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Adherence to COVID-19 measures and the associated factors: evidence from a two-wave longitudinal study in Singapore

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Abstract

Background At the onset of the Coronavirus disease (COVID-19) pandemic when pharmaceutical interventions were not readily available, governments relied on public health mandates and social distancing measures to counter rising infection rates. In order to address the dearth of longitudinal studies, this study sought to identify factors associated with continued adherence to COVID-19 preventive behaviours in Singapore.

Methods Data were from a two-wave longitudinal cohort study; baseline study was conducted from May 2020 to June 2021 and follow-up study from October 2021 to September 2022. Participants ($n=858$) were Singapore residents, aged 18 and above, and able to speak English, Chinese or Malay. Weighted multivariable logistic regressions were conducted to identify factors associated with adherence to the COVID-19 measures.

Results Adherence rates of 'avoid dining out', 'crowded places', 'people with flu symptoms' and 'small group gatherings' at baseline were 39.41%, 60.82%, 79.82%, and 44.82% respectively. All measures had a decrease in adherence rates across the two-waves. Older age groups were associated with greater adherence to 'avoid dining out' and 'avoid crowded places'. Having high trust in local public health experts was associated with greater adherence to 'avoid crowded places' and 'avoid people with flu symptoms'. Fear of family and friends getting infected with COVID-19 was associated with 'avoid dining out' and 'avoid crowded places'.

Conclusions Soft interventions like nudges can be implemented at crowded places to remind the public of the ease of transmitting the virus to their loved ones. Increasing media presence of public health experts can be a viable alternative to improve adherence.

Keywords Adherence, COVID-19, Public health and social measures, Pandemic, Social norms

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Introduction

Since the initial outbreak of the Coronavirus disease (COVID-19) in 2019, the World Health Organisation (WHO) has reported more than 750 million infected cases and roughly 7 million deaths worldwide [1, 2]. Fortunately, global infection rates have been on a downwards trend since the beginning of 2023 [2]. At its peak, most countries adopted mandatory public health and social measures (PHSM) such as mask-wearing, lockdowns, quarantine/ self-isolation, and stay-at-home restrictions to supress the widespread transmission of COVID-19 [3, 4]. Due to the lack of vaccines and medicines in the early phases of the pandemic, governments around the world could only rely on non-pharmaceutical interventions to fight against COVID-19 [3].

After the first case of COVID-19 was confirmed in Singapore, measures such as mask wearing, and physical distancing were mandated by the government in March 2020. Reported adherence rates of these measures were relatively high, where 97.2%, 89.8%, 96.8%, and 82.0% of residents complied with mask wearing, not visiting relatives or friends, avoiding crowded places, and physical distancing respectively [5, 6]. 'Safe distancing ambassadors' were deployed at places with high human traffic to ensure that residents abided by these measures at public vicinities like shopping malls and supermarkets [7]. These efforts in its totality helped Singapore suppressed the infection rates in the early phases of the pandemic. However, between March to April 2020, infection rates increased exponentially due to the close community living conditions of migrant workers in dormitories [8]. In response to the surge in infections, a lockdown described as 'Circuit breaker' was implemented from 7 April to 1 June 2020, where residents were instructed to stay at home and self-isolate, to curb movements in the city-state and prevent spill over of virus transmission to the wider population [7, 9]. Subsequently, on 2 June 2020, Singapore exited the lockdown and rules related to home visiting, dining out and working from office were allowed and progressively relaxed in phases (Phase 1- Most stringent, Phase 3- Least stringent) [10]. However, due to fluctuating infection rates, regulations were tightened from time-to-time, with the country veering back and forth between Phase 2 and 3, with phases differing between the number of pax permitted for dining out and group gatherings.

There are a multitude of factors that influence a person's adherence to PHSM. Numerous studies have attempted to explore these factors to aid policy makers and improve compliance globally. However, results were mostly mixed. Contradictory findings related to chronic conditions were reported in two separate studies conducted in the United States (US), where one reported presence of chronic conditions to affect one's adherence while the other did not [11, 12]. Majority of such studies were conducted in the early phases of COVID-19, where information on coronavirus was scarce, and the effectiveness of PHSM were not well-established yet. Together with the dynamic COVID-19 landscape, these reasons might have contributed to the differences in attitudes and behaviours towards the pandemic measures.

Currently, COVID-19 vaccines are widely available across the globe. The increased proportions of vaccinated individuals had helped build herd immunity in various countries, leading to the WHO declaring an end to COVID-19 as a public health emergency on 5 May 2023 [13]. Following the announcement, several countries, including Singapore, have declared COVID-19 as endemic [14]. Nonetheless, there are still valuable insights to be learnt from it. Especially since mortality rates are still high in countries such as the US and Brazil, and the emergence of new variants like EG.5, and XBB 1.16, which can potentially lead to new waves of infection globally [15, 16].

With sparse number of longitudinal studies investigating the factors associated with adherence to COVID-19 PHSM, our study can provide insights and allow policy makers to design interventions that would be effective for any new pandemic in the future. Therefore, with a two-wave longitudinal data, our study aimed to (1) characterize the changes in adherence levels for COVID-19 PHSM during the pandemic and (2) investigate the associations between demographic and social factors associated with adherence to COVID-19 PHSM over two waves.

Methods

Study design

Our longitudinal cohort study included two waves of structured interviews. Flow diagram of recruitment and non-participation numbers from the two studies were included as supplementary Fig. 1. Participants of the previous nationwide Singapore Mental Health Study 2016 (SMHS2016) [17] who agreed to be re-contacted for future studies (n=3370) were invited via phone and email to participate in the first wave (baseline study). A house visit/ Zoom session was only arranged by a trained interviewer if the participant was keen. The baseline study was conducted between May 2020 to June 2021 with a response rate of 54.8% (n=1129, after removing respondents with invalid contact details). It coincided with the early phases of the COVID-19 pandemic, when the cessation of 'Circuit breaker' was announced, and the nation was relaxing the COVID-19 measures. Vaccines were also mainly unavailable to the general population throughout the study period. Those respondents that agreed to be re-contacted for the follow-up study were contacted again via phone and email during October 2021 to September 2022 for the second wave (follow-up

study) with a response rate of 76.0% ($n=858$) and an average follow-up duration of 14 months. The follow-up study was mainly conducted throughout the later stages of the pandemic where the country was going through a stabilisation and transition phase to adapt to living with COVID-19 and majority of Singapore residents were fully vaccinated. Detailed description of our study design was earlier reported in a separate publication [17]. A timeline of the infection and vaccination rates in Singapore and our study periods were included as Supplementary Fig. 2.

Reflecting the same inclusion criteria as SMHS2016, recruited participants were (1) Singapore citizens and/or permanent residents, (2) 18 years old and above, (3) had the ability to speak English/ Chinese/ Malay, and (4) available for interview via video conferencing platform Zoom or face-to-face. Exclusion criteria included (1) severe physical or mental disorders that limited participation in the study and (2) not staying in Singapore during the study period. Written informed consent was obtained from all participants either in person or via an online software prior to the survey. The two studies were approved by National Healthcare Group Domain Specific Review Board (Reference no. 2020/00462 and 2021/00566).

Measures

Demographic factors

Age, gender, ethnicity, highest education attained, employment status, personal monthly income, and marital status were collected as sociodemographic data. Highest education attained was categorized into 'Below Secondary School', 'Pre-University', and 'University and above'. Employment status was categorized into 'Employed/Self-employed', 'Unemployed' and 'Economically inactive'. Marital status was categorized into 'Married/Cohabitation', 'Never married', and 'Divorced/Widowed/Separated'. All sociodemographic variables were included in the multivariable logistic regression analyses [18].

Variables-of-interest

Apart from demographic factors, the following variables-of-interest were included in the regression based on the social ecological model which follows a multilevel approach that proposes (1) individual, (2) interpersonal or community, and (3) public policy are all interrelated factors that affects a person's adherence towards the pandemic measures [19]. These included variables such as lifetime chronic conditions, risk perception of infection and economic losses, and trust factors, which are explained in greater detail below.

Lifetime chronic conditions

A checklist of eighteen common chronic medical conditions was used to assess the participants' medical history [11, 20]. Participants were asked the following questions 'Please indicate if you were diagnosed with any of these' at baseline and 'Have you been diagnosed with any chronic medical conditions in the past year' at the subsequent 1 year follow up. The participants could reply with 'yes' or 'no' to each of the conditions. Respondents were classified as having a lifetime chronic condition if response was 'yes' throughout the study period. All items were summed up, and responses were categorised into 'none' or '≥1 conditions'.

Risk perception of infection and economic losses

Perceived susceptibility to COVID-19 were measured by asking respondents the following two questions: 'In the past month, did you feel anxious due to some of the following thoughts or concerns related to the COVID-19 outbreak?' (1) I might be infected with COVID-19 and, (2) my family members and friends might be infected with COVID-19. To measure perceived economic risk, participants were also asked if they were anxious about 'unemployment' and 'financial loss, such as losing work opportunities or having to take unpaid leave'. Participants could reply with a 'yes' or 'no' and responses were further dichotomized into 'Never anxious' or 'Anxious at least once' across the two time-points. More detailed description of the above-mentioned scale can be found in a separate publication [21].

Trust factors

Trust in sources for COVID-19 information were measured by three questions on a 10-points Likert scale from (1–10) (1) 'How much do you trust social media (e.g. Facebook, Whatsapp, Instagram, Telegram, online forums such as Twitter, WeChat, Weibo, YouTube) on COVID-19 related information?', (2) 'How much do you trust local public health and infectious disease experts on COVID-19 related information?', and (3) 'How much do you trust the government departments and related institutions like Ministry of Health (MOH) and Multi-Ministry taskforce (MTF) on COVID-19 related information?' (1=No trust at all; 10=Complete trust). Scores were first categorized into high trust (8–10) and not high trust (1–7) [22], and thereafter dichotomized into 'Never had high trust before' or 'Had high trust before' across the two time-points. This scale was developed locally for the purpose of this study, and more details of this scale has been published elsewhere [22].

Outcome variables

Adherence to COVID-19 PHSM were answered by the few questions i.e., (1) 'Avoid dining out', (2) 'Avoid going

to crowded places', (3) 'Avoid contact with people with flu symptoms', and (4) 'Avoid smaller group gatherings, such as family gatherings or parties'. The four measures included here were specifically chosen as the behaviours were mainly made on a voluntary basis throughout our study period [9, 23]. To reduce social desirability bias, interviews were done in a private setting with participants being informed of the anonymity of the data and the exclusion of mandated measures such as mask wearing, physical distancing, and work-from-home arrangements. Participants would be less likely to underreport their non-compliance for voluntary measures as there were no consequences involved. Participants could respond with 'yes' or 'no' to each of the question. Responses for both baseline and follow-up studies were recorded and dichotomized into whether an individual was 'partially/ fully adherent' or 'not adherent' throughout the pandemic. Sensitivity analyses were also performed using multinomial logistic regressions with four outcome categories (i.e., 1. Never adherent, 2. Increased adherence over time, 3. Lowered adherence over time, 4. Completely adherent) to ensure dichotomization was acceptable. Further description of the scale was provided in Supplementary Table 1.

Statistical analysis

All the analyses were performed using STATA S/E version 15 and p-value of <0.05 was considered significant. Figures were produced in R (https://www.R-project.org/). Post-stratification survey weights were calculated and included in all analyses to ensure results were representative of the general population. Summary statistics were presented as weighted percentage and unweighted frequency for categorical variables. Univariable logistic regressions were performed with adherence rates as the dependent variable and time-points as the independent variable; to detect any significant changes between the adherence rates over time. Thereafter, to identify significant factors associated with adherence to COVID-19 PMSHs, multivariable logistic regressions were used by including the sociodemographic factors and variables of interest together in the same model. Adjusted odds ratio and 95% confidence intervals were reported in the tables below. Variables-of-interest such as lifetime chronic condition, risk perception and trust factors were chosen and included in the regression models based on the existing literature on social-ecological model and the factors related to adherence towards PHSM [19]. Missing data were handled using the listwise deletion method.

Results

Summary of the sample's sociodemographic profile is presented in Table 1. Of the 858 participants, 30.07% were aged 35–49, 76.77% were of Chinese ethnicity, 51.11% were male, 36.29% had university and above education level, 72.31% were employed/self-employed, 62.96% were currently married, 48.49% had no chronic conditions, and 62.70% had a monthly personal income of below SGD$4,000.

From Fig. 1, weighted adherence rates of 'avoid dining out', 'avoid crowded places', 'avoid contact with people with flu symptoms' and 'avoid small group gatherings' were 39.41%, 60.82%, 79.82%, 44.82% respectively at baseline. However, adherence levels decreased at follow-up to 36.62%, 57.41%, 72.42%, and 42.08% for the aforementioned PHSM respectively. Using univariable logistic regression, a significant difference in adherence rates between time-points was only detected for 'avoiding contact with people with flu symptoms' (p-value=0.017). Across the two studies, 55.34%, 77.12%, 89.52%, and 61.25% participants were 'partially/fully adherent' throughout the pandemic for 'avoid dining out', 'avoid crowded places', 'avoid contact with people with flu symptoms' and 'avoid small group gatherings' respectively.

The weighted proportions of the variables of interest are summarized in Table 2. A minority of the participants (21.84%) reported having high trust in social media for COVID-19 related information over the two time-points. Conversely, majority of the respondents reported having high trust in local public health or infectious disease experts (81.32%), and government departments like MOH or MTF (83.73%) on COVID-19 related information. 75.88% responded that they were anxious at least once to the item 'I might be infected with COVID-19', 74.48% for 'My family members and friends might be infected with COVID-19'.

As shown in Table 3, differing findings from the multivariable logistic regression were observed for the various COVID-19 PHSM. For 'avoid dining out', age group 35–49 as compared to 21–34 was more likely to be adherent. Furthermore, fear of family and friends getting infected with COVID was significantly associated with being more adherent. For 'avoiding crowded places', significant factors associated with being adherent included older age groups, having high trust in local public health and infectious disease experts, and fear of family and friends getting infected with COVID-19. For 'avoiding contact with people with flu symptoms', high trust in local public health and infectious disease experts was significantly associated with being more adherent. For 'avoiding small group gatherings', unemployed participants or participants with below secondary school education were significantly associated with being more adherent.

Interestingly, presence of chronic conditions, unemployment, feeling stressed about financial losses, and high trust in government were not significant factors for being adherent.

Table 1 Descriptive statistic for sample's sociodemographic

	Weighted %	Unweighted *n*
Age group		
21–34	27.76	332
35–49	30.07	286
50–64	27.33	161
≥ 65	14.84	79
Gender		
Female	48.89	392
Male	51.11	466
Ethnicity		
Chinese	76.77	323
Malay	10.95	190
Indian	7.59	213
Others	4.69	132
Highest education attained[#]		
Below Secondary School	36.94	143
Pre-University	26.77	299
University and above	36.29	413
Employment Status[#]		
Unemployed	6.35	49
Economically inactive	21.26	147
Employed/Self-employed	72.31	661
Monthly Personal Income (SGD)[#]		
Below 4,000	62.70	476
4,000 to 5,999	18.44	186
Above 6,000	18.86	188
Marital status		
Married/Cohabitation	62.96	517
Never married	28.16	285
Divorced/Widowed/Separated	8.88	56
Chronic condition		
None	48.49	487
≥ 1 condition	47.12	340
I don't know/Refused	4.39	31

#Missing data $n=3$ for highest education attained, $n=1$ for employment status, $n=8$ for monthly personal income, $n=31$ for chronic conditions. Pre-university includes polytechnic, Institute of Technical Education, and Junior College

Discussion

Overall, our study observed that adherence rates to COVID-19 PMHs in Singapore decreased over time from 2020 to 2022. The decrease was minimal, with an average decrease of 3%. An exception was noted for the measure 'avoiding contact with people with flu symptoms' which had a significant reduction from 79.82–72.42%. Subsequently, we also identified factors that were significantly associated with adherence to these COVID-19 measures such as being older, having high trust in local public health and infectious disease experts, and fear that family members and friends might be infected with COVID-19.

A plausible reason for the declining trend in our overall adherence rates could be the attitude shift of residents becoming less wary about COVID-19 and the high vaccination rates in the country [23]. This decrease in compliance is not unique to Singapore. Longitudinal studies conducted in Hong Kong [24] and Japan [25] observed a similar decline for 'avoiding crowds' and 'avoiding group gatherings' measures. Some studies further characterized this phenomenon of decreased adherence as 'pandemic fatigue', where residents were tired of complying to the COVID-19 measures [26]. To effectively tackle this issue, policy makers would require longitudinal data to determine the significant factors associated with adherence throughout the pandemic phases [27].

Our findings were slightly mixed. Firstly, high trust in local public health experts were significantly associated with 'avoiding crowded places' and 'avoiding contact with people with flu'; however high trust in the government was not significantly associated with adherence to any COVID-19 PHSM. Debates on how trust affects adherence behaviour to COVID-19 PHSM have been ongoing ever since the pandemic started [28–30], with

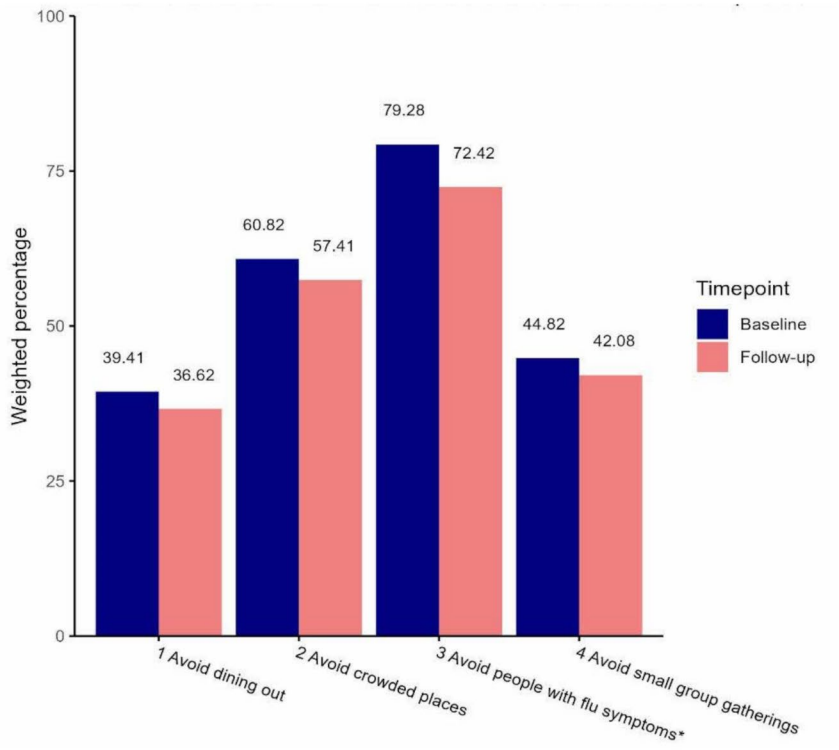

Fig. 1 Adherence levels to COVID-19 public health measures in Singapore across the time-points. * *p*-value < 0.05

Table 2 Descriptive statistics of the variables of interest

Variables	Weighted %	Unweighted *n*
Trust factors (8–10)		
Social media	21.84	143
Local public health or infectious disease experts	81.32	706
Government and related institutions like MOH and MTF	83.73	717
Perceived susceptibility and economic losses *(Anxious at least once)*		
I might be infected with COVID-19	75.88	651
My family members or friends might be infected with COVID-19	74.48	634
Unemployment	72.26	588
Financial loss, such as losing work opportunities or having to take unpaid leave	83.52	723

Missing data: Trust in social media = 20, trust in government *n* = 2. I might be infected with COVID, *n* = 3, family members or friends might be infected *n* = 1, unemployment = 4, financial loss *n* = 10

mixed results reported within Singapore. Trust in government was found to be significantly associated with higher adherence rates in Singapore in one study [6], on the other hand, another local study reasoned that high trust in government can also lead to an underestimation of risk, and thereafter, increased non-compliant behaviours [31]. The latter argument was echoed by other studies as well [29, 32]. Apart from trust in government, researchers are now advocating to target trust in public health experts to increase adherence and compliance to COVID-19 measures [33–35]. This conclusion was further supported by a previous Hong Kong study conducted during the severe acute respiratory syndrome (SARS) outbreak. The authors proposed that focus should be placed on promoting trust in the government and medical institutions in order to lower anxiety amongst residents which in turn may reduce the possibility of collective subversive actions [36]. Thus, having high trust in local public health experts appears to be an important factor in achieving better adherence rates.

Our study revealed that those belonging to older age groups were more adherent to the COVID-19 PHSM than younger individuals. This relationship has already been studied extensively and established in different countries [37]. One notable study utilizing international longitudinal data found that across time, older participants were still more likely to avoid crowds [27]. Some studies have attributed this adherent inclination to older

Table 3 Multivariable logistic regression to identify factors associated with being partially/completely adherent to COVID-19 public health and social measures over the two time-points

	Avoid dining out (*n* = 800)	**Avoid crowded places (*n* = 807)**	**Avoid contact with people with flu symptoms (*n* = 724)**	**Avoid small group gatherings (*n* = 798)**
	Adjusted odds ratio (95% Confidence interval)			
Age group				
21–34 (ref)				
35–49	**2.1 (1.23 to 3.58)***	**2.02 (1.14 to 3.57)***	1.48 (0.67 to 3.29)	1.77 (0.99 to 3.16)
50–64	1.15 (0.6 to 2.22)	**2.79 (1.24 to 6.28)***	4.1 (0.82 to 20.66)	0.71 (0.36 to 1.42)
65+	1.91 (0.71 to 5.13)	**3.76 (1.05 to 13.5)***	2.63 (0.52 to 13.46)	1.44 (0.56 to 3.76)
Gender				
Female (ref)				
Male	1.31 (0.86 to 2)	0.88 (0.54 to 1.44)	0.63 (0.31 to 1.28)	1.2 (0.76 to 1.88)
Ethnicity				
Chinese (ref)				
Malay	1.47 (0.89 to 2.42)	1.7 (0.95 to 3.06)	1.51 (0.62 to 3.68)	1.12 (0.68 to 1.85)
Indian	0.89 (0.57 to 1.4)	1.24 (0.75 to 2.06)	1.02 (0.5 to 2.07)	1.26 (0.8 to 1.97)
Other	0.67 (0.39 to 1.13)	0.89 (0.47 to 1.67)	0.59 (0.26 to 1.36)	0.68 (0.4 to 1.16)
Marital status				
Never married (ref)				
Married/Cohab	0.69 (0.41 to 1.15)	1.05 (0.62 to 1.79)	1.31 (0.57 to 2.99)	1.18 (0.71 to 1.99)
Divorced/Widowed/Separated	1.53 (0.6 to 3.87)	0.72 (0.25 to 2.13)	2.03 (0.39 to 10.77)	0.77 (0.28 to 2.1)
Highest education attained				
University and above (ref)				
Below secondary school	0.94 (0.5 to 1.75)	0.98 (0.46 to 2.1)	0.65 (0.23 to 1.84)	**2.02 (1.02 to 4.02)***
Pre-University	0.71 (0.43 to 1.16)	0.79 (0.46 to 1.36)	0.82 (0.35 to 1.96)	1.26 (0.77 to 2.08)
Monthly personal income				
4,000 to 5,999 (ref)				
Below 4,000	**0.52 (0.3 to 0.92)***	0.64 (0.34 to 1.21)	0.93 (0.37 to 2.34)	0.82 (0.47 to 1.45)
6,000 above	0.72 (0.39 to 1.33)	0.62 (0.31 to 1.24)	1.01 (0.39 to 2.65)	0.62 (0.34 to 1.14)
Employment status				
Employed/Self-employed(ref)				
Unemployed	1.82 (0.65 to 5.11)	1.2 (0.47 to 3.08)	0.58 (0.15 to 2.28)	**2.68 (1.02 to 7.07)***
Economically inactive	1.75 (0.93 to 3.3)	1.24 (0.53 to 2.9)	1.33 (0.43 to 4.12)	1.07 (0.54 to 2.14)
Chronic condition				
None (ref)				
≥ 1 condition	1.15 (0.71 to 1.84)	0.87 (0.51 to 1.5)	1.13 (0.52 to 2.46)	0.79 (0.49 to 1.27)
High trust on the information provided by				
Social media				
Never had high trust (ref)				

Table 3 (continued)

	Avoid dining out (*n* = 800)	Avoid crowded places (*n* = 807)	Avoid contact with people with flu symptoms (*n* = 724)	Avoid small group gatherings (*n* = 798)
	Adjusted odds ratio (95% Confidence interval)			
Had high trust before	0.7 (0.4 to 1.21)	0.99 (0.51 to 1.95)	0.67 (0.26 to 1.7)	0.85 (0.48 to 1.5)
Local public health experts and infectious disease experts				
Never had high trust (ref)				
Had high trust before	1.12 (0.57 to 2.22)	**2.35 (1.02 to 5.41)***	**4.03 (1.1 to 14.86)***	1.55 (0.75 to 3.22)
Government departments and related institutions				
Never had high trust (ref)				
Had high trust before	1.1 (0.56 to 2.17)	0.79 (0.37 to 1.69)	0.86 (0.26 to 2.8)	0.98 (0.48 to 2.01)
Risk Perceived susceptibility and economic losses				
I might be infected with COVID-19				
Never anxious (ref)				
Anxious at least once	1.06 (0.63 to 1.8)	0.93 (0.49 to 1.75)	1.11 (0.39 to 3.22)	0.94 (0.53 to 1.67)
My family and friends might be infected with COVID-19				
Never anxious (ref)				
Anxious at least once	**1.8 (1.07 to 3.02)***	**2.23 (1.19 to 4.22)***	1.91 (0.76 to 4.83)	1.02 (0.57 to 1.83)
Unemployment				
Never anxious (ref)				
Anxious at least once	0.98 (0.62 to 1.57)	0.89 (0.54 to 1.47)	0.74 (0.35 to 1.57)	0.76 (0.48 to 1.21)
Financial loss, such as losing work opportunities or having to take unpaid leave				
Never anxious (ref)				
Anxious at least once	0.73 (0.41 to 1.3)	0.74 (0.39 to 1.42)	1.45 (0.62 to 3.4)	0.91 (0.5 to 1.65)

* p-value < 0.05

adults' vulnerability and their higher perceived severity of infection [38]. The differences in life experience may have possibly heightened older adults' perceived severity. Back in 2003, SARS was touted as a highly infectious and deadly virus with a mortality rate of 14% in Singapore [39]. Given the similar transmissibility and clinical presentations of SARS and COVID-19 such as cough and fever [40], it might have evoked unpleasant memories of SARS and reminded them of its severity. These reasons might have been a factor as to why older adults perceived COVID-19 as more severe, and hence, a better adherence to PHSM.

Lastly, fear of family and friends getting infected with COVID-19 was a significant factor associated with higher adherence. However, the fear of being self-infected with the virus was not significant. Several studies supported our findings that individuals were more likely to be adherent if they have family or vulnerable members in their household [41, 42]. In Singapore, the idea of practicing social responsibility to protect our vulnerable population was highly emphasized throughout the pandemic, where the government catered priority timings for senior citizens to buy groceries, and or, to stay at home when sick [43]. By highlighting and reiterating the importance of social responsibility by the government [41], this COVID-19 measure could have been normalised and followed strictly by the residents. With Singapore's culturally close-knit society [44], being non-adherent to this might bring about informal punishment such as being judged or shunned by others [45]. Furthermore, this factor appears to improve non-adherence in young adults; with 94% of respondents reported being adherent to keep oneself, family members and others safe [46]. Results from a local qualitative study supports this finding as well [31]. Out of 10 participants, two were adherent towards the social distancing and circuit breaker measures. Despite having low trust in the government, these participants remained adherent because they had children at home and were probably concerned about passing on the infections to their family members [31].

Implications

Our findings here have a few implications. In particular, fear of family and friends getting infected with COVID-19 was significantly associated with a greater adherence to 'avoiding dining out' and 'avoiding crowded places'. Based on our results, one viable suggestion could be to install nudges at places where such behaviours are apparent (i.e., food courts, shopping malls, and supermarket). The nudges can be designed in a way to highlight the possibility of spreading the virus to people's loved ones and the benefits of being adherent. This approach has been widely used alongside mandatory measures in numerous countries and its effectiveness has been demonstrated in multiple studies [46]. In addition, the use of identifiable victim effect in nudges can also be implemented [47]. In Indonesia, a visual nudge of a mother's face and a reminder that the virus is lethal for the elderly was sufficient in reducing the participant's intention to gather for an event during the pandemic [48]. Despite the effectiveness, the utilization of nudges has been cautioned by some researchers due to the short-lasting impact on residents [49]. Therefore, the timing of nudges implementation must be carefully planned out throughout a pandemic.

Subsequently, shifting the focus to public health experts can be advantageous in improving adherence rate. In Singapore, this was reflected in MTF's press-releases where alongside ministers, prominent public health experts were frequently present to provide recommendations and updates of the COVID-19 situation to the residents [23]. As a result, it may have increased and retained the public's trust in public health experts [33], which thereafter, promoted greater adherence.

An alternative can be to arrange for dialogue sessions or interviews with public health experts to convey evidence-based information to clarify and disprove fake news [50], which can then be played on traditional and social media to target all demographic groups. Having these sessions can provide the public with trustworthy information sources that can provide reassurance regarding the pandemic situation, improve health literacy, and ultimately improve trust in public health experts. Undeniably, the need to retain high trust in the government is vital. A comparison between US (low government trust) and New Zealand (high government trust) revealed that even though both countries had high trust in public health experts, US mortality rates were still six times higher than New Zealand [51]. The frequent misalignment of public health messages between the US government and the coronavirus task force were one of the main reasons for the poor enforcement and non-adherence of preventive measures [52, 53]. Ultimately, by increasing the public presence of public health experts, and allowing them to present reliable information that are aligned with the government may play a part in improving adherence to public health measures. All in all, with the dynamic nature of pandemics, crucial factors such as being transparent, consistent, and the cohesiveness between the government and public health experts are essential to retain the public's trust [33].

Although the COVID-19 pandemic has subsided in 2023, the findings here can be appropriated and adapted to tackle public health diseases in future. Results here can also allow stakeholders to better prepare and equip the country more effectively should the next pandemic strike.

Limitations

Since our study commenced at the tail end of Singapore's circuit breaker [7], pre-lockdown data were not obtained and baseline adherence were not established for comparison. Abiding by social norms is a valued behaviour in Singapore [44], with low tolerance for deviancy. Interpersonal and community factors may have affected our adherence rates more as compared to other populations that have an individualistic culture. As our study involved pandemic-related social norms [54], social desirability bias may still be present where respondents under-report their non-compliance despite the emphasis of confidentiality by the researchers and the private setting of the interview. In view of this, actual adherence rates towards PHSM might be lower than what was reported.

Conclusion

Our study revealed that factors such as older age, high trust in public health experts and fear of infecting family and friends were significantly associated with greater adherence to COVID-19 PHSM across the pandemic. Soft interventions like nudges can be designed and installed at crowded places to remind residents of the high transmissibility of the virus to their loved ones. Increasing the media presence of local public health experts can also be an alternative to improve adherence rates in Singapore.

Abbreviations

COVID-19	Coronavirus disease
PHSM	Public health and Social Measures
WHO	World Health Organization
SMHS	Singapore Mental Health Study
MOH	Ministry of Health
MTF	Multi-ministry Taskforce
SARS	Severe Acute Respiratory Syndrome

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions
EH: Writing- original draft, formal analysis, visualization. S Shafie, S Shahwan, YJ, PZ, PS, FD, SC: Writing- review and editing, project administration. MY, PL: Conceptualization, methodology, writing- review and editing. MS: Conceptualization, methodology, writing- review and editing, supervision, funding acquisition.

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Data availability
The data is available from the corresponding author on request.

Declarations

Ethics approval
The study was approved by the National Healthcare Group Domain Specific Review Board (Ref: 2020/ 00462 and 2021/ 00566). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to participate
Written informed consent was obtained from all participants prior to the survey using an online software or in person. Structured interviews were conducted via Zoom platform or in person.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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