | \(<0.001\) | \(<0.01\) | \(<0.002\) | \(<0.003\) | \(<0.004\) | \(<0.005\) | \(<0.006\) | \(<0.007\) | \(<0.008\) | \(<0.009\) | \(<0.01\) | \(<0.02\) | \(<0.03\) | \(<0.04\) | \(<0.05\) | \(<0.06\) | \(<0.07\) | \(<0.08\) | \(<0.09\) | \(<0.1\)  |
|--------------------------------------|-----|----|------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| White-collar, admin or clerical      | 53  | 52 | (98.1)     |          | 54        | (97.6)    | 54        | (97.6)    | 54        | (97.6)    | 54        | (97.6)    | 54        | (97.6)    | 54       | (97.6)  | 54       | (97.6)  | 54       | (97.6)  | 54       | (97.6)  | 54       | (97.6)  | 54       | (97.6)  |
| Blue-collar                          | 64  | 61 | (95.3)     |          | 64        | (95.3)    | 64        | (95.3)    | 64        | (95.3)    | 64        | (95.3)    | 64        | (95.3)    | 64       | (95.3)  | 64       | (95.3)  | 64       | (95.3)  | 64       | (95.3)  | 64       | (95.3)  | 64       | (95.3)  |
| Self-employed or others              | 58  | 57 | (98.3)     |          | 57        | (98.3)    | 57        | (98.3)    | 57        | (98.3)    | 57        | (98.3)    | 57        | (98.3)    | 57       | (98.3)  | 57       | (98.3)  | 57       | (98.3)  | 57       | (98.3)  | 57       | (98.3)  | 57       | (98.3)  |
| Unemployed, housewife or retired     | 312 | 304| (97.4)     | 0.719    | 314       | 250 (79.6)| 0.487     | 355       | 330 (93.0)| 0.001(\()| 365       | 225 (61.6)| 0.646     | 348       | 283 (81.3)| 0.454    | 382      | 370 (96.9)| 0.479    | 382      | 320 (83.8)| 0.017(\()| 418      | 374 (89.5)| 0.180    | 426      | 266 (62.4)| 0.103    | 403      | 318 (78.9)| 0.263    |

### Place of residence

| Place of residence | North | South | East | West | North | South | East | West | North | South | East | West |
|--------------------|-------|-------|------|------|-------|-------|------|------|-------|-------|------|------|
| Singapore          | 382   | 370   | 382  | 320  | 382   | 370   | 382  | 320  | 382   | 370   | 382  | 320  |
| China              | 23    | 23    | 23   | 21   | 23    | 23    | 23   | 21   | 23    | 23    | 23   | 21   |
| Malaysia           | 94    | 92    | 95   | 72   | 94    | 92    | 95   | 72   | 94    | 92    | 95   | 72   |
| India              | 26    | 24    | 26   | 16   | 26    | 24    | 26   | 16   | 26    | 24    | 26   | 16   |
| Others             | 16    | 16    | 16   | 12   | 16    | 16    | 16   | 12   | 16    | 16    | 16   | 12   |

### Marital Status

| Marital Status                  | No     | Yes    |
|---------------------------------|--------|--------|
| Single or never married         | 29     | 29     |
| Married                         | 400    | 385    |
| Separated, divorced or widowed  | 113    | 112    |

### Living alone

| Living alone | No | Yes |
|--------------|----|-----|
|              | 492| 44  |

### Main Language

| Main Language | English | Chinese | Malay | Tamil | Others |
|--------------|---------|---------|-------|-------|--------|
|              | 161     | 143     | 51    | 77    | 110    |

### Country of birth

| Country of birth | Singapore | China | Malaysia | India | Others |
|------------------|-----------|-------|----------|-------|--------|
| Singapore        | 382       | 23    | 94       | 26    | 16     |
| China            | 23        | 23    | 92       | 24    | 16     |
| Malaysia         | 94        | 23    | 24       | 16    | 16     |
| India            | 26        | 94    | 24       | 16    | 16     |
| Others           | 16        | 23    | 24       | 16    | 16     |
|                      | Never | Past | Current |
|----------------------|-------|------|---------|
| Alcohol use          |       |      |         |
| Never                | 422   | 39   | 63      |
| Past                 | 407   | 38   | 63      |
| Current              | 345   | 30   | 53      |
| Diabetes             |       |      |         |
| No                   | 379   | 172  | 169     |
| Yes                  | 173   | 107  | 169     |
| Cardiovascular disease|      |      |         |
| No                   | 418   | 104  | 107     |
| Yes                  | 405   | 104  | 107     |
| Chronic kidney disease|     |      |         |
| No                   | 418   | 68   | 68      |
| Yes                  | 407   | 97.1 | 97.1    |
| Hypertension         |       |      |         |
| No                   | 86    | 83   | 70      |
| Yes                  | 453   | 97.2 | 97.2    |
| Hyperlipidaemia      |       |      |         |
| No                   | 348   | 166  | 172     |
| Yes                  | 339   | 97.4 | 97.4    |

Significant pairwise comparisons based on Chi-squared test

(a) Indian vs. Chinese
(b) None, housewife or retired and Blue-collar vs. White-collar, admin or clerical and Self-employed or others
(c) Chinese vs. English and Tamil; Tamil vs. Others
(d) Tamil vs. English, Chinese and Others
(e) West vs. North and East
(f) Singapore vs. India; China vs. India
Supplementary Table S6. Association between knowledge and attitudes towards COVID-19 and related government-endorsed preventive measures, perception of susceptibility scores, and practices (always) of the measures in univariable analyses

|                         | Knowledge       | Symptoms       | Preventive measures | Attitudes towards preventive measures | Perception of susceptibility |
|-------------------------|-----------------|----------------|--------------------|---------------------------------------|-----------------------------|
|                         | n (%)           | n (%)          | n (%)              | n (%)                                | n (%)                        |
|                         | mean ± SD       | mean ± SD      | mean ± SD          | mean ± SD                            | mean ± SD                   |
| 1. Wear a mask          |                 |                |                    |                                       |                             |
| No                      | 16 (2.8)        | 16 (2.8)       | 16 (2.8)           | 15 (2.9)                              | 16 (2.8)                    |
|                         | 7.19 ± 2.17     | 5.75 ± 0.58    | 5.19 ± 1.33        | 1.67 ± 0.82                           |
| Yes                     | 557 (97.2)      | 557 (97.2)     | 557 (97.2)         | 500 (97.1)                            |                             |
|                         | P = 0.776       | P = 0.553      | P = 0.186          | P = 0.958                             |
| 2. Safe distance        |                 |                |                    |                                       |                             |
| No                      | 103 (17.9)      | 103 (17.9)     | 103 (17.9)         | 93 (18.1)                             | 103 (17.9)                  |
|                         | 6.82 ± 2.43     | 5.71 ± 0.69    | 5.40 ± 1.04        | 1.71 ± 0.64                           |
| Yes                     | 471 (82.1)      | 471 (82.1)     | 471 (82.1)         | 422 (81.9)                            |                             |
|                         | P = 0.015       | P = 0.028      | P = 0.008          | P = 0.576                             |
| 3. Not visiting         |                 |                |                    |                                       |                             |
| No                      | 65 (10.3)       | 65 (10.3)      | 65 (10.3)          | 62 (10.9)                             | 65 (10.3)                   |
|                         | 7.18 ± 2.06     | 4.91 ± 1.00    | 4.68 ± 1.12        | 1.66 ± 0.81                           |
| Yes                     | 567 (89.7)      | 567 (89.7)     | 567 (89.7)         | 505 (89.1)                            |                             |
|                         | P = 0.528       | P = <0.001     | P = <0.001         | P = 0.940                             |
| 4. Hand washing         |                 |                |                    |                                       |                             |
| No                      | 247 (38.2)      | 247 (38.2)     | 247 (38.2)         | 227 (39.1)                            | 247 (38.2)                  |
|                         | 7.19 ± 2.23     | 5.77 ± 0.61    | 5.52 ± 0.94        | 1.70 ± 0.71                           |
| Yes                     | 400 (61.8)      | 400 (61.8)     | 400 (61.8)         | 354 (60.9)                            |                             |
|                         | P = 0.299       | P = 0.021      | P = 0.016          | P = 0.444                             |
| 6. Stay home            |                 |                |                    |                                       |                             |
| No                      | 115 (18.9)      | 115 (18.9)     | 115 (18.9)         | 104 (19.2)                            | 115 (18.9)                  |
|                         | 6.95 ± 2.63     | 5.94 ± 0.27    | 5.69 ± 0.79        | 1.56 ± 0.57                           |
| Yes                     | 493 (81.1)      | 493 (81.1)     | 493 (81.1)         | 438 (80.8)                            |                             |
|                         | P = 0.056       | P = 0.462      | P = 0.388          | P = 0.035                             |