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The impact of gardening on mental resilience in times of stress: A case study during the COVID-19 pandemic in Singapore

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ABSTRACT

To curb the spread of Covid-19, Singapore, like other cities, had to impose movement restriction and social distancing measures that may affect the well-being of its residents. In this paper, we assessed the potential benefits of gardening on the mental well-being of Singapore residents, based on the concept of mental resilience. We hypothesized that gardening activities promote mental resilience. A survey was administered on 8,786 participants of a “Gardening with Edibles” programme, measuring their mental resilience status, engagement in gardening activities and socio-demographic information. The mental resilience scores of participants who engaged in weekly gardening were compared with the scores derived from another survey conducted during the pandemic on an online community comprising demographically representative respondents with an interest on Covid-19 related community care. The results showed that the mental resilience of those who gardened was statistically significantly higher than the online community. Within the gardening group, those with less than one hour of weekly gardening time had significantly lower scores in their total mental resilience, and five out of seven resilience factors, “emotional regulation”, “relationship”, “confidence”, “positive thinking” and “spirituality”, compared to those with more weekly gardening time, showing that the efficacy of the mediating effects may peak at a weekly gardening time of between one to four hours. Home gardening may be an effective way for people living in densely populated cities to interact with nature and build mental resilience during the pandemic.

1. Introduction

Mental or psychological resilience, a construct centred around two core concepts –the presence of adversity and positive adaptation in response (Fletcher and Sarkar, 2013; Chue and Cheung, 2021), refers to the ability to use “mental processes and behaviours in promoting personal assets and protecting self from the potential negative effects of stressors” to emotionally cope with a crisis and return to the pre-crisis psychological state (de Terte and Stephens, 2014). In this paper, we used the two terms “mental resilience” and “psychological resilience” interchangeably. Individuals who are mentally or psychologically resilient are expected to handle hardships and flourish in personal and social lives (Manning, 2013). The current coronavirus disease 2019 (COVID-19) pandemic, with more 211 million cases and 4 million deaths reported worldwide (World Health Organization, 2021), presented an unprecedented level of stresses on most countries and people as

lock-downs, stay-at-home orders, closures of recreational spaces and social distancing measures had to be implemented to curb the pandemic (Ammar et al., 2020; Galea et al., 2020; Rajkumar, 2020). For example, Giuntella et al. (2021) tracked the mental well-being of a longitudinal dataset of several cohorts of young adults before and during the COVID-19 pandemic in the United States, and found significant disruptions to physical activity, sleep, social interactions, as well as increase in screen time at the onset of the pandemic. Mental health was adversely impacted during the pandemic, with 46 %–61 % of the participants deemed to be at risk for clinical depression, which was an increase of nearly 90 % in depression rates. This underscores the urgent need to understand the multitude of stresses and pathways leading to the deterioration of mental health and the interventions that can enhance mental resilience, in order to mitigate the adverse effects of stress brought about by the current COVID-19 pandemic (Poole et al., 2017; Sheerin et al., 2018; Douglas et al., 2020; Holmes et al., 2020).

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Over the past months, the role of urban nature in fostering mental health during the COVID-19 has been demonstrated in numerous studies worldwide. For instance, a study found that exposure to public natural spaces in Portugal during lockdowns was related with lower levels of stress, while for Spain, which experienced a stricter lockdown, contact with indoor plants and use of private community green spaces, was beneficial (Ribeiro et al., 2021). Another study in Japan found that higher frequency of greenspace use and green view through windows from home was associated with increased levels of self-esteem, life satisfaction, and subjective happiness and decreased levels of depression, anxiety, and loneliness (Soga et al., 2020, 2021). Similarly, studies in Australia and the United States reported positive findings; that increased urban green space use during the COVID-19 pandemic had the potential to ameliorate some of the negative effects of the stressor and offer significant protective effect for depression and mental health (Berdejo-Espinola et al., 2021 and Wortzel et al., 2021). However, COVID-19 restrictions could disrupt human-nature interactions by limiting opportunities, capability, and motivation to connect with nature (Soga et al., 2020, 2021). Considering the well-documented benefits of various forms of nature engagement before the pandemic – for example, visual contact with real flowers, green plants, and wooden materials had positive effects on cerebral and autonomic nervous activities (Miyazaki et al., 2019) and at least two hours in nature significantly greater health and well-being (White et al., 2019), the question of interest is how various levels of engagement with nature can be enhanced during this challenging period, whether through viewing nature, functional engagement or incidental exposure, and active participation through either visits to nature and green spaces or involvement in a nature-based activity, such as gardening (Barton and Pretty, 2010).

Gardening can be an important nature-based activity that continues to provide connection to nature with mental well-being benefits during the COVID-19 pandemic. First, gardening is a low-cost activity that is affordable to most people across social and economic spectra in the community. Second, it can be readily performed outdoors or indoors – during times of home confinement or restricted activities in curbing the spread of COVID-19, gardening can be performed individually or in small groups. Third and more importantly, it has been demonstrated to provide a wide range of health benefits. A meta-analysis of studies in temperate environments showed that gardening can reduce depression, anxiety and body mass index, and increase life satisfaction, quality of life, as well as sense of community (Soga et al., 2017). Likewise, a more recent meta-analysis, which included seven studies with a total of 22 effect sizes, indicated a positive and moderate effect of horticultural or gardening interventions on psychosocial well-being (Spano et al., 2020). The benefits of gardening on mental well-being could be attributed, in part, to the sense of satisfaction and accomplishment that one gets from planning, planting and harvesting a garden, and sustained engagement with nature that can focus one's attention away from the stresses around us (Kaplan, 1973; Kaplan and Kaplan, 1989). Corroborating this, Wood et al. (2016) had reported improved self-esteem, mood, and general health with less depression and fatigue, among allotment gardeners in north-western England, regardless of the time spent or tenure in allotment gardening. Gardening could also provide a form of physical exercise, especially for the aged, with two to three times a week found to correspond with greatest perceived health benefits (de Bell et al., 2020; Chalmin-Pui et al., 2021). More recently, the general well-being benefits of gardening have also been documented in Singapore (Koay and Dillion, 2020, Ng et al., 2018; Sia and Diehl, 2020). Sia et al. (2020) reported that participants showed reduced anxiety after engagement in a 24-session gardening or therapeutic horticulture programme, thereby suggesting that the activity contributed towards emotional regulation, which could in turn increase mental resilience. Likewise, during the current pandemic, gardening was shown to be associated with lower psychopathological distress (Theodorou et al., 2021), and home gardens could in fact, be more effective than public parks and green views in reducing mental distress (Marques et al., 2021). A study in Scotland also

showed that higher frequency of garden usage during the pandemic lockdown was associated with better self-rated physical health, emotional and mental health, sleep quality in older adults (Corley et al., 2021).

Gardening, arguably the most popular hobby in the world, thus has important health benefits that are only beginning to be demonstrated. In linking gardening to individual health, a key question that remains unanswered is whether gardening also improves mental resilience. This has important implication on how urban populations can live with COVID-19 in the long-run, given that the pandemic is likely to become an endemic disease for the foreseeable future. While Aerts et al. (2021) suggested that exposure to green spaces can strengthen resilience to support mental health, there is little empirical evidence that we are aware of that links mental resilience to green space exposure. In this study, we focused on gardening as a level of green space exposure and used two data sets collected in Singapore to assess the relationship between gardening and mental resilience.

1.1. The Singapore context

Singapore stands out in the world as a highly green city among high-density cities (Tan et al., 2013). As one of the most densely populated country in the world, it is at high risk of an uncontrollable pandemic outbreak. It has, however, developed healthcare and surveillance systems for pandemic preparedness responses, based on its experience with the severe acute respiratory syndrome (SARS) outbreak in 2003 (Yip et al., 2021). The COVID-19 pandemic response of Singapore has been regarded as a successful model framework (Kuguyo et al., 2020). As of 30th August 2021, the country reported 55 fatalities, 1,157 active cases and 66,092 fully recovered cases, with a vaccination rate of 80 % (<https://www.moh.gov.sg/covid-19/statistics>).

A crucial action taken by Singapore in the handling of the pandemic was the passing of the COVID-19 (Temporary Measures) Act 2020. The Act introduces restrictions to social activities as needed and sets out alternative arrangements for the conduct of corporate meetings to limit physical interactions. There were several periods in both 2020 and 2021 when working from home was the arrangement by default, in conjunction with several other movement restrictions. Before the pandemic, local festivals happened on a near-monthly basis and residents had high overseas travel mobility, for instance it recorded an average of 3.51 overseas trips per person in 2017 (Hirschmann, 2021). Therefore, these “confining measures” have altered the societal norm and conditions of Singaporeans' daily lives considerably. Lower number of social interactions reduces stimulations and choices along the dimensions of life, which may have a detrimental effect on mental health (Stier et al., 2021). As a result, the feeling of loneliness may be elevated, which researchers regarded as a critical public mental health concern in the era of COVID-19 (Killgore et al., 2020). A preliminary study in Singapore, which found 13 percent of its participants reporting symptoms of anxiety or depression, suggested that there was a likely increase in mental health issues amid Covid-19 (Goh, 2021). This points to the importance of mental resilience in coping with the disruptions in lifestyle brought about by COVID-19. For instance, Song et al. (2021) found that respondents with high level of mental resilience and active coping styles were more likely to experience lower levels of depression and anxiety during the outbreak of COVID-19. In this regard, initiatives such as community programmes that enhance individuals' mental resilience could be beneficial.

During the current pandemic, home gardening bloomed around the world (Timmins, 2020; Walljasper and Polansek, 2020). Strong cross-country interest in gardening was reported as lockdowns became more widespread (Lin et al., 2021). Likewise, plant retail centres in Singapore reported an anecdotal increase in plant sales and Instagram posts related to home gardening saw many-fold increase in the number of followers (Lee, 2020). Home gardening was not a widespread activity among the general population in Singapore due to their busy lifestyles

(Newstex, 2014). This change was likely attributed to more people picking up gardening as a hobby to keep themselves occupied, while being “confined”. A related initiative, the “Gardening with Edibles” programme, was launched in June 2020 during the COVID-19 pandemic by the National Parks Board (NParks), the national government agency responsible for nature conservation, veterinary care, and greenery and recreation in the city-state. The programme aimed to encourage the public to grow edible plants at home, to bring forth the benefits of health and well-being. Members of public who registered interest on NParks’ website (<https://www.nparks.gov.sg/gardening/gardening-with-edibles>) during the specified timeframe would receive free packets of leafy and fruited vegetable seeds. In conjunction with the seed distribution, NParks also provided a series of useful online resources and organised webinars on gardening.

The programme attracted participants who were interested in gardening, some of whom provided email addresses and consent to be contacted for future surveys. This database of edible gardening registrants provided an opportunity to assess the possible effects of gardening on mental resilience, which was undertaken through an online survey. Next, we obtained mental resilience data from another large online community survey (see Methods). This allowed comparison of mental resilience scores of participants from the two surveys. The specific objectives were to assess: (1) if gardening showed increase mental resilience compared to the general community group; (2) if length of time spent in gardening activities influenced mental resilience; (3) the influence of different mental resilience constructs among gardeners; and (4) if socio-demographic variables like age and housing type influenced the relationship between gardening and mental resilience.

2. Methods

2.1. Gardening with edibles survey

The “Gardening with Edibles” programme, launched in June 2020, was broadcasted nationally across the local news media (Goh, 2020). Any resident in Singapore who was interested in receiving seed packets to grow edible plants at home could register by providing their email contact details on the NParks website. The programme attracted 324,

000 registrants, of which 42,678 consented to be contacted for future surveys. The latter, comprising residents with interest in gardening, formed the target population of the Gardening with Edibles survey recruited through convenience sampling. The survey questionnaire was finalised after discussions with researchers from the Mind Science Centre who developed the mental resilience questions (Table 1). The usability and technical functionality of the electronic questionnaire was tested on a group of ten NParks’ staff and friends before fielding the questionnaire between May and June 2021, when an email was sent to the target population with a secured link to the online survey. Invitees were informed that the purpose of the survey was to assess the Gardening with Edibles initiative, and that participation was optional. The survey was conducted following the ESOMAR Guideline for Social Research (<http://www.mrssingapore.org.sg/standards-overview/standards-code-of-professional-behaviour/>) where respondents were assured that confidentiality of data will be maintained by de-linking identifying information from the survey data and provided the link (<https://www.nparks.gov.sg/privacy-statement>) which contained details on NParks’ data protection policy. By completing the survey, respondents consented to NParks collecting and using the information for the study, and no further incentives were given. The survey was hosted on a government online platform and all responses were encrypted end-to-end and accessible only by the research team. There was neither follow-up e-mail nor reinforcements after the link was sent. The survey was closed after one month. The response rate of the survey was about 20 percent, with a total of 8,786 returns. Of the returned responses, 64 respondents (0.7 %) indicated that they did not engage in gardening and 3,081 respondents (35.1 %) did not complete the questions on the Mental Resilience Scale. Hence, only 5,705 respondents could be included in this study. Of these respondents, another 44 were excluded as they did not engage in gardening. This resulted in a remaining 5,661 respondents who are designated as the “Gardening group” in this study.

2.2. Online survey on respondents interested in Covid-19 related community care

The online survey was conducted jointly by the Mind Science Centre and the Community Care Buddy. The former is an academic centre for

Table 1
Questions in Gardening with Edibles Survey.

The current pandemic has affected our lives and resulted in some changes in our routines. On the bright side, we are spending more time with our family and engaging in activities such as gardening. As research has shown that participating in gardening enhances our mental wellbeing and emotional resilience, we would like to understand how you, as our participant of the Growing with Edibles programme, are coping during this period. The set of statements below, adapted from the Singapore Mental Health Resilience survey, is a simple scale that assesses your level of resilience. Please select the option which best describes how much you agree or disagree with each statement. (Please be assured that your answers will be kept confidential.)

Statement	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
1 I am able to handle unpleasant emotions, like sadness, fear and anger.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
2 I stay calm in difficult circumstances.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
3 My religious or moral beliefs give me strength and courage for my life.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
4 I believe my life has a meaning and purpose.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
5 My family understands how I feel.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
6 I am confident that I can solve problems in life.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
7 I can find humor in difficult situations.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
8 The problems I have are caused by other people.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
9 In most situations I worry that something bad will happen to me or those I love.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
10 I do not keep thinking about things I cannot change.	<input type="checkbox"/>	Always	<input type="checkbox"/>	Most of the time	<input type="checkbox"/>	About half the time	<input type="checkbox"/>	Sometimes	<input type="checkbox"/>	Never
11 How much time do you spend in a week on gardening?	<input type="checkbox"/>	< 1 h	<input type="checkbox"/>	1 to 4 h	<input type="checkbox"/>	> 8 h				
	<input type="checkbox"/>	4 to 8 h	<input type="checkbox"/>							
	<input type="checkbox"/>	N.A. I do not garden								
12 Email _____										
13 Place of residence	<input type="checkbox"/>	Public apartment (HDB housing)	<input type="checkbox"/>	Under 18	<input type="checkbox"/>	45 – 54				
	<input type="checkbox"/>	Private apartment (Condominium etc.)	<input type="checkbox"/>	18 – 24	<input type="checkbox"/>	55 – 64				
	<input type="checkbox"/>	Landed housing	<input type="checkbox"/>	25 – 34	<input type="checkbox"/>	65 – 74				
			<input type="checkbox"/>	35 – 44	<input type="checkbox"/>	>74				

psychological research, education, and service with an emphasis on non-drug approach, under the National University Health System of Singapore, whereas the latter is a non-profit organization. The survey was hosted on the “I am a Community Care Buddy” website (<https://iamaccb.sg/all-things-ccb/>) between 20th May 2020 to 3rd June 2020. The website provided content about mental wellness during the pandemic. Information on the survey was broadcasted nationally across the local news media through a joint press release, and disseminated to 3,256 respondents who had previously registered with the website to receive information on Covid-19 related community care. Any member of the public who visited the website during the period could take part in the online survey. The survey questionnaire, designed and tested by researchers from the Mind Science Centre, is described in the next section. A total of 1,849 responses was received and the participants, comprising members of the public from the general community, formed the Community group recruited through convenience sampling.

2.3. Outcome measure

The outcome measure was a set of ten questions adapted from the validated Singapore Youth Resilience Scale (SYRSS), developed previously for the Singapore population and tested for internal consistency and convergent validity with the Connor-Davidson Resilience Scale, World Health Organisation Quality of Life (WHOQOL-BREF) and the General Health Questionnaire (GHQ-28) (Lim et al., 2011). The ten items selected corresponded to seven resilience factors, “emotional regulation”, “spirituality”, “relationship”, “confidence”, “positive thinking”, “control” and “flexibility” (Table 2). The SYRSS has a total of 50 items, but the items on “commitment” and “positive self-image”, which target youths, were not included in the current study. The 10-item mental resilience questions had good internal consistency, with Cronbach’s alpha of 0.78 for the Gardening group and 0.81 for the Community group. The overall mental resilience score was computed by adding the scores in all the ten questions, and higher scores suggest higher mental resilience.

2.4. Statistical analyses

Non-parametric tests were used in the analyses as the distributions of the Gardening and Community groups were not normal, based on the Shapiro-Wilk’s test ($p < 0.05$). All analyses were performed using IBM SPSS Statistics version 27. Alpha level of 0.05 was used as a level of statistical significance.

We used the Kruskal-Wallis H test, followed by pairwise Dunn’s procedure of pairwise comparison with a Bonferroni adjustment to examine the effect of age on mental resilience in both groups. Then, we compared mental resilience scores between the Gardening group and Community group across age categories, using Mann-Whitney U test. We

Table 2
Mental Resilience statements and corresponding resilience factors.

Questions	Resilience Factor
1 I am able to handle unpleasant emotions, like sadness, fear and anger.	Emotional Regulation
2 I stay calm in difficult circumstances.	Emotional Regulation
3 My religious or moral beliefs give me strength and courage for my life.	Spirituality
4 I believe my life has a meaning and purpose.	Spirituality
5 My family understands how I feel.	Relationship/Social Support
6 I am confident that I can solve problems in life.	Confidence
7 I can find humor in difficult situations.	Positive Thinking
8 The problems I have are caused by other people.*	Control
9 In most situations I worry that something bad will happen to me or those I love.*	Control
10 I do not keep thinking about things I cannot change.	Flexibility

* Reverse scoring.

repeated the Kruskal-Wallis H test within the Gardening group, to examine the effects of age and housing type on gardening time.

Participants within the Gardening group were classified into four sub-groups based on their weekly gardening time, i.e., “< 1 h”, “1–4 h”, “4–8 h” and “> 8 h”. Quade’s rank analysis of covariance was used to determine if there were any significant differences in mental resilience scores across the four sub-groups with different weekly gardening time, controlling for age and housing type. Here, we first ranked all cases on mental resilience scores and covariates and ran a linear regression of the resulting ranks to obtain the unstandardized residuals. This is followed by a one-way analysis of variance (ANOVA), using the residuals. We reported Welch and Games-Howell test statistics, as equal variances were not assumed. Finally, we repeated the Quade’s rank analysis of covariance on the seven individual mental resilience factors across the four sub-groups with different weekly gardening time. Additionally, a Spearman’s rank-order correlation was run to assess the relationship between the resilience factors and weekly gardening time.

3. Results

3.1. Descriptives of respondents

The median age of the respondents in the Gardening Group was between 45–54 years. In comparison, the median age for the Community Group, was younger, 25–34 years. The distribution of respondents by housing type within the Gardening Group was 63.6 % public apartment, 22.6 % private apartment and 13.9 % landed housing. This followed the national distribution trend on housing types, which was 78.6 % public apartment, 16.2 % private apartment and 5.0 % landed housing. Information on housing type was not available for the Community Group. Within the Gardening Group, majority (52.39 %) indicated that they spent 1–4 h each week on gardening activities. The characteristics of the respondents in the two groups are summarised in Table 3.

3.2. Effect of age on mental resilience

Within the Gardening group, mental resilience scores differed significantly among the age categories, $H^2(6) = 114.546$, $p < 0.001$. Post hoc analysis showed that the scores of those aged >55 years (i.e.,

Table 3
Characteristics of all respondents.

	Frequency	Percent	Frequency	Percent
	Gardening group		Community Group	
Age Group				
< 24 years	166	2.93	280	15.14
25 to 34 years	712	12.58	648	35.05
35 to 44 years	1550	27.38	455	24.61
45 to 54 years	1527	26.97	317	17.14
55 to 64 years	1172	20.70	106	5.73
65 to 74 years	475	8.39	37	2.00
> 74 years	59	1.04	6	0.32
Median Age Group	45 to 54 years		25 to 34 years	
Housing Type				
Public apartment	3606	63.60	–	–
Private apartment	1278	22.50	–	–
Landed housing	787	13.90	–	–
Weekly Gardening Time				
Less than 1 hour	1397	24.68	–	–
1 to 4 hours	2966	52.39	–	–
4 to 8 hours	872	15.40	–	–
More than 8 hours	426	7.53	–	–

Notes: NA denotes Not Available (information on Housing Type and Weekly Gardening Time was not available for the Community group).

“55–64 years”, “65–74 years” and “>74 years”) had significantly higher scores than those aged <35 years (i.e., “25–34 years” and “<24 years”). Those “45–54 years” and “35–44 years” had significantly higher scores than the younger groups (i.e., “25–34 years” and “<24 years”) (Table 4, Fig. 1). Similarly, within the Community group, mental resilience scores were also significantly different among the age categories, $H^2(6) = 76.181$, $p < 0.001$. Post hoc analysis showed that the scores for “55–64 years”, “65–74 years” were significantly higher than those <35 years (i.e., “25–34 years” and “<24 years”). Those “45–54 years” and “35–44 years” had significantly higher scores than the younger groups (i.e., “25–34 years” and “<24 years”). There were no significant differences between “>74 years” and any other groups (Table 5, Fig. 2).

3.3. Difference in mental resilience scores between Gardening and Community groups

As the median ages of the two groups were different, comparative analysis was conducted across different age groups, rather than using the means of the two study populations. Results of the Mann-Whitney u test showed that mental resilience scores for the Gardening group were significantly higher, compared to the Community group, across all age categories. The largest differences were found in “25–34 years”, “35–44 years” and “>74 years”, as evidenced by the relatively larger effect sizes of 0.44, 0.34 and 0.39, respectively (Table 6).

3.4. Effects of age on weekly gardening time

Within the Gardening group, weekly gardening time differed significantly among the age categories, $H2(7) = 175.038$, $p < 0.001$. Post hoc analysis showed that those aged >55 years (i.e., “55–64 years”, “65–74 years” and “>74 years”) spent significantly more time gardening each week than the younger groups (i.e., “35–44 years”, “25–34 years” and “<24 years”). Those aged >65 years (i.e., “65–74 years” and “>74 years”) spent significantly more time gardening each week than those aged 55–64 years (Table 7).

Table 4
Comparison of Median Mental Resilience scores by Age categories in Gardening group (Kruskal-Wallis H test).

	Mean	Median	MD	Test Statistic	Asymptotic Sig. (2-sided test)
Gardening group				114.456 ^a	<0.001
< 24 years	34.39	35.00			
25–34 years	36.63	37.00			
35–44 years	37.33	38.00			
45–54 years	37.62	38.00			
55–64 years	38.21	39.00			
65–74 years	38.46	39.00			
>74 years	39.53	41.00			
Subgroup 1 - Subgroup 2					
">74" - "35–44" years			2.20*	728.490	0.016
">74" - "25–34" years			2.90*	956.677	<0.001
">74" - "<24" years			5.13*	1534.137	<0.001
"65–74" - "35–44" years			1.14*	347.390	0.001
"65–74" - "25–34" years			1.84*	575.577	<0.001
"65–74" - "<24" years			4.07*	1153.037	<0.001
"55–64" - "35–44" years			0.88*	260.559	0.001
"55–64" - "25–34" years			1.58*	488.746	<0.001
"55–64" - "<24" years			3.82*	1066.206	<0.001
"45–54" - "25–34" years			1.00*	334.386	<0.001
"45–54" - "<24" years			3.23*	911.846	<0.001
"35–44" - "25–35" years			0.70*	228.187	0.042
"35–44" - "<24" years			2.93*	805.647	<0.001
"25–34" - "<24" years			2.23*	577.460	0.001

Note: MD denotes Mean Difference. Only pairwise comparisons with significance are shown.

^a The test statistic is adjusted for ties.

3.5. Effects of housing type on weekly gardening time

Within the Gardening group, weekly gardening time differed significantly among the housing types, $H2(2) = 108.531$, $p < 0.001$. Post hoc analysis showed that those residing in landed housing spent significantly more time gardening each week than those residing in public and private apartments (Table 8).

3.6. Effects of weekly gardening time on mental resilience

Quade’s rank analysis of covariance, controlling for age and housing type, was run within the Gardening group to assess the differences among the four sub-groups with different weekly gardening time. The results showed that length of weekly gardening time had significant effects on mental resilience scores (Welch’s $F(3, 1507.654) = 16.072$, $p < 0.001$). Post hoc analysis showed that those with “<1 h” weekly gardening time had significantly lower scores than all other three groups with more weekly gardening time. The sub-group with “1–4 h” weekly gardening time was significantly lower than “> 8 h”, but no difference was found with “4–8 h”. There was also no significant difference found between “4–8 h” and “>8 h” (Table 9).

3.7. Effects of weekly gardening time on mental resilience factors

Similar analysis on the individual resilience factors showed that weekly gardening time had significant effect on “emotional regulation”, “spirituality”, “relationship”, “confidence” and “positive thinking”, but not on “control” and “flexibility”. Post hoc analysis on these factors showed that the mean scores were significantly lower in the sub-group with the least weekly gardening time of “< 1 h”, than all the other sub-groups with more gardening time. For “relationship”, the mean score was also significantly lower in the sub-group “1–4 h”, compared with the sub-groups with more gardening time. On the other hand, for “positive thinking”, scores for “<1 h” was only significantly lower than “4–8 h” and “>8 h”, but not “1–4 h” (Table 10). The Spearman’s rank-order correlation analysis showed that there were statistically significant, positive correlations between weekly gardening time and all the resilience factors, except for “control” (Table 11).

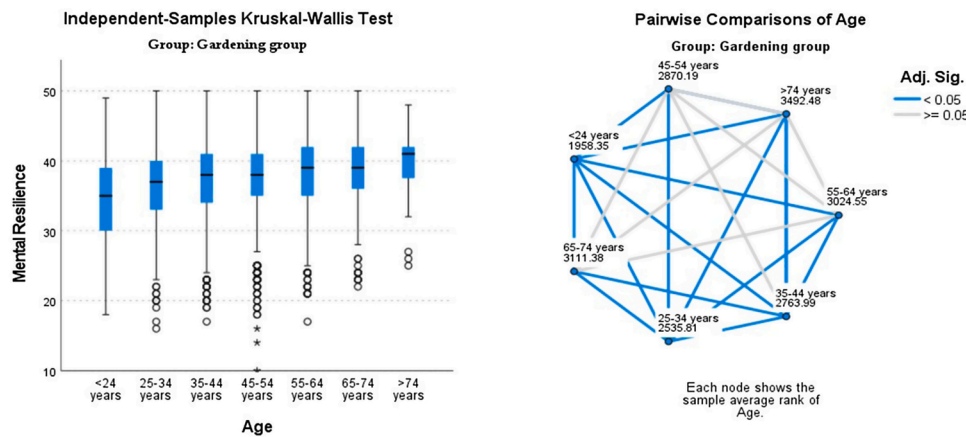


Fig. 1. Mental Resilience scores by Age Categories in Gardening group. Box plots (left), Pairwise comparisons (right).

Table 5
Comparison of Median Mental Resilience scores by Age categories in Community group (Kruskal-Wallis H test).

	Mean	Median	MD	Test Statistic	Asymptotic Sig. (2-sided test)
Community group				76.181 ^a	<0.001
< 24 years	30.43	30.00			
25–34 years	31.21	31.00			
35–44 years	32.11	32.00			
45–54 years	33.14	33.00			
55–64 years	33.14	36.00			
65–74 years	36.41	35.00			
>74 years	30.17	30.50			
Subgroup 1 - Subgroup 2					
"65–74" - "35–44" years			4.30*	329.634	0.006
"65–74" - "25–34" years			5.19*	406.978	<0.001
"65–74" - "<24" years			5.98*	476.270	<0.001
"55–64" - "35–44" years			1.03*	237.916	0.001
"55–64" - "25–34" years			1.93*	315.260	<0.001
"55–64" - "<24" years			2.71*	384.552	<0.001
"45–54" - "25–34" years			1.93*	158.996	<0.001
"45–54" - "<24" years			2.71*	228.289	<0.001
"35–44" - "<24" years			1.68*	146.637	0.006

Note: MD denotes Mean Difference. Only pairwise comparisons with significance are shown. The test statistic is adjusted for ties.

3.8. Effect of housing type on mental resilience

Analysis showed that mental resilience scores were significantly different among housing types, $H^2(2) = 56.611, p < 0.001$. Post hoc analysis showed that those living in “public apartment” had significantly lower score than those living in “private apartment” and “landed housing”. There was no significant difference between those living in “private apartment” in comparison with “landed housing” (Table 12).

4. Discussion

The World Health Organisation defines well-being as “the state in which an individual realises his or her own abilities, can cope with normal stresses of life, can work productively, and is able to make a contribution to his or her own community”. Mental resilience and well-being are very much inter-related, as evidenced by a recent study which found that resilience, a developmental characteristic that can be enhanced through interventions, played a buffering role in the mental health and perceived stress on Slovene adults at the beginning of the COVID-19 outbreak (Kavčič et al., 2021). Another study on respondents

from nine countries also found that psychological resilience was an important factor that predicted the likelihood of showing symptoms of depression and/or anxiety during the pandemic (Pouso et al., 2021). Earlier studies had focused on the positive relationship between gardening and mental well-being (Koay and Dillon, 2020; Sia et al., 2020; de Bell et al., 2020; Chalmin-Pui et al., 2021), with limited evidence on the role of gardening on mental resilience. This present study provides preliminary evidence on the positive association between gardening and mental resilience in Singapore.

It is generally acknowledged that the COVID-19 pandemic has impacted the lifestyles of people across the world significantly, and for a prolonged period. Like other cities, Singapore’s various safe management measures to curb the spread of the disease, while being relatively successful, may have some adverse effect on the mental well-being of people. Gardening is a cost-effective activity and brings multiple benefits, ranging from increasing physical activity to improving mental well-being through the nurturing of plants. The Gardening with Edibles initiative involves the distribution of free seeds and provision of online resources on home gardening. Among those who responded in the survey, majority (99.23 %) indicated that they engaged in weekly gardening activities after receiving the seeds, showing that the programme has increased interest in gardening.

Analysis of mental resilience scores across age categories within the Community and Gardening groups showed that older participants in the age categories “55–64 years” and “65–74 years” had higher mental resilience than those in the younger age categories. This is consistent with a previous study which found that younger people had higher odds of depression and anxiety symptoms than older people during the pandemic, despite being less severely hit by the disease, with generally milder physical symptoms (Pouso et al., 2021). This could be partly attributed to older individuals having greater mental resilience to begin with, hence they are better able to regulate their emotions and find solutions to their problems (Gooding et al., 2012). Interestingly, participants “>74 years” in the Gardening group also had significantly higher mental resilience than the younger participants, in contrast with the trend in the Community group which showed a decline in mental resilience for those in the “>74 years” age category. From our analysis of the Gardening group, we found that those “>74 years” spent significantly more time gardening each week than those who were younger. This suggested that gardening may be an activity that promotes mental resilience in seniors who are advanced in age.

Chalmin-Pui et al. (2021) found that perceived stress was significantly lower for individuals in the United Kingdom living in semi-detached or detached houses, compared to those living in flats. We had consistent findings in the present study – mental resilience scores and gardening time were lower in participants living in public

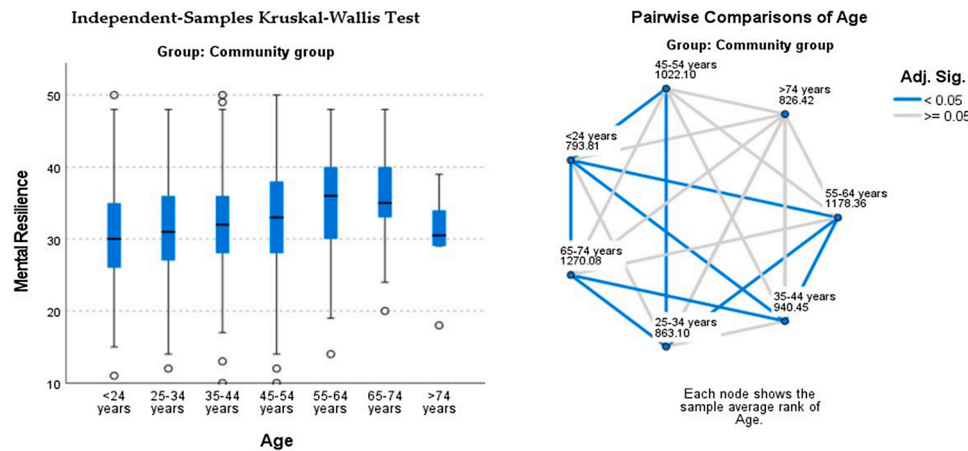


Fig. 2. Mental Resilience scores by Age Categories in Community group. Box plots (left), Pairwise comparisons (right).

Table 6 Comparison of Mental Resilience scores between Gardening and Community groups (Mann-Whitney U test).

	Median		Test statistic	Standardized Test statistic	Asymptotic Sig. (2-sided test)	Effect Size
	Gardening group	Community group				
< 24 years	35.00	30.00	15095.00	-6.197	<0.001	0.29
25-34 years	37.00	31.00	114336.50	-16.103	<0.001	0.44
35-44 years	38.00	32.00	186137.00	-15.354	<0.001	0.34
45-54 years	38.00	33.00	147286.50	-11.001	<0.001	0.26
55-64 years	39.00	36.00	44662.50	-4.805	<0.001	0.13
65-74 years	39.00	35.00	6715.50	-2.396	0.017	0.11
>74 years	41.00	30.50	38.00	-3.164	0.002	0.39

Notes. The significance level is 0.050 and asymptotic significance is displayed.

Table 7 Comparison of Weekly Gardening Time by Age categories (Kruskal-Wallis H test).

	Test Statistic	Standardised Test statistic	Adj. Sig. ^b
Subgroup 1 - Subgroup 2	175.038 ^a		<0.001 ^c
"<24" - "55 to 64" years	-441.51	-3.22	0.027
"<24" - "65 to 74" years	-851.71	-5.79	<0.001
"<24" - ">74" years	-1373.10	-5.89	<0.001
"25 to 34" - "45 to 54" years	-208.86	-3.10	0.041
"25 to 34" - "55 to 64" years	-474.85	-6.73	<0.001
"25 to 34" - "65 to 74" years	-885.04	-10.06	<0.001
"25 to 34" - ">74" years	-1406.44	-6.99	<0.001
"35 to 44" - "55 to 64" years	-314.35	-5.47	<0.001
"35 to 44" - "65 to 74" years	-724.55	-9.30	<0.001
"35 to 44" - ">74" years	-1245.94	-6.32	<0.001
"45 to 54" - "55 to 64" years	-265.98	-4.61	<0.001
"45 to 54" - "65 to 74" years	-676.18	-8.66	<0.001
"45 to 54" - ">74" years	-1197.57	-6.08	<0.001
"55 to 64" - "65 to 74" years	-410.20	-5.08	<0.001
"55 to 64" - ">74" years	-931.59	-4.70	<0.001

Note: Only pairwise comparisons with significance are shown.

- ^a The test statistic is adjusted for ties.
- ^b Significance values have been adjusted by the Bonferroni correction for multiple tests.
- ^c Asymptotic Sig.(2-sided test).

apartments. This reflects the quantum of space for gardening as landed housing and private apartments typically correspond with the presence of outdoor gardens and balconies in Singapore respectively. While some public apartments do have balconies, most public apartments have limited gardening space with the corridors linking the apartment units serving partially for gardening. A potential implication of this finding is

Table 8 Comparison of Weekly Gardening Time by Housing Type (Kruskal-Wallis H test).

	Test Statistic	Standardised Test statistic	Adj. Sig. ^b
Subgroup 1 - Subgroup 2	108.531 ^a		<0.001 ^c
"Public apartment" - "Landed housing"	-611.65	-10.38	<0.001
"Private apartment" - "Landed housing"	-542.01	-7.99	<0.001
"Public apartment" - "Private apartment"	-69.64	-1.43	0.458

Note: Only pairwise comparisons with significance are shown.

- ^a The test statistic is adjusted for ties.
- ^b Significance values have been adjusted by the Bonferroni correction for multiple tests.
- ^c Asymptotic Sig.(2-sided test).

Table 9 Comparison of Mental Resilience scores (Unstandardized Residual) by Weekly Gardening time, with Age category and Housing type as covariates (Quade's rank analysis of covariance and Games-Howell post hoc tests).

Gardening Time	Pairwise Comparison	Mean Difference	F	Sig.
			16.072	<0.001
< 1 h	1-4 h	-0.937 [*]		0.001
	4-8 h	-1.307 [*]		0.006
	>8 h	-1.774 [*]		0.001
1-4 h	4-8 h	0.37		0.999
4-8 h	>8 h	-0.837		0.499
>8 h	>8 h	-0.47		0.820

* The mean difference is significant at the 0.05 level.

Table 10
Comparison of Resilience factors (Unstandardized Residual) by Weekly gardening time, with Age category and Housing type as covariates (Quade’s rank analysis of covariance and Games-Howell post hoc tests).

Factor	Gardening Time	Pairwise Comparison	Mean Difference	F	Sig.		
Emotional Regulation	< 1 h	1–4 h	−0.086*	7.579*	<0.001		
		4–8 h	−0.120		0.002		
		>8 h	0.177*		<0.001		
	1–4 h	4–8 h	−0.034		0.660		
		>8 h	−0.091		0.118		
		>8 h	−0.057		0.605		
	Spirituality	< 1 h	1–4 h		−0.106*	9.641*	<0.001
			4–8 h		−0.161*		<0.001
			>8 h		−0.212*		<0.001
1–4 h		4–8 h	−0.056	0.306			
		>8 h	−0.106	0.005			
		>8 h	−0.050	0.712			
Relationship		< 1 h	1–4 h	−0.188*	21.670*		<0.001
			4–8 h	−0.304*			<0.001
			>8 h	−0.349*			<0.001
	1–4 h	4–8 h	−0.116*	0.008			
		>8 h	−0.161*	0.011			
		>8 h	−0.045	0.867			
	Confidence	< 1 h	1–4 h	−0.121*		9.298*	<0.001
			4–8 h	−0.129*			0.002
			>8 h	−0.199*			<0.001
1–4 h		4–8 h	−0.007	0.995			
		>8 h	−0.078	0.255			
		>8 h	−118.932	0.994			
Positive Thinking		< 1 h	1–4 h	−0.087	5.419*		0.001
			4–8 h	−0.135*			0.051
			>8 h	0.197*			0.011
	1–4 h	4–8 h	−0.048	0.003			
		>8 h	−0.110	0.595			
		>8 h	−0.062	0.163			
	Control	< 1 h	1–4 h	−0.053		1.495	0.729
			4–8 h	−0.037			0.214
			>8 h	−0.070			0.508
1–4 h		4–8 h	−0.017	0.747			
		>8 h	−0.017	0.438			
		>8 h	−0.034	0.956			
Flexibility		< 1 h	1–4 h	−0.050	1.946		0.981
			4–8 h	−0.103			0.908
			>8 h	−0.111			0.120
	1–4 h	4–8 h	−0.053	0.508			
		>8 h	−0.060	0.152			
		>8 h	−0.008	0.302			

Covariates appearing in the model are Age Group and Housing Type.

* Denotes statistical significance.

for city planners to review structural provisions to capitalize on the current interest in gardening, as we enter a future with potentially more pandemics and other public health crises (Lin et al., 2021), to provide diverse gardening space in housing, regardless of floor area, consistent with the recommendation by other researchers, for instance, by Kim and Ohara (2010). This is also aligned with the concerted effort to optimise green spaces for community and allotment gardens within the public housing estates in Singapore (Er et al., 2016).

Interestingly, a previous study in the Netherlands found that people

Table 11
Correlation of Weekly Gardening Time and Mental Resilience factors (Spearman Rank-order).

	Spearman’s rho	Sig. (2-tailed)
Mental Resilience	0.084*	<0.001
Factors		
Emotional Regulation	0.067*	<0.001
Spirituality	0.059*	<0.001
Relationship	0.105*	<0.001
Confidence	0.065*	<0.001
Positive Thinking	0.051*	<0.001
Control	0.024	0.071
Flexibility	0.035*	0.009

* Correlation is significant at the 0.01 level (2-tailed).

who were between 45 and 54 years old and residing with surrounding green spaces had worse mental health, and this was explained by the fact that people in this age group, while having the means to buy a house in a green area, lack the opportunity to make use of the green space because of a busy job and family life (Bos et al., 2016). Our study shows that gardening associates positively with increased mental resilience. The positive trend is consistent across all age categories, including those between 45 and 54 years old, validating the importance of active forms of engagement with nature. Higher mental resilience translates to the ability to better cope with stress during challenging times (De Terte and Stephens, 2014). Findings from the present study also corroborates with the study by Theodorou et al. (2021) reporting the effects of gardening in lowering psychopathological distress through decreased COVID-19 related distress.

Our results further showed that mental resilience and several resilience factors peaked at a weekly gardening time of between 1–4 h. Several other studies have also investigated the efficacy of the varying doses of nature and well-being. A recent study on the benefits of gardening during COVID-19 pandemic found that a gardening frequency of at least 2–3 times a week corresponded with perceived health benefits (Chalmin-Pui et al., 2021), although Wood et al. (2016) did not report any difference in time spent or tenure of allotment gardening on improving self-esteem and mood of gardeners. Other studies, not specifically targeted at gardening, also provided similar evidence of varying doses of exposure to nature. For example, White et al. (2019) showed that a weekly dose of at least two hours in nature promotes well-being outcomes, while Shanahan et al. (2016) reported that visits to outdoor green spaces for 30 min. or more a week could reduce the population prevalence of depression and high blood pressure by up to 7% and 9% respectively.

How might gardening contribute towards increased mental resilience? In this study, we found that there were significant correlations with “relationship”, “emotional regulation”, “confidence”, “spirituality” and “positive thinking”, with “relationship” and “emotional regulation” having the strongest effects. This could be attributed to several reasons. First, gardening has been shown to sustain engagement with nature, thereby bringing about attention restoration and reduced stress levels (Kapan, 1973; Kaplan and Kaplan, 1989). Ng et al. (2018), in their study on effects of therapeutic horticulture, a form of gardening, on older adults found a reduction in interleukin-6, a cytokine associated with depression, in participants, further validating the restorative benefits of the activity. This can translate to reduction in anxiety and improved cognitive functioning, thereby better emotional regulation (Wood et al., 2016; Soga et al., 2017; Sia et al., 2020), a protective factor in times of stress (Troy and Mauss, 2011). Second, the connection with nature through gardening at home (in the balcony or home garden) or in an allotment plot can help to counter the temporary loss of human-nature interactions, i.e. “extinction of experience” (Soga and Gaston, 2016) during periods of home confinement and restriction of activities. The act of gardening provides a welcomed break or “being away” from the routine of desk-bound working from home and when outdoor activities

Table 12
Comparison of Median Mental Resilience scores by Housing Type within Gardening group (Kruskal-Wallis H test).

	Mean	Median	Sample1-Sample 2	Test statistic	Standardized Test statistic	Asymptotic Sig. (2-sided test)
Gardening group				56.61		<0.001
Public apartment	37.1	38.00	Public apartment-Private apartment	-284.35	-5.353	0.000
Private apartment	38.1	39.00	Public apartment-Landed housing	-406.25	-6.322	0.000
Landed housing	38.4	39.00	Private apartment-Landed housing	-121.90	-1.648	0.298

are restricted. The activity offers cues that connect gardeners with their personal history and instil awe in the wonders of nature. Examples include witnessing the phenological cycles of plants from seed to flower and fruit, visits by pollinators like birds, bees and butterflies to flowers. These intimate gardener-nature interactions within an individual’s home can enhance positive identity to the garden and bring about a sense of spirituality (Bernardini and Irvine, 2007). Third, gardening promotes fascination, which in turn motivates the gardener to seek knowledge, exchange ideas and share one’s development progress in gardening (Kaplan, 1973). This, coupled with the sharing of fruits and produce from the garden with the family and friends, builds strong inter-personal relationships and bonds, leading to greater relationship (Soga et al., 2017). Pollard et al. (2018) also found that while it might not be apparent that home gardeners valued social connection, they were likely to participate in other avenues of relationship building, such as via social learning sources or by sharing food with others. It should be noted that this benefit would probably be more strongly manifested amongst community gardeners than individual gardeners (Koay and Dillon, 2020), as shown in a previous study where respondents who engaged in allotment gardening at a low frequency and short duration were found to report similar levels of health as those who did so regularly and for longer duration (Soga et al., 2017). Additionally, the satisfaction of seeing one’s garden take shape and the growth of the plants can instil confidence and positive thinking, thereby enhancing self-esteem (Wood et al., 2016; de Bell et al., 2020; Chalmin-Pui et al., 2021). Finally, gardening involves physical activity, and this may trigger the release of protective neurotrophic factors, giving rise to the positive outcomes observed. For example, a study by Park et al. (2020) showed that gardening intervention significantly increased levels of brain-derived neurotrophic factor (BDNF) in elderly participants after the activity. BDNF is a key protein that is upregulated after exercise and can promote cell proliferation. It may play a role in emotional regulation, since BDNF levels were found to be reduced in untreated patients with major depressive disorders, and restored with antidepressant treatment (Lee and Kim, 2010). These various pathways to mental resilience are summarised in Fig. 3.

However, gardening is not without uncertainties. The successful sowing of seeds and fruiting of edible plants in a garden are dependent on many other environmental factors such as weather and presence of pollinator and are not entirely within the gardener’s control. This may

be the reason why we did not find any association between gardening and the mental resilience factor of “control” and “flexibility”. While this may mirror the feeling of helplessness during the COVID-19 pandemic, it is compensated by the more significant positive effects of gardening on the other factors of mental resilience.

4.1. Limitations of study and future research

The study has several limitations. The mental resilience score of the Community group was derived from the online survey conducted by the Mind Science Centre. Online surveys have inherent biasedness (Greenacre, 2016), but the relatively large sample size of 1,849 increased the representativeness of the population. The response rate of the “Gardening with Edibles” survey was also relatively low. However, this is expected of online surveys, especially in consideration that no reminders were sent and there were no further incentives offered for survey participation. The comparison of the two surveys which were conducted one year apart was a study limitation, as time may have some effect on the outcome measured. However, this limitation was moderated by the fact that both surveys were conducted using the same methodology, convenience sampling and online, within the context of the same pandemic and government measures. The prolonged Covid-19 situation, evolution of more potent variants of the virus with increasing number of cases may not favour the mental resilience of the Gardening group (survey conducted one year later than the Community group). However, this may be compensated by the adaptation to the pandemic one year on. In addition, we applied nonparametric analysis methods, which do not make any assumptions of the distributions of the two groups under comparison, and characteristically have lower statistical power, to reduce the risk of drawing incorrect conclusions.

The study did not also consider efficacy of gardening compared with outdoor nature-based activities. This may be further examined. Future studies using within-subject design may be conducted to ascertain the pathways through which gardening promotes mental well-being and resilience and the effect sizes.

5. Conclusion

Singapore was not conceived to have a widespread home gardening culture due to space constraints in residences. There has, however, been a concerted effort over the years to optimise green spaces, including community and allotment gardens. With an anticipated increase in gardening interest and growing evidence of benefits of gardening, home gardening may be the alternative way for people to receive the associated benefits. This, coupled with the restrictions in activities during the Covid-19 pandemic, has given rise to initiatives such as the “Gardening with Edibles” programme to promote home gardening, and potentially build resilience into health and food systems in the light of future pandemics (Niala, 2020). This study is significant in providing the evidence that gardening may increase mental resilience through the pathways of fostering “emotional regulation”, “relationship”, “confidence”, “positive thinking” and “spirituality”, with an efficacious weekly dose of between 1–4 h. The findings may be potentially applicable to other tropical cities, as urbanites worldwide continue to find ways to cope mentally with the stressors of city living and the current Covid-19 pandemic, notwithstanding (Stier et al., 2021).

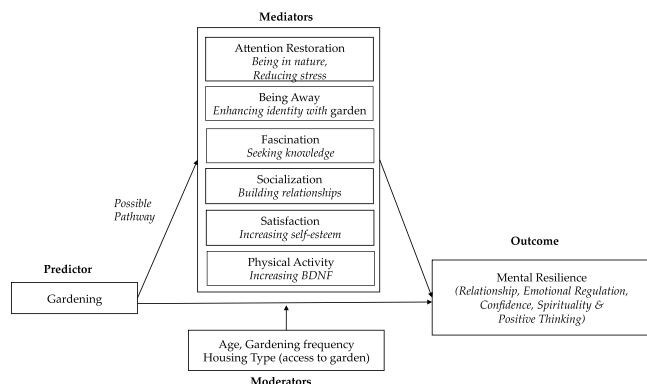


Fig. 3. Possible conceptual framework for association between gardening and mental resilience.

Author contributions

K.E., S.A. and A.S conceived and planned the study. A.S and A.W.F. carried out the survey. K.E., T. P. Y. and A.S. contributed to the interpretation of the results and took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Declaration of Competing Interest

The authors declare no competing interests (Goh, 2020).

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