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

Amudha Aravindhan[1], MPA, Alfred Tau Liang Gan[1], MSc, Ester Pei Xuan Lee[1], MSc, Preeti Gupta[1], PhD, Ryan Man[1,2], PhD, Kam Chun Ho[1,3,4], PhD, Sharon C Sung[2,5], PhD, Ching-Yu Cheng[1,2], PhD, Moi Lin Ling[2,6], FRCPA, Hiang Khoon Tan[7,8], FRCS (Ed), PhD, Tien Yin Wong[1,2], PhD, Eva K Fenwick[1*], PhD, Ecosse L Lamoureux[1,2,*], PhD

[1]Singapore Eye Research Institute, Singapore National Eye Centre, [2]Duke-NUS Medical School, Singapore, [3]University of New South Wales, [4]The George Institute for Global Health, Australia, [5]Department of Child and Adolescent Psychiatry, Institute of Mental Health, [6]Infection Prevention and Epidemiology, Singapore General Hospital, [7]Division of Surgery and Surgical Oncology, Singapore General Hospital and National Cancer Centre, [8]SingHealth Duke-NUS Global Health Institute, Singapore

*These two authors contributed equally as senior authors in this work.

Correspondence: Prof Ecosse L Lamoureux, Director, Population Health and Clinical Epidemiology Platform, Singapore Eye Research Institute, 20 College Road Discovery Tower, Level 6, The Academia, Singapore 169856. ecosse.lamoureux@seri.com.sg

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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).[1,2] 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.[3,4]

Since Singapore's first confirmed COVID-19 case in January 2020,[5] 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.[5] In contrast to many other countries, some of these measures are compulsory, closely monitored, and enforced, with significant legal consequences if not adhered to.[6]

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.[7] 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.[8] 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.[9] 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.[10] 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,[16] 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'.[18] 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 β: -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, β: -0.16, CI -0.32 to -0.00, P=0.049; and β: -0.22, CI -0.32 to -0.11, P<0.001, respectively), and 1-2 rooms public housing (vs. 3-5 room public/private β: -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, β: -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.[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[27] and the current COVID-19 outbreak in Chicago, USA.[10] This could be because older adults have reduced cognitive capacity to understand complex health information and acquire new information,[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.[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.[10,29] Importantly, our findings were independent of SES, which is often considered a proxy for ethnicity,[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.[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.[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,[34] 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[6] and related punitive controls e.g. fines,[5] 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,[35] and underscores less risk-taking behaviours among women.[36] 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.[29] 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[37] 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.[38] Our finding that better knowledge/attitudes was associated with higher odds of practicing preventive measures is similar to related studies,[12,39] suggesting that improving knowledge/attitudes via targeted educational/behavioural campaigns may have a measurable impact on suppression of this aggressive virus.[40] 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.

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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 Coronovirus 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 Novemeber 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-c3c2-4c55-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						
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	453 (75.5)	7.40 ± 2.34	0.008[(h)]	449 (75.5)	5.86 ± 0.48	0.407
Past	105 (17.5)	6.87 ± 2.35		104 (17.5)	5.79 ± 0.60	
Current	42 (7.0)	6.43 ± 2.74		42 (7.1)	5.83 ± 0.54	
Alcohol use						
Never	492 (82.0)	7.30 ± 2.38	0.309	487 (81.8)	5.86 ± 0.48	0.372
Past	42 (7.0)	7.24 ± 2.12		42 (7.1)	5.81 ± 0.59	
Current	66 (11.0)	6.82 ± 2.59		66 (11.1)	5.77 ± 0.63	
Diabetes						
No	433 (68.6)	7.33 ± 2.32	0.067	430 (68.8)	5.86 ± 0.48	0.254
Yes	198 (31.4)	6.95 ± 2.56		195 (31.2)	5.81 ± 0.57	
Cardiovascular disease						
No	472 (78.7)	7.37 ± 2.27	0.012	469 (78.8)	5.84 ± 0.52	0.399
Yes	128 (21.3)	6.77 ± 2.75		126 (21.2)	5.88 ± 0.45	
Chronic kidney disease						
No	464 (84.5)	7.36 ± 2.29	0.048	460 (84.7)	5.85 ± 0.51	0.460
Yes	85 (15.5)	6.81 ± 2.66		83 (15.3)	5.89 ± 0.44	
Hypertension						
No	94 (14.9)	7.50 ± 2.23	0.211	92 (14.7)	5.86 ± 0.48	0.777
Yes	537 (85.1)	7.16 ± 2.43		533 (85.3)	5.84 ± 0.51	
Hyperlipidaemia						
No	190 (32.1)	7.21 ± 2.39	0.782	186 (31.7)	5.80 ± 0.58	0.063
Yes	402 (67.9)	7.27 ± 2.38		400 (68.3)	5.88 ± 0.45	

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	*Age (per year increase)*	-0.00 (-0.01 to 0.00)	0.544
Gender			*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			*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			*Housing*		
Secondary or above	REF		3-5 rooms public or private housing	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			*Occupation*		
3-5 rooms public or private housing	REF		Unemployed, housewife or retired	REF	
1-2 rooms public housing	-1.07 (-1.86 to -0.28)	0.008	White-collar, admin or clerical	-0.06 (-0.21 to 0.09)	0.442
Marital status			Blue-collar	0.07 (-0.07 to 0.22)	0.322
Married	REF		Self-employed or others	-0.18 (-0.32 to -0.04)	0.011
Single or never married	-0.06 (-0.97 to 0.85)	0.896	*Country of birth*		
Separated, divorced or widowed	-0.25 (-0.76 to 0.26)	0.336	Singapore	REF	
Smoking status			China	-0.06 (-0.26 to 0.14)	0.546
Never	REF		Malaysia	-0.16 (-0.27 to -0.04)	0.008
Past	-0.17 (-0.74 to 0.41)	0.565	Indian	-0.16 (-0.36 to 0.04)	0.124

Current	-0.41 (-1.22 to 0.40)	0.319	Others	0.12 (-0.10 to 0.35)	0.282
Alcohol use					
Never	REF				
Past	0.43 (-0.35 to 1.21)	0.282			
Current	-0.85 (-1.46 to -0.24)	0.007			
Diabetes					
No	REF				
Yes	-0.01 (-0.43 to 0.41)	0.957			
Cardiovascular disease					
No	REF				
Yes	-0.42 (-0.91 to 0.07)	0.091			
Chronic kidney disease					
No	REF				
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) ɤ

	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)	··
2. Stay at least 1-2 metres away from other people ǂ	647 (99.1)	2 (0.3)	4 (0.6)	613 (94.0)	16 (2.5)	23 (3.5)	473 (82.0)	97 (16.8)	7 (1.2)	··
3. For K and A: Not visit relatives or friends For P: Visit relatives or friends§	644 (98.6)	7 (1.1)	2 (0.3)	624 (95.7)	15 (2.3)	13 (2.0)	570 (89.8)	17 (2.7)	8 (1.3)	40 (6.3)
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)	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 (32.1)	9 (17.0)
Mean correct response ± SD	5.8 ± 0.5			5.6 ± 0.9			3.7 ± 0.3			

SD - Standard deviation ɤ10 refused to answer ^74 not applicable responses ǂ73 not applicable responses ¥558 not applicable responses §15 not applicable responses

Table 4. Factors associated with attitudes towards COVID-19 related government-endorsed preventive measures, and perception of susceptibility in multiple linear regression analyses‡

	Attitudes towards preventive measures			**Perception of susceptibility**	
	Beta (95% CI)	**P**		**Beta (95% CI)**	**P**
Age (per year increase)	-0.02 (-0.04 to -0.01)	0.001	*Age (per year increase)*	0.00 (-0.01 to 0.01)	0.748
Gender			*Education*		
Male	REF		Primary or lower	REF	
Female	0.03 (-0.17 to 0.22)	0.789	Secondary or above	-0.19 (-0.32 to -0.06)	0.005
Income			*Housing Type*		
<$2000	REF		1-2 rooms public housing	REF	
$2000 and above	-0.25 (-0.46 to - 0.04)	0.021	3-5 rooms public or private housing	0.12 (-0.11 to 0.35)	0.319
			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

Table 5. Factors associated with 'always' practicing COVID-19 related government-endorsed preventive measures in multiple logistic regression analyses‡

	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**	**OR (95% CI)**	**P**	**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		REF		REF		..	..
Malay	..	..	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)	0.820	..	..
Indian	..	..	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)	0.032	..	..
Housing										
1-2 rooms public housing	..	..	..	..	REF		REF		..	..
3-5 rooms public or private housing	..	..	..	..	2.73 (0.90 to 8.27)	0.075	0.38 (0.17 to 0.89)	0.025	..	..
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										
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										
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										
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	OR (95% CI)	P	OR (95% CI)	P
Knowledge											
Symptoms	Age-gender adjusted	1.01 (0.81 to 1.25)	0.937	1.13 (1.03 to 1.24)	0.009	1.04 (0.93 to 1.16)	0.504	1.03 (0.96 to 1.10)	0.456	1.10 (1.01 to 1.20)	0.028
	Multivariable-adjusted*	1.01 (0.81 to 1.25)	0.937	1.11 (1.01 to 1.22)	0.035	1.03 (0.88 to 1.20)	0.744	1.03 (0.95 to 1.11)	0.471	1.08 (0.98 to 1.19)	0.125
Preventive Measures	Age-gender adjusted	1.20 (0.54 to 2.65)	0.651	1.65 (1.16 to 2.34)	0.005	14.11 (8.06 to 24.68)	<0.001	1.43 (1.05 to 1.94)	0.023	1.42 (0.65 to 3.07)	0.378
	Multivariable-adjusted*	1.20 (0.54 to 2.65)	0.651	1.48 (1.03 to 2.12)	0.034	12.93 (6.19 to 27.03)	<0.001	1.41 (1.01 to 1.97)	0.041	1.32 (0.54 to 3.22)	0.540
Attitudes											
Preventive Measures	Age-gender adjusted	1.48 (0.98 to 2.25)	0.061	1.44 (1.15 to 1.80)	0.001	2.85 (2.20 to 3.70)	<0.001	1.26 (1.04 to 1.51)	0.016	1.14 (0.89 to 1.47)	0.306
	Multivariable-adjusted*	1.48 (0.98 to 2.25)	0.061	1.37 (1.08 to 1.72)	0.008	2.62 (1.85 to 3.69)	<0.001	1.19 (0.98 to 1.45)	0.076	0.98 (0.71 to 1.35)	0.913
Perception of susceptibility	Age-gender adjusted	1.05 (0.49 to 2.25)	0.893	0.92 (0.66 to 1.27)	0.602	0.98 (0.66 to 1.44)	0.906	0.91 (0.71 to 1.17)	0.476	1.35 (0.97 to 1.89)	0.075
	Multivariable-adjusted*	1.05 (0.49 to 2.25)	0.893	0.89 (0.64 to 1.23)	0.474	0.95 (0.58 to 1.55)	0.846	0.89 (0.69 to 1.15)	0.383	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

Supplementary Table S2. Number of observed and missing values for each variable of interest

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
Fatigure (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			
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)	
	N (%)
Age (in years)	
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	

North	249 (38.5)
South	121 (18.7)
East	130 (20.1)
West	147 (22.7)
Country of birth	
Singapore	429 (69.4)
China	28 (4.5)
Malaysia	104 (16.8)
India	34 (5.5)
Others	23 (3.7)
Smoking status	
Never	453 (75.5)
Past	105 (17.5)
Current	42 (7.0)
Alcohol use	
Never	492 (82.0)
Past	42 (7.0)
Current	66 (11.0)
Diabetes (yes)	198 (31.4)
Cardiovascular disease (yes)	128 (21.3)
Chronic kidney disease (yes)	85 (15.5)
Hypertension (yes)	537 (85.1)
Hyperlipidaemia (yes)	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		129 (22.2)	1.62 ± 0.66	
70 - 74	157 (24.1)	5.53 ± 0.94		139 (23.9)	1.65 ± 0.60	
75 - 79	101 (15.5)	5.52 ± 1.14		89 (15.3)	1.53 ± 0.62	
80 and above	155 (23.8)	5.60 ± 0.98		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		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		61 (10.6)	1.61 ± 0.61	
Indian	173 (26.9)	5.55 ± 0.91		155 (27.0)	1.63 ± 0.71	
Others	2 (0.3)	6.00 ± 0.00		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		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		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		151 (45.2)	1.66 ± 0.70	
Occupation						

Unemployed, housewife or retired	366 (66.8)	5.64 ± 0.91	0.868	324 (66.3)	1.66 ± 0.64	0.415
White-collar, admin or clerical	54 (9.9)	5.69 ± 0.80		48 (9.8)	1.65 ± 0.79	
Blue-collar	65 (11.9)	5.65 ± 0.78		60 (12.3)	1.75 ± 0.73	
Self-employed or others	63 (11.5)	5.56 ± 0.80		57 (11.7)	1.81 ± 0.74	
Marital status						
Single or never married	30 (4.9)	5.90 ± 0.31	0.211	26 (4.7)	1.42 ± 0.64	0.134
Married	445 (72.5)	5.61 ± 0.90		401 (72.8)	1.67 ± 0.68	
Separated, divorced or widowed	139 (22.6)	5.59 ± 0.98		124 (22.5)	1.72 ± 0.70	
Lives alone						
No	561 (92.4)	5.60 ± 0.92	0.147	505 (92.8)	1.68 ± 0.68	0.319
Yes	46 (7.6)	5.80 ± 0.54		39 (7.2)	1.56 ± 0.72	
Main language						
English	171 (27.9)	5.56 ± 0.99	0.181	153 (27.8)	1.48 ± 0.63	<0.001[(b)]
Mandarin	158 (25.7)	5.72 ± 0.85		146 (26.5)	1.81 ± 0.69	
Malay	64 (10.4)	5.53 ± 0.85		63 (11.4)	1.57 ± 0.61	
Tamil	84 (13.7)	5.49 ± 0.91		73 (13.2)	1.68 ± 0.74	
Others	137 (22.3)	5.71 ± 0.83		116 (21.1)	1.79 ± 0.68	
Zone						
North	246 (38.4)	5.60 ± 0.92	0.089	225 (39.2)	1.70 ± 0.66	0.352
South	118 (18.4)	5.79 ± 0.64		104 (18.1)	1.73 ± 0.69	
East	130 (20.3)	5.50 ± 1.07		110 (19.2)	1.59 ± 0.71	
West	146 (22.8)	5.60 ± 0.91		135 (23.5)	1.63 ± 0.70	
Country of birth						
Singapore	428 (69.8)	5.63 ± 0.88	0.582	389 (70.7)	1.62 ± 0.68	0.077
China	28 (4.6)	5.71 ± 0.85		24 (4.4)	1.96 ± 0.55	
Malaysia	102 (16.6)	5.50 ± 1.11		89 (16.2)	1.75 ± 0.70	
India	33 (5.4)	5.64 ± 0.70		30 (5.5)	1.70 ± 0.75	
Others	22 (3.6)	5.77 ± 0.43		18 (3.3)	1.83 ± 0.62	
Smoking status						
Never	449 (75.5)	5.64 ± 0.87	0.084	403 (75.6)	1.66 ± 0.69	0.712

Past	104 (17.5)	5.46 ± 1.12		89 (16.7)	1.71 ± 0.66	
Current	42 (7.1)	5.79 ± 0.52		41 (7.7)	1.73 ± 0.67	
Alcohol use						
Never	487 (81.8)	5.63 ± 0.91	0.807	438 (82.2)	1.67 ± 0.70	1.000
Past	42 (7.1)	5.55 ± 0.97		37 (6.9)	1.68 ± 0.53	
Current	66 (11.1)	5.59 ± 0.80		58 (10.9)	1.67 ± 0.63	
Diabetes						
No	430 (68.8)	5.64 ± 0.86	0.385	379 (68.0)	1.66 ± 0.67	0.362
Yes	195 (31.2)	5.57 ± 0.98		178 (32.0)	1.71 ± 0.71	
Cardiovascular disease						
No	469 (78.8)	5.63 ± 0.86	0.551	419 (78.6)	1.67 ± 0.68	0.619
Yes	126 (21.2)	5.58 ± 1.05		114 (21.4)	1.70 ± 0.68	
Chronic kidney disease						
No	460 (84.7)	5.64 ± 0.84	0.832	415 (84.2)	1.65 ± 0.69	0.112
Yes	83 (15.3)	5.66 ± 0.86		78 (15.8)	1.78 ± 0.66	
Hypertension						
No	92 (14.7)	5.61 ± 0.96	0.889	84 (15.1)	1.69 ± 0.66	0.822
Yes	533 (85.3)	5.62 ± 0.89		473 (84.9)	1.67 ± 0.69	
Hyperlipidaemia						
No	186 (31.7)	5.59 ± 0.90	0.375	167 (31.6)	1.68 ± 0.68	0.927
Yes	400 (68.3)	5.66 ± 0.86		362 (68.4)	1.68 ± 0.68	

Overall P-value based on ANOVA

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

	1. Wear a mask			2. Safe distance			3. Not visiting			4. Wash hands			5. Stay home		
	N	Practice always (%)	P	N	Practice always (%)	P	N	Practice always (%)	P	N	Practice always (%)	P	N	Practice always (%)	P
Age Group															
60 - 64	92	89 (96.7)	0.568	91	67 (73.6)	0.088	95	83 (87.4)	0.174	96	53 (55.2)	0.704	91	72 (79.1)	0.503
65 - 69	135	133 (98.5)		134	117 (87.3)		138	120 (87.0)		142	89 (62.7)		137	110 (80.3)	
70 - 74	147	142 (96.6)		149	122 (81.9)		153	134 (87.6)		157	97 (61.8)		139	114 (82.0)	
75 - 79	85	84 (98.8)		84	72 (85.7)		97	91 (93.8)		99	63 (63.6)		96	73 (76.0)	
80 and above	116	111 (95.7)		118	94 (79.7)		150	140 (93.3)		154	98 (63.6)		146	124 (84.9)	
Gender															
Male	274	262 (95.6)	0.027	274	222 (81.0)	0.609	293	256 (87.4)	0.054	303	168 (55.4)	0.002	279	221 (79.2)	0.323
Female	299	295 (98.7)		300	248 (82.7)		338	311 (92.0)		343	230 (67.1)		329	271 (82.4)	
Ethnicity															
Chinese	361	352 (97.5)	0.915	361	311 (86.1)	0.004[(a)]	394	365 (92.6)	0.018[(a)]	404	259 (64.1)	0.153	393	311 (79.1)	0.272
Malay	51	49 (96.1)		52	41 (78.8)		62	52 (83.9)		63	39 (61.9)		54	46 (85.2)	
Indian	155	150 (96.8)		155	114 (73.5)		168	143 (85.1)		172	95 (55.2)		154	130 (84.4)	
Others	2	2 (100.0)		2	1 (50.0)		2	2 (100.0)		2	2 (100.0)		2	1 (50.0)	
Education level															
Primary or lower	185	182 (98.4)	0.188	184	150 (81.5)	0.958	215	204 (94.9)	0.001	217	147 (67.7)	0.014	208	166 (79.8)	0.745
Secondary or above	357	344 (96.4)		359	292 (81.3)		384	332 (86.5)		394	227 (57.6)		367	297 (80.9)	
Housing Type															
1-2 rooms public housing	40	38 (95.0)	0.427	40	34 (85.0)	0.543	44	36 (81.8)	0.085	44	36 (81.8)	0.004	40	29 (72.5)	0.184
3-5 rooms public or private housing	502	488 (97.2)		503	408 (81.1)		555	500 (90.1)		567	338 (59.6)		535	434 (81.1)	
Income															
<$2000	182	179 (98.4)	0.051	183	154 (84.2)	0.356	204	186 (91.2)	0.007	207	138 (66.7)	0.096	195	154 (79.0)	0.289
$2000 and above	164	155 (94.5)		163	131 (80.4)		169	138 (81.7)		173	101 (58.4)		157	131 (83.4)	
Occupation															

Unemployed, housewife or retired	312	304 (97.4)	0.719	314	250 (79.6)	0.487	355	330 (93.0)	<0.001[b]	365	225 (61.6)	0.646	348	283 (81.3)	0.454
White-collar, admin or clerical	53	52 (98.1)		53	44 (83.0)		54	43 (79.6)		54	31 (57.4)		50	42 (84.0)	
Blue-collar	64	61 (95.3)		64	56 (87.5)		64	60 (93.8)		65	38 (58.5)		63	53 (84.1)	
Self-employed or others	58	57 (98.3)		57	45 (78.9)		61	47 (77.0)		62	42 (67.7)		53	39 (73.6)	
Marital Status															
Single or never married	29	29 (100.0)	0.178	29	24 (82.8)	0.084	30	26 (86.7)	0.728	30	16 (53.3)	0.060	30	22 (73.3)	0.200
Married	400	385 (96.3)		401	318 (79.3)		433	390 (90.1)		443	262 (59.1)		415	330 (79.5)	
Separated, divorced or widowed	113	112 (99.1)		113	100 (88.5)		136	120 (88.2)		138	96 (69.6)		130	111 (85.4)	
Living alone															
No	492	476 (96.7)	0.225	493	398 (80.7)	0.197	547	490 (89.6)	0.884	558	335 (60.0)	0.015	523	418 (79.9)	0.427
Yes	44	44 (100.0)		44	39 (88.6)		45	40 (88.9)		46	36 (78.3)		46	39 (84.8)	
Main Language															
English	161	153 (95.0)	0.323	161	136 (84.5)	0.001[d]	164	140 (85.4)	0.124	170	97 (57.1)	0.009[c]	157	120 (76.4)	0.327
Chinese	143	140 (97.9)		142	121 (85.2)		154	143 (92.9)		157	107 (68.2)		155	127 (81.9)	
Malay	51	50 (98.0)		52	41 (78.8)		63	54 (85.7)		64	38 (59.4)		56	50 (89.3)	
Tamil	77	74 (96.1)		77	49 (63.6)		82	73 (89.0)		84	40 (47.6)		75	60 (80.0)	
Others	110	109 (99.1)		111	95 (85.6)		136	126 (92.6)		136	92 (67.6)		132	106 (80.3)	
Place of residence															
North	217	214 (98.6)	0.335	218	180 (82.6)	0.339	239	219 (91.6)	0.473	244	143 (58.6)	0.184	230	191 (83.0)	0.048[e]
South	104	101 (97.1)		106	88 (83.0)		116	105 (90.5)		118	77 (65.3)		114	94 (82.5)	
East	114	110 (96.5)		114	98 (86.0)		127	110 (86.6)		130	90 (69.2)		121	104 (86.0)	
West	129	123 (95.3)		127	98 (77.2)		142	126 (88.7)		145	87 (60.0)		135	99 (73.3)	
Country of birth															
Singapore	382	370 (96.9)	0.479	382	320 (83.8)	0.017[f]	418	374 (89.5)	0.180	426	266 (62.4)	0.103	403	318 (78.9)	0.263
China	23	23 (100.0)		23	21 (91.3)		28	27 (96.4)		28	17 (60.7)		27	25 (92.6)	
Malaysia	94	92 (97.9)		95	72 (75.8)		97	87 (89.7)		101	60 (59.4)		93	74 (79.6)	
India	26	24 (92.3)		26	16 (61.5)		33	26 (78.8)		33	14 (42.4)		29	26 (89.7)	
Others	16	16 (100.0)		16	12 (75.0)		22	21 (95.5)		22	17 (77.3)		22	19 (86.4)	
Smoking status															

Never	396	387 (97.7)	0.191	397	329 (82.9)	0.270	436	395 (90.6)	0.223	446	284 (63.7)	0.052	424	347 (81.8)	0.529
Past	89	84 (94.4)		90	68 (75.6)		102	87 (85.3)		104	53 (51.0)		95	73 (76.8)	
Current	40	38 (95.0)		39	32 (82.1)		42	39 (92.9)		42	27 (64.3)		40	32 (80.0)	
Alcohol use															
Never	422	407 (96.4)	0.305	424	345 (81.4)	0.795	473	427 (90.3)	0.301	483	308 (63.8)	0.055	459	369 (80.4)	0.845
Past	39	38 (97.4)		38	30 (78.9)		41	38 (92.7)		42	20 (47.6)		39	32 (82.1)	
Current	63	63 (100.0)		63	53 (84.1)		65	55 (84.6)		66	36 (54.5)		60	50 (83.3)	
Diabetes															
No	379	367 (96.8)	0.579	381	317 (83.2)	0.313	416	375 (90.1)	0.972	429	266 (62.0)	0.934	406	322 (79.3)	0.070
Yes	173	169 (97.7)		172	137 (79.7)		191	172 (90.1)		193	119 (61.7)		181	155 (85.6)	
Cardiovascular disease															
No	418	405 (96.9)	0.869	419	342 (81.6)	0.940	458	408 (89.1)	0.250	468	288 (61.5)	0.960	439	358 (81.5)	0.427
Yes	107	104 (97.2)		107	87 (81.3)		122	113 (92.6)		124	76 (61.3)		120	94 (78.3)	
Chronic kidney disease															
No	418	407 (97.4)	0.914	418	343 (82.1)	0.640	450	403 (89.6)	0.257	460	287 (62.4)	0.307	433	345 (79.7)	0.785
Yes	70	68 (97.1)		69	55 (79.7)		79	74 (93.7)		82	56 (68.3)		79	64 (81.0)	
Hypertension															
No	86	83 (96.5)	0.723	86	74 (86.0)	0.299	89	80 (89.9)	0.938	92	50 (54.3)	0.106	87	68 (78.2)	0.422
Yes	466	453 (97.2)		467	380 (81.4)		518	467 (90.2)		530	335 (63.2)		500	409 (81.8)	
Hyperlipidaemia															
No	172	166 (96.5)	0.563	172	145 (84.3)	0.315	181	156 (86.2)	0.028	186	114 (61.3)	0.637	171	134 (78.4)	0.331
Yes	348	339 (97.4)		347	280 (80.7)		390	359 (92.1)		398	252 (63.3)		381	312 (81.9)	

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				Attitudes towards preventive measures		Perception of susceptibility	
	Symptoms		Preventive measures					
	n (%)	mean ± SD	n (%)	mean ± SD	n (%)	mean ± SD	n (%)	mean ± SD
1. Wear a mask								
No	16 (2.8)	7.19 ± 2.17	16 (2.8)	5.75 ± 0.58	16 (2.8)	5.19 ± 1.33	15 (2.9)	1.67 ± 0.82
Yes	557 (97.2)	7.35 ± 2.20	557 (97.2)	5.84 ± 0.52	557 (97.2)	5.65 ± 0.80	500 (97.1)	1.68 ± 0.68
		P = 0.776		P = 0.553		P = 0.186		P = 0.958
2. Safe distance								
No	103 (17.9)	6.82 ± 2.43	103 (17.9)	5.71 ± 0.69	103 (17.9)	5.40 ± 1.04	93 (18.1)	1.71 ± 0.64
Yes	471 (82.1)	7.45 ± 2.13	471 (82.1)	5.87 ± 0.47	471 (82.1)	5.69 ± 0.76	422 (81.9)	1.67 ± 0.69
		P = 0.015		P = 0.028		P = 0.008		P = 0.576
3. Not visiting								
No	65 (10.3)	7.18 ± 2.06	65 (10.3)	4.91 ± 1.00	65 (10.3)	4.68 ± 1.12	62 (10.9)	1.66 ± 0.81
Yes	567 (89.7)	7.36 ± 2.30	567 (89.7)	5.96 ± 0.23	567 (89.7)	5.76 ± 0.71	505 (89.1)	1.67 ± 0.67
		P = 0.528		P = <0.001		P = <0.001		P = 0.940
4. Hand washing								
No	247 (38.2)	7.19 ± 2.23	247 (38.2)	5.77 ± 0.61	247 (38.2)	5.52 ± 0.94	227 (39.1)	1.70 ± 0.71
Yes	400 (61.8)	7.38 ± 2.34	400 (61.8)	5.88 ± 0.45	400 (61.8)	5.70 ± 0.79	354 (60.9)	1.66 ± 0.66
		P = 0.299		P = 0.021		P = 0.016		P = 0.444
6. Stay home								
No	115 (18.9)	6.95 ± 2.63	115 (18.9)	5.94 ± 0.27	115 (18.9)	5.69 ± 0.79	104 (19.2)	1.56 ± 0.57
Yes	493 (81.1)	7.46 ± 2.19	493 (81.1)	5.96 ± 0.23	493 (81.1)	5.76 ± 0.73	438 (80.8)	1.70 ± 0.70
		P = 0.056		P = 0.462		P = 0.388		P = 0.035