ORIGINAL ARTICLE

Perceived Covid-19 Susceptibility and Depressive Symptoms in Malaysian Adults: The Mediating Role of Loneliness

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ABSTRACT

Introduction: Prior research on the impact of social isolation on the mental health of older adults during the Covid-19 pandemic has yielded contradictory results. This study explores the relationship between perceived Covid-19 susceptibility and depression by assessing whether loneliness mediates this relationship. **Materials and methods:** A cross-sectional analysis was done to compare mental health conditions between older adults (N=55, mean age=63.76±3.86) and the young-middle aged population (N=1884, mean age=29.55±8.10) during the pandemic. Regression analyses were employed to investigate the relationship between perceived Covid-19 susceptibility and depressive symptoms, and whether loneliness mediates these associations. To estimate the indirect and proportion of mediating effects, mediation analyses applying nonparametric bootstrapping techniques were conducted. **Results:** During the Malaysian outbreak, older adults (*M* = 36.56, *SD* = 3.75) reported higher perceived Covid-19 susceptibility than the young-middle aged population (*M* = 29.86, *SD* = 23.90, p = 0.41), albeit without a significant difference. Despite this, older adults (M = 9.45, SD = 5.86) had lower depressive symptoms than the young-middle aged population (*M* = 11.29, *SD* = 6.15, *p* = 0.03). Mediation analyses revealed that perceived Covid-19 susceptibility was significantly associated with loneliness, which was consequently related with depressive symptoms only in the young-middle aged population (β = 0.31, 95% CI = 0.20 - 0.44, *p*<.001). **Conclusion:** Therefore, older individuals may be more resilient when confronted with unique circumstances such as the pandemic. Nevertheless, given its significant association with more severe depressive symptoms, research focusing on the impact of loneliness warrants further investigation.
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INTRODUCTION

The global Covid-19 pandemic had seriously impacted the public health system and the well-being of individuals. As the endemic phase of the pandemic began, many nations have lifted the lockdown imposed to contain the transmission of Covid-19, thus shifting the focus to the psychological sequelae of the virus. Recent studies in mental health have demonstrated that pre-existing mental health disparities have been aggravated by the global stressor of the Covid-19 pandemic, particularly in more vulnerable populations (48).

In Malaysia, various studies have reported high prevalence of various mental health disorders, such as psychological distress during the pandemic and across the lifespan, including in women (3), middle-aged/older adults (28) and the general population (2), with up to 30% prevalence of mild to severe depression (2). This highlights that individuals from all walks of life have suffered mental disturbances during this crisis. In particular, the Covid-19 pandemic has amplified the risk factors associated with deficient mental health outcomes, including social isolation, fear of contracting the virus and socioeconomic disruption. Greater perceptions of individual vulnerability to the virus and perceived social isolation (i.e. loneliness) have emerged as important predictors among the many risk factors for depression during the pandemic (32). However, the interplay between these two important psychosocial risk factors during the pandemic and its effect on mental health is relatively unexplored.

Prior research has utilised the Health Belief Model (HBM) which provides an insight on the individuals' adherence to Covid-19 preventive strategies (47). Perceived susceptibility, part of the HBM, is defined by the level

to which one feels vulnerable to a disease condition. Individuals who perceive a greater risk of being infected by the virus are more likely to adhere to the stay-at-home orders than those with lower self-perceived risk. While older individuals are particularly susceptible to Covid-19 due to weaker immunity (30) and existing underlying comorbidities (31), they are inclined to perceive greater levels of Covid-19 susceptibility than younger adults (27) during the pandemic. However, prolonged concern about contracting the disease and perceived Covid-19 susceptibility may act as sustained psychological stressors that may potentially lead to increased levels of depressive symptoms (36). Therefore, it is still unclear whether higher perceived Covid-19 susceptibility has a detrimental effect on mental health outcomes.

In addition, perceived susceptibility is also used in the risk perception attitude framework (RPA) (41) to predict health protective behaviours. As depicted in RPA, the intention to practice health protective behaviours is greatly influenced by threats, which is conceptualised as a two-dimensional factor, including perceived susceptibility and severity of the illness. Although perceived severity is an important consideration for individuals to adhere to Covid-19 preventive measures, risk perception (perceived susceptibility) has been shown to play a mediating role between intention and actual manifestation of the behaviours in other crises (4). Thus, it is imperative to have a further understanding on how perceived susceptibility to Covid-19 influences an individuals' decision to practice self-protective behaviours such as stay-at-home orders, which may result in heightened loneliness.

The psychological sequelae of Covid-19 are not just a direct consequence of the pandemic, but also mainly influenced by extended social isolation or lack of interactions with others (25). Loneliness is an emotional state characterised by a perceived disparity between the individual's expected and actual experiences of social interaction (35). Prior to the pandemic, loneliness has already been established as a notable public health issue, particularly among the older adult population (37). Specifically, a plethora of mental and physical health conditions has been correlated with this construct, including depression, cognitive decline, suicidal risk, premature mortality, cardiovascular disease, and substance use (22). Social isolation during Covid-19 crisis have a significant association with feelings of uncertainty about the future and fear of infections, resulting in increased depressive symptoms (15). However, conflicting evidence has emerged on whether the younger or older populations suffer more from Covid-19 related psychological distress (40) that warrants further investigations.

However, more than the fear of the virus itself, non-pharmaceutical interventions (NPI) such as movement restrictions, lockdowns, quarantine etc., and the new norms arising from the crisis such as working-from-home, on-line meeting/learning etc., are disrupting our basic needs to stay connected socially (6). Further, being homebound and having infrequent contact with others during the pandemic is particularly threatening from the viewpoint of the Evolutionary Theory of Loneliness (ELT) (10), which asserts that sustained absence of dependable social connections can lead to a bias towards self-preservation and implicit attentiveness toward threats. Therefore, the restricted movements and strict lockdowns during the pandemic can lead to increased loneliness, which has been demonstrated to be a primary risk factor for depression (10, 34). Moreover, the potential adverse impact of the quarantine on mental health outcomes, including depression, was corroborated in a recent review (9). This is mainly due to sustained periods of self-isolation that could lead to a greater impact on vulnerable groups, particularly older adults as they are functionally very dependent on family members or supported by community services.

To date, no other study has examined the interplay between perceptions of individual vulnerability to Covid-19 and loneliness arising from the prolonged movement control orders (MCO) during the pandemic, which then may be associated with depressive symptoms. Specifically, the present study aims to investigate whether loneliness functions as a potential mediator in the link between perceived Covid-19 susceptibility and depression in the older and young-middle aged populations. We hypothesised a differential mediating role of loneliness on the association between perceived Covid-19 susceptibility and depression in the older and young-middle aged populations, independent of key sociodemographic factors.

MATERIALS AND METHODS

Study setting and population

As part of a bigger research project, which is a time-series longitudinal study, we present here the results from phase one of the time-series study that was conducted between April to July 2020 (during the early phase of the Covid-19 pandemic). Participants were recruited via convenience sampling using snowballing techniques through the personal networks of the researchers and public social media posts. Additional participants were recruited from a health and demographic surveillance system (HDSS) that collaborated in this project - the South East Asia Community Observatory (SEACO) study platform. Data collection was conducted either through a survey online or via the telephone. Participants were healthy adults (minimum age of 18 years), and they were compensated through a lucky draw where 30 participants would share gifts worth USD200 in total. The inclusion criteria were for participants to be aged 18 years and older. No exclusion criteria were employed in this study. The dropout criteria were to include only

participants who completed all available variables of interest for complete-case analyses. In the dropout analysis, there were no age or gender differences between the excluded and included participants. Informed consent was obtained from every participant, and the Monash University Human Research Ethics Committee has approved the study (MUHREC; project ID: 25807).

The Qualtrics platform was used to conduct the survey. Interested participants of the study were directed to the Qualtrics survey after clicking on the link included in our broadcasted message, which was circulated through various social media platforms. The survey started with an explanatory statement, where study objectives, participants' rights, and voluntary participation were informed to the participants. Next, they provided their informed consent before continuing the survey. The participants then completed the survey, which included baseline demographic information, the UCLA-3 Loneliness scale, the Center for Epidemiologic Studies Depression Scale (CES-D), and a perceived Covid-19 susceptibility question. Considering that Malaysia is a multiethnic nation, three language versions of the survey were provided (English, Bahasa Melayu and Chinese), to enable participants with the opportunity to answer the survey in their native language; thus, reducing language barriers. We have utilised the validated versions of the UCLA-3 (23) and CES-D (11) scales in English and Bahasa Melayu (45, 29). Meanwhile, we also used the validated Chinese version (24) of the CES-D. However, the UCLA-3 scale was back-translated into Chinese by native speakers from the research team.

The total time taken to finish the online survey was approximately 15 minutes. SEACO participants either participated directly through Qualtrics or were telephone-interviewed by SEACO data collectors, who then keyed into the Qualtrics software on their behalf. The average time taken for the telephone interview was approximately 30 minutes.

A total of 1,939 individuals from Malaysia participated in this project. This final sample size was calculated after accounting for data cleaning procedures by removing duplicate data, data from participants who did not answer our primary measures such as the depression scale, and data from participants who answered the survey in less than five minutes (indicating an unrealistic time frame to be completing the survey genuinely). The final sample consisted of 1,177 (61%) females and 762 (39%) males, aged between 18-80 years old (M = 30.52, SD ± 9.82), which is considerably more than the suggested size of G*Power analysis (N = 98), with a power of 80% and a medium effect size.

Outcome

Depression

As for the measurement of depressive symptoms, this study used the revised version of the Center for Epidemiologic Studies Depression Scale (CES-D) by Carleton et al. (11). Compared to the original 20-items 4-factors CES-D developed by Radloff (39), this shorter revised version, with 14-items, has been shown to be more psychometrically robust, with three unbiased factors (i.e., anhedonia, somatic symptoms, and negative affect), which are more aligned with contemporary diagnostic criteria for depression (11). In this revised version of the CES-D, 6 items are used to measure somatic symptoms observed in the last one week, which include items such as "I did not feel like eating; my appetite was poor". As for negative affect, 4 items are used, which include items such as "I felt depressed"; and for anhedonia, 4 items are used, which include reversed items such as "I felt hopeful about the future". All items are measured on a 4-point scale [0 = Rarely or none of the time (less than 1 day) and 3 = Most or all of the time (5-7 days)]. The scoring of positive items was reversed. The cut-off point for subthreshold depression is determined to be at 15.5 and has demonstrated adequate reliability and validity (31). All translated versions for CES-D showed acceptable internal consistency (English, α = .88; Bahasa Melayu, α = .75; Chinese, α = .86). The observed Cronbach's alpha for the total sample in the current study was α = .79.

Covariates

Loneliness

Loneliness was assessed by the 3-item UCLA Loneliness scale developed by Hughes et al. (23). The measure consists of three items asking individuals whether they have felt left out, lacked companionship, and felt isolated in the past seven days. The measure uses a 3-response category of 1 (hardly ever) to 3 (often) and the scores can range from 3 to 9 by summing the three items. Higher total scores denote higher levels of loneliness. The 3-item UCLA measure is a well validated measure of loneliness with high internal consistency and the reported Cronbach's alpha in past studies ranged from .89 to .94 (28). The original English version of this measure was used in the English survey, and the validated translations of this measure were used for other languages. The different language versions of UCLA showed strong internal consistency (English, α = .86; Bahasa Melayu, α = .78; Chinese, α = .75), and the observed Cronbach's alpha for the total sample in the current study was .80.

Perceived susceptibility of COVID-19

The perceived Covid-19 susceptibility of participants was assessed using a single question - "What are your

chances of catching Covid-19?" and was measured in percentage (0 to 100%).

Other covariates

Sociodemographic variables included age (years), gender (Female = 0; Male = 1) and education. The participants reported their highest level of formal education (0 = Never attended school, 1 = Primary school, 2 = Secondary school, 3 = Diploma, 4 = Pre-university, 5 = Bachelor's Degree, 6 = Master's Degree, 7 = PhD).

Statistical Analyses

We conducted complete-case analyses and included only participants with all available variables of interest. Descriptive analyses were performed in SPSS 28.0.1.1. Regression analyses were conducted in R Version 1.2.5033 and mediation analyses were done by employing the 'Mediation' package in R, with the significance level set at 0.05. The STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) guidelines for observational studies was followed by the present study description. Data cleaning, which included removing duplicates, participants who did not answer the CES-D inventory, and those who completed the survey in less than five minutes, were conducted prior to running analyses. Assumptions checking, including homoscedasticity and linearity, have been performed. Multicollinearity has also been investigated by checking the Variance inflation factor (VIF) of the variables. Results of the variance inflation factor analysis showed that multicollinearity was not an issue as the VIF of all the variables was below 2.

Baseline study participants' characteristics are displayed for the older and young-middle aged populations. Meanwhile, continuous variables were summarised as mean (±standard deviation) and compared between the older and young-middle aged populations using the t-test. We operationalize the young-middle aged adults as those aging from 18 to 59 years old, and the older adults as those aged 60 years old and above. Multivariate linear models were conducted to evaluate the associations between perceived Covid-19 susceptibility, loneliness, and depression (outcome). The models were adjusted for age, gender, and education. Additional regression models were used to examine if loneliness modifies the association between perceived Covid-19 susceptibility and depression. The interaction term of Covid-19 susceptibility*loneliness was also added to the regression models.

The mediation models were defined following the four-step framework outlined by Baron and Kenny (5). As shown in Fig. 1, Step 1 assessed the association between perceived Covid-19 susceptibility and loneliness (path a). Step 2 assessed the association between loneliness and depression while adjusting for perceived Covid-19 susceptibility (path b). Step 3 examined the link between perceived Covid-19 susceptibility and depression (path c). Step 4 examined the relationship between perceived Covid-19 susceptibility and depression while controlling for loneliness (path c'). Path c refers to the direct effect, while path c' refers to the total effect. Finally, we performed the mediation analysis with nonparametric bootstrap using 1000 resamples to compute the magnitude of the average total effect, the proportion mediated, and the statistical significance of the indirect effects (46).

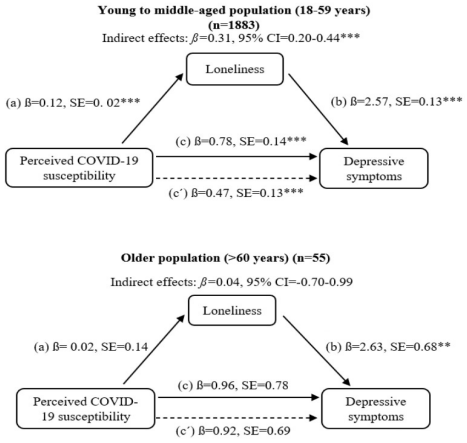

Fig. 1: Mediation analysis of loneliness (measured by perceived social isolation) on the association between perceived Covid-19 susceptibility and depressive symptoms in the young to middle-aged and older populations. Graphical representation of the mediation analysis: Path a probes the relationship between perceived Covid-19 susceptibility and depressive symptoms. Path b probes the relationship between loneliness and depressive symptoms, while controlling for perceived Covid-19 susceptibility. Path c probes the relationship between perceived Covid-19 susceptibility and depressive symptoms. Path c' probes the relationship between perceived Covid-19 susceptibility and depressive symptoms, while controlling for loneliness. Standardised beta estimes with standard errors and p-values are reported for eash association examined. ***p<0.0001, **p<0.001.

The power of the mediation effect of loneliness on the link between perceived Covid-19 susceptibility and depression of the present dataset was tested in the Monte Carlo power analysis for indirect effects (42). The power analysis showed that the present study had an adequate sample size to detect approximately 80% of power to show an indirect effect of perceived Covid-19 susceptibility on depression through loneliness in both the older and young-middle aged samples.

RESULTS

Descriptive statistics

The present investigation includes 1,939 participants (61% females and 39% males) with a mean age of 30 years (18 – 80 years) that were eligible for analyses. Table I displays the study participants' characteristics according to the older and young-middle aged populations. Older individuals had lower mean of CES-D scores (mean±SD: 9.45 ±5.86) compared to the young to middle-aged population (11.29 ±6.15) with a small effect size (Cohen's *d*: 0.30). In terms of educational attainment, the young-middle aged population were

more educated (have a Bachelor's degree) as compared to the older population. Even though the levels of perceived Covid-19 susceptibility and loneliness were higher in the older population than the young-middle aged population, the association did not reach a statistically discernible effect.

Table I: Participant's characteristics (young-middle aged vs. older population) - frequencies, % (n) of categorical variables and mean (±SD) of each continuous variable, including the *P*-value for differences between old and general population.

	Young-Middle Aged Population			Older Population						
	N	***M***	***SD***	***N***	***M***	***SD***	***df***	***t***	***p* (two-sided)**	**Cohen's *d***
Perceived COVID-19 Susceptibility	1884	29.86	23.90	55	36.56	3.75	1937	-2.04	0.41	-0.28
Loneliness	1884	4.53	1.74	55	4.58	1.58	1937	-0.21	0.84	-0.30
Age	1884	29.55	8.10	55	63.76	3.86	68.73	-61.83	<.001	-4.27
Gender	1884	0.39[b]		55	0.67[b]		1	18.54[a]	<.001	
Education level	1884	3.87	1.37	55	3.24	1.84	55.77	2.54	0.014	0.46
Depression score	1884	11.29	6.15	55	9.45	5.86	1937	2.18	0.03	0.30

[a] Chi-square test statistic
[b] % of male participants

Multivariate analyses

Table II displays the results from the multivariate linear regression models that examined the interrelation of perceived Covid-19 susceptibility, loneliness and depressive symptoms, adjusted for important covariates. In the total sample, greater perceived Covid-19 susceptibility and loneliness were independently associated with greater depressive symptoms (perceived Covid-19 susceptibility: ß = 0.49, SE = 0.13, p < 0.0001; loneliness: ß = 2.58, SE = 0.13, p < 0.0001). Similarly, the significant associations of higher perceived Covid-19 susceptibility and loneliness with depressive symptoms remained in a subsample of young-middle aged population (perceived Covid-19 susceptibility: ß = 0.47, SE = 0.13, p < 0.0001; loneliness: ß = 2.57, SE = 0.13, p < 0.0001). However, in the older adults' sample, only loneliness, but not perceived Covid-19 susceptibility, was significantly associated with depressive symptoms (loneliness: ß = 2.63, SE = 0.68, p < 0.0001; perceived Covid-19 susceptibility: ß = 0.91, SE = 0.69, p = 0.19). With regards to other covariates, age was negatively correlated with depressive symptoms in the total and young-middle aged population but not in the older adults' sample, albeit with relatively small beta values. Gender and educational levels were not significantly associated with depressive symptoms in all models. Moreover, significant interaction terms of perceived Covid-19 susceptibility X loneliness and depressive symptoms were not found in all sample populations.

Table II: Standardised ß estimates (SE) and *P*-values of the associations of perceived COVID-19 susceptibility, loneliness and interaction term (perceived COVID-19 susceptibility X loneliness with depressive symptoms).

	Model 1		Model 2	
Total Population (N=1938)	**ß (SE)**	***P***	**ß (SE)**	***P***
Perceived COVID-19 Susceptibility	0.49 (0.13)	<.0001	-0.05 (0.45)	0.96
Loneliness	2.58 (0.13)	<.0001	2.31 (0.20)	<.0001

CONTINUE

Table II: Standardised ß estimates (SE) and *P*-values of the associations of perceived COVID-19 susceptibility, loneliness and interaction term (perceived COVID-19 susceptibility X loneliness with depressive symptoms). (CONT.)

	Model 1		Model 2	
Total Population (N=1938)	**ß (SE)**	***P***	**ß (SE)**	***P***
Perceived COVID-19 Susceptibility X Loneliness	-		0.21 (0.12)	0.10
Age	-0.08 (0.01)	<.0001	-0.08 (0.01)	<.0001
Gender	-0.38 (0.26)	0.14	-0.37(0.26)	0.15
Education	0.11 (0.09)	0.21	0.12 (0.90)	0.19
Young-Middle Aged Population (N=1883)				
Perceived COVID-19 Susceptibility	0.47 (0.13)	<.0001	-0.04 (0.35)	0.90
Loneliness	2.57 (0.13)	<.0001	2.31 (0.21)	<.0001
Perceived COVID-19 Susceptibility X Loneliness	-		0.20 (0.13)	0.11
Age	-0.09 (0.12)	<.0001	0.15 (0.09)	<.0001
Gender	-0.34 (0.26)	0.20	-0.33 (0.26)	0.20
Education	0.14 (0.09)	0.11	0.15 (0.09)	0.10
Older Population (N=55)				
Perceived COVID-19 Susceptibility	0.91 (0.69)	0.19	-1.54 (2.39)	0.52
Loneliness	2.63 (0.68)	<.0001	1.81 (1.02)	0.08
Perceived COVID-19 Susceptibility X Loneliness	-		0.85 (0.79)	0.29
Age	-0.25 (0.19)	0.20	-0.27 (0.19)	0.16
Gender	-2.43 (1.54)	0.12	0.04 (0.03)	0.26
Education	-0.42 (0.38)	0.27	-0.43 (0.38)	0.25

Model 1: Association of perceived COVID-19 susceptibility, loneliness on depressive symptoms (as outcome) with adjustment for age, gender and educational levels.
Model 2: Association of perceived COVID-19 susceptibility, loneliness, interaction term of perceived COVID-19 susceptibility X loneliness on depressive symptoms (as outcome) with adjustment for age, gender and educational levels.

Mediation analyses

Mediation analyses were performed using non-parametric bootstrapping methods to estimate the indirect effect of an indirect association and the proportion mediating effect. Fig. 1 shows the multivariate-adjusted path analytic models that examine an indirect association between perceived Covid-19 susceptibility and depression via loneliness. First, in the young-middle aged population, perceived Covid-19 susceptibility was associated with depression (in the model not adjusted for loneliness) (path c: β = 0.78, SE = 0.14, p < .0001). Second, perceived Covid-19 susceptibility was significantly associated with loneliness (path a: β = 0.12, SE = 0.02, p < .0001). Third, we observed a significant correlation between loneliness and depression while controlling for perceived COVID-19 susceptibility (path b: β = 2.57, SE = 0.13, p < .0001). Finally, we observed a decreasing strength of the relationship between perceived Covid-19 susceptibility and depression in the presence of the mediating variable, loneliness (path c': β = 0.47, SE = 0.13, p < .0001), indicating that the relationship between perceived Covid-19 susceptibility and depression is partly accounted for by loneliness.

Meanwhile, in the older population, perceived Covid-19 susceptibility was not significantly associated with depression (in the model not adjusted for loneliness) (path c: β = 0.96, SE = 0.78, p = 0.22). Perceived Covid-19 susceptibility was also not significantly associated with loneliness (path a: β = 0.02, SE = 0.14, p = 0.92). Next, loneliness was significantly associated with depression after controlling for perceived Covid-19 susceptibility (path b: β = 2.63, SE = 0.68, p < .0001). Lastly, the weakening of the association between perceived Covid-19 susceptibility and depression with the inclusion of the mediating variable, loneliness (path c': β = 0.92, SE = 0.69, p = 0.19), was not significant, indicating that the relationship between perceived Covid-19 susceptibility and depression was not mediated by loneliness in the older population.

Table III summarises the multiple regression analyses of the mediation model, specifically, the mediating effect of loneliness on the correlation between perceived Covid-19 susceptibility and depressive symptoms, along with adjustments for age, gender and educational levels. As can be seen in Table IV, in the young-middle aged population, the pathway consisting of the indirect effect found a significant relationship between perceived Covid-19 susceptibility and depression, mediated by loneliness (Adjusted model: β = 0.31, 95% CI = 0.20 - 0.44, p <.001). The mediation analysis further showed that the proportion mediated by perceived COVID-19 susceptibility was 40% (β = 0.40, 95% CI = 0.26 - 0.62, p <.001), demonstrating the degree that loneliness has partly influenced the indirect relationship between perceived COVID-19 susceptibility and depression. Meanwhile, in the older population, the indirect effect of loneliness on depression was not found to be significant (Adjusted model: β = 0.04, 95% CI = -0.70 - 0.99, p = 0.90). Lastly, the proportion mediated by perceived COVID-19 susceptibility was found to be not significant at 4% (β = 0.04, 95% CI = -4.65 - 2.26, p = 0.78).

Table III: Summary of multiple regression analyses for the mediation model.

	(i) Total effects (Perceived COVID-19 susceptibility ↦Depressive symptoms)	(ii) Perceived COVID-19 susceptibility ↦ Loneliness	(iii) Indirect effects (Perceived COVID-19 susceptibility↦ Loneliness ↦ Depressive symptoms)
Total Population (N=1938)			
Perceived COVID-19 Susceptibility	0.80 (0.14)***	0.12 (0.02)***	0.50 (0.13)***
Loneliness			2.58 (0.13)***
Age	-0.10 (0.01)***	-0.01 (0.002)***	-0.08 (0.01)***
Gender	-0.34 (0.28)	0.01 (0.05)	-0.38 (0.26)
Education level	0.08 (0.10)	-0.01 (0.02)	0.11 (0.09)
Young to Middle-Aged Population (N=1883)			
Perceived COVID-19 Susceptibility	0.78 (0.14)***	0.12 (0.02)***	0.47 (0.13)***
Loneliness			2.57 (0.13)***
Age	-0.11 (0.02)***	-0.01 (0.003)*	-0.10 (0.02)***
Gender	-0.32 (0.29)	0.01 (0.05)	-0.34 (0.26)
Education level	0.12 (0.10)	-0.01 (0.02)	0.15 (0.09)
Older Population (N=55)			
Perceived COVID-19 Susceptibility	0.96 (0.78)	0.02 (0.14)	0.92 (0.69)
Loneliness			2.63 (0.68)***
Age	-0.30 (0.21)	-0.02 (0.04)	-0.25 (0.19)
Gender	-1.95 (1.74)	0.18 (0.32)	-2.43 (1.55)
Education level	-0.49 (0.42)	-0.03 (0.08)	-0.42 (0.38)

***p <.0001, ** p<0.001: *p<0.05

Standardised Я estimates (SE) of (i) the total effects of perceived COVID-19 susceptibility on depressive symptoms (assessed by the Center for Epidemiological Studies Depression scale), (ii) the association between perceived COVID-19 susceptibility and loneliness (on a continuous scale), and (iii) the indirect effect of perceived COVID-19 susceptibility on depressive symptoms while controlling for loneliness. Both the independent variable (perceived COVID-19 susceptibility) and the mediator (loneliness) were included in the multiple linear regression model to assess the indirect effects. Lastly, the multiple regression models were adjusted for covariates including age, sex, and education level.

Table IV: Mediation analysis of the association between perceived COVID-19 susceptibility and depressive symptoms, mediated by loneliness.

Direct effects		Indirect effects (Mediation effect)		Total effects		Proportion mediated	
ß (95% CI)	*P*	ß (95% CI)	*P*	ß (95% CI)	*P*	ß (95% CI)	*P*
Total population (N = 1938)							
0.50 (0.26, 0.77)	<.001	0.30 (0.19, 0.43)	<.001	0.80 (0.54, 1.08	<.001	0.38 (0.25, 0.56)	<.001
Young to middle-aged population (n = 1883)							
0.47 (0.21, 0.71)	<.001	0.31 (0.20, 0.44)	<.001	0.80 (0.50, 1.05)	<.001	0.40 (0.26, 0.62)	<.001
Older population (n= 55)							
0.92 (-0.45, 2.29)	0.20	0.04 (-0.70, 0.99)	0.90	0.96 (-0.54, 2.70)	0.19	0.04 (-4.65, 2.26)	0.78

Models were adjusted for age, sex, and education level. Standardised Я estimates (95% CI) and P-values are shown for the direct effects, indirect effects, total effects and proportion mediated.

DISCUSSION

The present study provides further understanding of the interplay between perceptions of individual vulnerability to Covid-19 and loneliness during the pandemic on depressive symptoms in a sample of 1,939 adults across the lifespan in Malaysia during the initial phase of the Covid-19 pandemic. Our findings showed that perceived Covid-19 susceptibility was significantly associated with depressive symptoms, which was partially mediated by feelings of loneliness. While perceived susceptibility to Covid-19 and loneliness have been shown to be substantive determinants of depressive symptoms in the overall population in our study, our results showed that they have differential effects on the young-middle and older aged population. Our data revealed that neither perceived susceptibility nor loneliness scores differed significantly between the two populations. However, older individuals reported lower depressive symptoms compared to their younger peers.

Depressive symptoms in older and young-middle aged population

Older individuals reported fewer depressive symptoms than young-middle aged adults, corroborating earlier findings that they may be more resilient to psychologically related mental health disorders during the initial phase of the Covid-19 pandemic as compared to younger adults (44). Moreover, various studies have revealed that older adults have lower prevalence rates for anxiety and depression during the pandemic (17). This is unexpected, as this population has been regarded as the "high risk" group for contracting Covid-19 and suffers greater severity (e.g., hospitalisation and dying) from the virus (1). Various reasons have been suggested for the mental resilience of the older population, such as greater negotiated resources and strategies in the face of adversities (21), and our findings provided further evidence to support such an argument. Indeed, our results showed that while perceived susceptibility to Covid-19 and the heightened loneliness (as a result of various movement restriction policies) were affecting the mental health status (depression) of young-middle aged individuals, their effects were less obvious in the older population. Older adults are inclined to have lower stress reactivity and generally better emotional regulation and well-being compared with younger adults (13).

Association between perceived susceptibility of Covid-19 and depressive symptoms

Although previous research has suggested that responses adaptation to perceived disease vulnerability promotes health-seeking behaviours (43), the current findings suggest that greater perceived vulnerability during the Covid-19 pandemic may heighten stress response, which may in turn contribute to adverse mental health outcomes (8). In accordance with the developing literature of the pandemic's adverse impact on mental health, this relationship between perceived Covid-19 infection risk and depressive symptoms further strengthens the notion of the positive association between risk perceptions and psychiatric morbidity (32). For instance, perceived Covid-19 susceptibility significantly predicts more severe depressive symptoms among the general South African population (mean age = 45 years) (33). However, our results posit that the impact of perceived susceptibility to Covid-19 on depressive symptoms may not be equally distributed across all populations. While the expected positive linkage between perceived susceptibility and depression was evident in the young-middle aged participants, its effect was much weaker in the older population. This may reflect a greater emotional resilience in older adults during this crisis, as compared to young-middle aged adults (13).

Loneliness mediates the link between perceived susceptibility of Covid-19 and depressive symptoms

Furthermore, our study demonstrated that the link between perceived Covid-19 risk and depressive symptoms was partly driven by a heightened feeling of loneliness during the pandemic. Our findings support previous studies on the relationship between perceived susceptibility of Covid-19 and loneliness (19) among the young-middle aged population but not the older population. It should be highlighted that this finding of greater risk perception being related to depression is consistent with previous research (16). Personal experiences with the virus can heighten the perception

of threat related to the pandemic, adding to heightened psychological distress. Of note, greater risk perception contributes to more protective behaviour, such as social distancing and self-isolation, which may consequently contribute to feelings of loneliness and despair (16).

According to the evolutionary theory of loneliness (10), it has been demonstrated that loneliness predicts greater stress appraisals (20) and heightened threat perception (38), rendering it plausible that lonely individuals assess the pandemic more negatively and suffer from increased levels of psychological distress. In the longer term, loneliness may provoke further disconnection from others and can have a detrimental impact on health (22), leading to depression. Indeed, there is increasing evidence demonstrating that the pandemic-induced loneliness may contribute to the onset of depression in various populations (34), confirming our findings.

However, loneliness, acting as a significant mediator in the link between Covid-19 susceptibility and depression was only seen in the young-middle aged group. The path analysis showed that Covid-19 susceptibility has neither significant influence on the depressive state nor the perceived loneliness feeling of the older adults. Instead, only loneliness was predictive of depressive symptoms in this group. Young-middle aged adults may be more susceptible to this mediating effect of loneliness on depression compared to older adults due to having less mental resilience, poorer coping strategies and less experience in dealing with global stressors (18). Further, this showcased that the mental health of the older adult population was not easily affected by the fear of the virus or any elevated loneliness induced by the pandemic.

Perceived susceptibility of Covid-19 in older and young-middle aged populations

Despite reporting higher perceived Covid-19 susceptibility, the mental health consequence of Covid-19 was less profound in the older as compared to the young-middle aged adults, albeit with a non-statistically discernible effect. Older individuals may be more adaptable when facing unique life circumstances such as a pandemic than the young-middle aged population (26). Carstensen's Socio-emotional Selectivity Theory (SST) (12) may impart some insights into the inconsistencies in the perceived susceptibility of older adults - whereby as one age, most of one's attention tend to be concentrated on present-moment events, thereby emphasizing on positive emotions and finding meaning in said events, and thus less attention on future circumstances (12). This is in line with a study whereby older individuals displayed a more positive attitude and perspective toward the pandemic in comparison to other age counterparts (14). Further, older adults in a separate study reported fewer negative emotions associated with Covid-19 exposure, despite reporting a greater perceived risk than younger adults (13). These results indicate that older individuals may be less impacted by the negative aspects of the Covid-19 pandemic, as can be seen in the lower prevalence of depressive symptoms.

Study strengths and limitations

The strengths of the present study include its large sample size of Malaysians during the height of the pandemic (April 2020), thus having access to a valuable data set of behavioural measures pertaining to the pandemic. Meanwhile, our study has several limitations. First, our chosen battery to measure depression cannot be used as a clinical diagnostic tool, although it is a common inventory used to assess depressive symptoms in observational study settings (49). Furthermore, data was collected from participants only during a single time point during the early phase of the pandemic in April 2020. This study includes a small sample of the older population which might bias the findings. This may be partly due to the fact that the study recruited participants mostly via social media, which were less likely to be used by the older adults (7). Further, the broad age range of our sample may introduce potential bias in our interpretation of results, which needs to be accounted for. However, a post-hoc sample calculation demonstrated that the mediation analysis has sufficient power (80%) to detect a significant association in the older adult population. Another limitation of this study is that the sample size exhibits a larger percentage of women than men, potentially affecting the generalizability of the findings to the broader population. Lastly, it is important to keep in mind that the cross-sectional design of this study does not imply a causal relationship.

CONCLUSION

The Covid-19 pandemic has clearly contributed to detrimental effects on psychological well-being, which require further investigations to understand its long-term consequences. The present study's findings support the necessity for healthcare professionals to address loneliness even beyond the Covid-19 pandemic, as it remains to be a potential psychosocial stressor across the lifespan. Finally, the Covid-19 pandemic has evidently demonstrated the impact of social isolation during an emerging pandemic wave which has contributed to adverse mental health. As we transition into the endemic phase of the disease, addressing issues related to the psychosocial determinants of health should remain as part of the public health preventive strategies. More importantly, our findings illustrated that factors affecting depression may not be the same between older adults and the younger groups. Customised approaches or policies may be necessary to address the mental health issues of various age groups during a crisis such as Covid-19.

Although lockdown measures are probably the best tool that governments have to combat the pandemic (before vaccination is available), they should be made cognizant

ofthe aftermath of the various lockdown measures that have resulted in heightened perceived loneliness, which is substantially contributing to the high prevalence rates of mental health risks. This results in the need for policymakers to find a way to balance the situation before mental health problems become a secondary pandemic by itself, even before the first one was resolved. While we acknowledge that the relationship between loneliness and depression may not necessarily be caused solely by policies of mobility reduction and physical distancing implemented during the pandemic, the fact that perceived loneliness remains as one of the most predominant predictors of mental health during a pandemic is a strong argument for the need to fine-tune the lockdown policies so as to minimise any elevation in perceived loneliness.

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