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Perceived COVID-19-related stress drives home gardening intentions and improves human health in Taiwan

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\textbf{ABSTRACT}

The COVID-19 pandemic has added a layer of mental health problems and perceived stress. Home gardening is considered a good method to reduce perceived stress. The current research evidence is insufficient to understand the relationship and influencing factors between the intentions, behaviors, and benefits of home gardening during short-term COVID-19 events. Although the duration from the onset to stabilization of the outbreak lasted for only 1.5 months from May to June 2021 throughout Taiwan, the significant pandemic changes might have affected the perceived stress along with the intentions, behaviors, and benefits of home gardening. This study explored the relationship between pandemic stress and home gardening through online snowball sampling because of the strict social distancing regulations. A total of 1455 non-follow-up and internet questionnaires throughout Taiwan were collected during the wave onset, peak, easing, and stabilization stages. The questionnaire included questions on personal information, perceived pandemic stress, gardening intentions, gardening behaviors, and gardening benefits. This study showed that perceived stress increased from the pandemic onset to its peak, and decreased from the peak to stabilization stages. Home gardening intentions and behaviors also revealed similar trends. Higher pandemic-perceived stress directly increased home-gardening intentions and indirectly promoted home-gardening behaviors and benefits. Our findings indicated that home gardening is a positive element in reducing perceived stress. Lower gardening intentions and behaviors were observed when the high perceived stress was removed. This study suggests that home gardening was a valuable strategy for staying close to nature and obtaining multiple benefits during the peak pandemic period. Providing small-scale gardening activities and spaces is appropriate for obtaining gardening benefits and avoiding space abandonment after the pandemic. Providing seeds, seedlings, tools, knowledge, online home gardening programs, and small residential and food gardens is a valuable strategy for obtaining multiple benefits during the peak of the pandemic.

1. Introduction

The COVID-19 pandemic is a global public health emergency that poses health risks and results in hospitalization and death (Marques et al., 2021). The pandemic has also added a layer of mental health problems and perceived stress, owing to confinement strategies (Gori et al., 2020; Husky et al., 2020; Achterberg et al., 2021; Marques et al., 2021; Basu et al., 2021). Several factors have contributed to increased perceived stress during the COVID-19 pandemic, including emotional distress, economic factors, psychosocial stressors (Shanahan et al., 2020), and boredom (Yan et al., 2021). Negative coping strategies produce perceived stress and overreactivity during COVID-19 long-term confinement (Achterberg et al., 2021). Coping strategies of perceived stress, such as maintaining a daily routine and physical activity, have become essential for people confined at home during the COVID-19 pandemic (Shanahan et al., 2020). This study focused on coping...
strategies and perceived stress.

Being close to nature has been an essential coping method for reducing perceived stress during the COVID-19 pandemic (Kleinschroth and Kowarik, 2020; Burnett et al., 2021). Several studies have indicated that the COVID-19 outbreak and lockdown measures have promoted recreational activity, the use of urban greenspaces, (Venter et al., 2020; Venter et al., 2021) and forest bathing (Derks et al., 2020). The need for urban green spaces has increased during the COVID-19 pandemic (Kleinschroth and Kowarik, 2020). However, some countries have implemented strict epidemic prevention policies to restrict the use of parks and greenspaces. In Taiwan, the government implemented a strict home-based prevention policy to avoid essential outdoor social contact from May to August 2021. These outdoor limitations applied to parks, recreational spaces, leisure farms, forest recreation areas, and campgrounds. Although the home-based prevention policy effectively reduced the number of infections, the need to be close to nature still exists.

Home gardening has been a useful method for staying close to nature, coping with acute stress (Van Den Berg and Custers, 2011), and bringing multiple benefits (Sofo and Sofo, 2020). Some studies have reported the benefits of home gardening during the COVID-19 pandemic, including benefits in terms of mental health (Corley et al., 2021; Theodorou et al., 2021), physical health (Corley et al., 2021), and food supply and safety (Lal, 2020; Mullins et al., 2021). Several studies on home gardening focused on food supply and safety during the COVID-19 pandemic owing to low food accessibility (Lal, 2020; Mullins et al., 2021). Corley et al. (2021) indicated that home gardening was associated with positive emotional and mental health during the COVID-19 pandemic. However, the relationship between pandemic stress and home gardening during the short-term COVID-19 pandemic remains unclear.

A COVID-19 outbreak occurred in Taipei City, Taiwan in May 2021 (Liu et al., 2022). The government established a screening strategy to reduce the spread of the virus on May 14 (Liu et al., 2022). The seven-day moving average of new daily cases was higher than 40 during the onset period (15th of May 2021) (Fig. 1). When Taiwan imposed strict home-based prevention policies to restrict outdoor activities in the entire Taiwan area during the peak period (29th of May 2021), the seven-day moving average was higher than 500 new daily cases. The seven-day moving average was lower than the 170 and 70 new daily cases respectively during the easing (19th of June 2021) and stabilization periods (1st of July 2021). The COVID-19 pandemic has been deemed to be under control in Taiwan. The pandemic occurred and peaked in May 2021 and declined in June 2021 throughout Taiwan. The pandemic events in 2021 in Taiwan were divided into four stages: onset (05/15/2021), peak (05/29/2021), easing (06/19/2021), and stabilization (07/01/2021). Although the onset to stabilization stages lasted only 1.5 months, the rapid and large-scale pandemic changes may have affected perceived stress. For example, college students reported more mood disorder symptoms and perceived stress about the COVID-19 pandemic from fall 2019 to spring 2020 (Charles et al., 2021). Due to the different epidemic conditions, this study hypothesizes that the four stages may produce different perceived pandemic stresses (H1).

The fourth stages may have affected home-gardening intentions, behaviors, and benefits. Some studies have indicated that people produced intentions and behaviors (Basarir et al., 2022; Cerda et al., 2022; Marsh et al., 2021; Lin et al., 2021) and obtained gardening benefits during the COVID-19 pandemic (Egerer et al., 2022; Janus et al., 2022; Marques et al., 2021; Kou et al., 2021; Zhang et al., 2021). Owing to the strict home-based prevention policies in Taiwan, outdoor and natural activities have been restricted. Home gardening may substitute for being close to nature in Taiwan. This study hypothesized that the four stages produce different home-gardening intentions (H2), behaviors (H3), and benefits (H4).

The current research evidence is insufficient to understand the relationships among and the influencing factors of the intentions, behaviors, and benefits of home gardening during pandemic events. This study addresses three questions to formulate specific hypotheses. Motivations for home gardening include socialization, food production, and stress reduction (Home and Vieli, 2020; Music et al., 2021; Mullins et al., 2021; Houessou et al., 2021). Stress reduction was found to be the primary benefit of home gardening in the COVID-19 pandemic (Egerer et al., 2022; Janus et al., 2022; Marques et al., 2021; Kou et al., 2021; Zhang et al., 2021). Therefore, the first question is: Does the pandemic’s perceived stress affect home-gardening intentions for the requirement of stress reduction? We hypothesized that pandemic-perceived stress affects home-gardening intentions in all stages (H5).

The second question is whether perceived pandemic stress motivates participation behavior through home-gardening intentions. Although intention is an essential factor for actual behavior, intention change may not be followed by behavioral change because of other considerations (Ajzen, 2020). In this study, home-based prevention policies may strengthen the relationship between gardening intentions and behaviors, because outdoor limitations reduce the possibility of other leisure activities. We hypothesized that home-gardening intentions affect behaviors during pandemic events (H6), and pandemic-perceived stress affects home-gardening behaviors through intentions (H7).

The third question is whether pandemic-perceived stress motivates

![Fig. 1. The new daily cases, seven-day moving average.](image-url)
the home-gardening. Gardening behavior has multiple benefits in the COVID-19 pandemic, including well-being; mental, social, and physical benefits; quality of life; and food production (Basu et al., 2021; Harding et al., 2022; Hsieh et al., 2022; Gerdes et al., 2022; Leibberger et al., 2021; Marsh et al., 2021; Janus et al., 2022; Ogura et al., 2022; Samus et al., 2022; Wang et al., 2022; Zhang et al., 2021). Community gardens provide social support after disasters (Shimpo et al., 2019). We hypothesized that home gardening behaviors would affect the benefits of pandemic events (H8), and pandemic-perceived stress motivates obtaining benefits through intentions and behaviors (H9). Finally, we also explored the effects of personal background on pandemic stress and home gardening to identify sensitive populations.

2. Methods

2.1. Social survey

This study used online and anonymous questionnaire deliveries to conduct a social survey. Because of strict social distancing regulations, we used a convenience and snowball sampling strategy. First, we distributed an online questionnaire through major social media platforms in Taiwan, including Facebook, Instagram, and Line. Second, potential respondents were encouraged to share the survey link with their contacts and the elderly using various methods. Four online surveys were conducted in Taiwan during the onset (05/15/2021), peak (05/29/2021), easing (06/19/2021), and stabilization (07/01/2021) stages. An online survey was conducted for approximately one week in each stage.

The online survey complied with guidelines for human ethics to inform participants of the research purpose, processes, benefits, academic use, anonymous responses, and anonymous analysis and to confirm consent to participate. Potential respondents chose to complete or quit the questionnaire. The survey did not include personal identifier data and did not involve observations, interventions, or interactions. The respondents could not be followed up because of anonymous questionnaire delivery. Ultimately, 1455 non-follow-up questionnaires were collected: 388, 394, 329, and 344 questionnaires were collected during the onset, peak, easing, and stabilization stages, respectively.

The topics of the present study were perceived stress and home gardening during the COVID-19 pandemic. Because face-to-face interactions were not possible during the pandemic, in-person surveys were impossible. Therefore, internet questionnaires included basic personal information such as age, sex, gardening experience, weekly free time, residence type, and residence area. Perceived stress during the pandemic was measured using a single question. This study also measured gardening intentions, behaviors, and benefits using seven, six, and eight possible responses, respectively. The 6-point scale is preferable because the 6-point scale is simple and has small-to-nonexistent psychometric differences compared to the 7-point scale (Simms et al., 2019). Therefore, this study used a 6-point scale to assess perceived pandemic stress, gardening behaviors, and gardening benefits from 1 (very strongly disagree) to 6 (very strongly agree).

2.2. Statistical analysis

Because the partial least squares structural equation modeling (PLS-SEM) is a common method to perform path analysis and mediation analysis with single-item independent variables (Hair et al., 2011; Hair et al., 2014; Hair et al., 2021), we used SmartPLS 3 software (Ringle et al., 2015) to perform the PLS-SEM and elucidate the path analysis. The measurement and structural model should consider the following criteria: Cronbach’s alpha > 0.7; composite reliability (CR) > 0.70; average variance extracted (AVE) > 0.50; square root of AVE > the variable correlations; outer loadings > 0.70, and cross-loadings; variance inflation factor (VIF) < 5.0. We used 5000 bootstrapped samples to access statistical significance (Hair et al., 2021). Measuring exogenous and endogenous variables from the same respondent potentially produces a common method bias that affects the true structural relationship (Kock et al., 2021; Fuller et al., 2016). The unrotated solution variance of Harman’s exploratory factor analysis with all measured items included should be lower than 50 %, indicating a lower common method bias (Kock et al., 2021; Fuller et al., 2016). One-way analysis of variance (ANOVA) was performed to analyze the effect of the four stages on perceived pandemic stress and the variable of home gardening. One-way ANOVA and independent sample t-tests explored the effects of personal background on perceived pandemic stress and psychological (relieves stress) benefits of home gardening.

3. Results

3.1. Effects of personal background on perceived pandemic stress

Among all respondents, the proportion of female respondents (63.4 %) was higher than that of male respondents (36.6 %) (Table 1). The majority of the respondents were aged 46–65 years (47.6 %) and 21–45 years (40.8 %). Half of the respondents were over 46 years old. One-third of the respondents had less than one year of gardening experience (33.0 %). Most respondents had more than one year of gardening experience. Major respondents had one- to two-day free time weekly (46.7 %). The proportion of urban residents (70.0 %) was higher than that of rural residents (30.0 %). The proportion of respondents in central Taiwan (59.4 %) was higher than that in the north (29.8 %) and south and east Taiwan (10.8 %).

The results showed that perceived pandemic stress was significantly higher in male respondents than in female respondents (t = 2.82; p < .01) (Table 2), which could be attributed to a higher percentage of male respondents working outside the home. Age did not significantly affect perceived pandemic stress (F = 2.27; p > .05), indicating that all age groups experienced similar stress during the pandemic events. The results showed that gardening experience significantly affected perceived pandemic stress (F = 2.82; p < .05), especially in the higher experience group. Weekly free time did not affect perceived pandemic stress (F = 1.50; p > .05), indicating that the groups with different free times had similar stress during pandemic events. Regarding residence type, rural residents had higher perceived stress than urban residents (t = −2.09; p < .05), possibly owing to fear of the lack of quality medical treatment in rural areas. The residence area significantly affected perceived stress (F = 3.51; p < .01). Residents in central Taiwan experienced high stress levels.

3.2. Perceived pandemic stress and home gardening behaviors in each wave stage

Perceived pandemic stress was 4.47 or greater in all four stages, indicating high stress levels for Taiwanese people during the pandemic (Table 3). Perceived stress levels at each stage were significantly different (F = 15.90; p < .001), supporting H1. The highest perceived pandemic stress at the wave peak was 5.04, which was significantly higher than the stabilization stage. There was a significant positive correlation between perceived pandemic stress and wave severity. Therefore, changes in pandemic severity influenced perceptions of pandemic stress.

The gardening intentions for each stage were significantly different (F = 11.56; p < .001) (Table 3), supporting H2. The wave peak presented significantly higher gardening intentions than the stabilization stage. The most popular gardening behavior during the pandemic was “all kinds of gardening.” The lower intention activity was “planting fruit trees,” although this was likely because most people in Taiwan live in small apartments that do not include space for planting fruit trees. “All kinds of gardening” presented the highest score at the wave peak, and the lowest score at the stabilization stage, indicating that changes in
The pandemic severity had a significant effect on gardening intention. The gardening behaviors at each stage were significantly different ($F = 4.40; p < .001$) (Table 3), supporting H3. “Receiving plants from friends/relatives” had the highest score of gardening behaviors. The lowest score was “self-propagating from stored seeds,” indicating that avoiding contact with strangers minimized the infection risk during the pandemic wave. The overall gardening behaviors showed a decreasing trend from the onset to stabilization stages.

The gardening benefits of each stage were significantly different ($F = 8.10; p < .001$) (Table 3), supporting H4. “Relieving stress” and “stretching muscles” were the most prominent benefits of home gardening, indicating that home gardening helped relieve psychological problems.
and physiological stress, which was similar the results in the study by Corley et al. (2021) indicating the mental and physical benefits of home gardening during pandemic events. The next highest scoring items were “beautifying the garden,” and “planting food for diet,” indicating that gardening contributes to environmental aesthetics and nutritional supplementation. Gardening benefits were higher at the onset, peak, and easing stages when outdoor activities were restricted. Conversely, the gardening benefits of the stabilization stage were significantly lower than those of the onset, peak, and easing stages. Overall, there was a clear upward trend of perceived stress from the onset to the peak stages and a downturn of perceived stress from the peak to the stabilization stages (Fig. 2). The gardening intentions, behaviors, and benefits showed a downward trend from the peak to stabilization stages.

3.3. Relationship between perceived stress from COVID-19 pandemic and home gardening

The highest factor explained 39.64 % of the variance through Harman’s single-factor test, which showed a lower common method bias. Three items of gardening behavior with a low loading factor were excluded. Cronbach’s alpha of gardening behavior was < 0.70, and four items of outer loading were lower than 0.70 (Table 4). However, the model presented acceptable values below the criteria, suitable internal consistency, convergent validity, and discriminant validity, and determined the final model; all CR and AVE matched the suggested values, indicating good convergent validity; all outer loadings were > the cross-loading, indicating good discriminant validity (Table 4); all square roots of the AVE’s were > the variable correlations, indicating good discriminant validity (Table 5); and all VIF matched the suggested values, showing a lower collinearity problem. All path coefficients had significant positive effects (Table 6, Fig. 3). Perceived pandemic stress directly affected gardening intentions (β = 0.21, bias-corrected [BC] 95 % confidence interval [CI] = 0.15–0.26), indicating that higher perceived stress produced higher home gardening intentions, supporting H5. Gardening intentions directly affected gardening behaviors (β = 0.39, BC 95 % CI = 0.34–0.43), supporting H6. Moreover, the perceived pandemic stress produced a specific indirect effect on gardening behaviors (β = 0.08, BC 95 % CI = 0.06–0.10), supporting H7. Gardening behaviors directly affected gardening benefits (β = 0.46, BC 95 % CI = 0.42–0.51), supporting H8. The perceived pandemic stress produced a specific indirect effect on gardening benefits (β = 0.04, BC 95 % CI = 0.03–0.05), supporting H9. In summary, perceived pandemic stress affected gardening benefits through gardening intentions and behaviors during the COVID-19 pandemic. The higher perceived pandemic stress might have increased home gardening during the four pandemic stages.

3.4. Effects of personal background on physiological and psychological benefits of home gardening

The results showed that sex did not affect the physiological (t = 0.08; p > 0.05) and psychological benefits (t = 0.74; p > 0.05) of home gardening (Table 2), indicating that men and women obtained similar benefits from home gardening. The age group significantly affected the physiological (F = 17.97; p < 0.001) and psychological benefits (F = 6.26; p < 0.001). The 46-65-years-old age group had significantly higher benefits. Gardening experience significantly affected physiological (F = 17.76; p < 0.001) and psychological benefits (F = 13.52; p < 0.001), especially in the higher experience group. Weekly

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Table 3

| Variables and items | Mean and SD of Pandemic waves | F-value |
|---------------------|-------------------------------|---------|
|                     | Onset (n = 388) | Peak (n = 394) | Easing (n = 329) | Stabilization (n = 344) | Total (n = 1455) |
| Perceived pandemic stress | 4.77 (1.26) | 5.04 (1.08) | 4.60 (1.29) | 4.47 (1.16) | 4.73 (1.21) |
| Gardening intention | 4.37 (1.29) | 4.72 (0.98) | 4.44 (1.29) | 4.16 (1.31) | 4.43 (1.23) |
| Planting vegetable | 4.34 (1.60) | 4.75 (1.27) | 4.41 (1.61) | 4.20 (1.57) | 4.43 (1.53) |
| Planting flower | 4.51 (1.57) | 4.75 (1.17) | 4.63 (1.46) | 4.35 (1.47) | 4.56 (1.43) |
| Planting fruit tree | 3.52 (1.78) | 4.11 (1.43) | 3.64 (1.78) | 3.24 (1.69) | 3.64 (1.70) |
| Maintaining garden | 4.67 (1.49) | 4.96 (1.16) | 4.73 (1.41) | 4.43 (1.53) | 4.71 (1.41) |
| All kinds of gardening | 4.80 (1.41) | 5.04 (1.12) | 4.77 (1.41) | 4.56 (1.44) | 4.80 (1.36) |
| Online gardening classes | 4.69 (1.40) | 4.76 (1.22) | 4.69 (1.36) | 4.46 (1.40) | 4.65 (1.35) |
| Recommending friends/family participate | 4.22 (1.50) | 4.28 (1.37) | 4.17 (1.57) | 4.06 (1.37) | 4.18 (1.45) |
| Gardening behaviors | 4.32 (0.94) | 4.25 (0.88) | 4.13 (1.03) | 4.09 (1.02) | 4.20 (0.97) |
| Receiving plants through friends/relatives | 4.29 (1.20) | 4.28 (1.07) | 4.33 (1.16) | 4.30 (1.21) | 4.30 (1.16) |
| Self-propagating plants | 4.42 (1.30) | 4.33 (1.19) | 4.12 (1.36) | 4.02 (1.35) | 4.23 (1.31) |
| Self-propagating from stored seeds | 4.24 (1.30) | 4.14 (1.23) | 3.93 (1.41) | 3.94 (1.33) | 4.07 (1.32) |
| Gardening benefits | 4.99 (0.71) | 4.96 (0.67) | 4.91 (0.76) | 4.75 (0.76) | 4.91 (0.73) |
| Stretching muscles | 5.10 (0.89) | 5.08 (0.83) | 5.14 (0.89) | 4.89 (0.97) | 5.05 (0.90) |
| Relieving stress | 5.29 (0.83) | 5.25 (0.81) | 5.27 (0.84) | 5.17 (0.87) | 5.25 (0.84) |
| Planting food for diet | 5.03 (1.00) | 4.96 (0.90) | 4.94 (1.06) | 4.74 (1.08) | 4.92 (1.01) |
| Planting fruits and vegetables for diet | 4.88 (1.04) | 4.81 (0.92) | 4.70 (1.08) | 4.53 (1.13) | 4.74 (1.05) |
| Spending time | 4.69 (1.08) | 4.73 (0.90) | 4.64 (1.07) | 4.54 (1.14) | 4.65 (1.05) |
| Developing a gardening hobby | 5.07 (0.97) | 4.99 (0.93) | 4.87 (1.09) | 4.74 (1.10) | 4.93 (1.03) |
| Strengthening family relationships | 4.63 (1.10) | 4.69 (0.92) | 4.53 (1.14) | 4.37 (1.11) | 4.56 (1.07) |
| Beautifying the garden | 5.22 (0.86) | 5.20 (0.82) | 5.16 (0.91) | 5.00 (0.96) | 5.15 (0.89) |

*p < 0.05, *p < 0.1, *p < 0.001

Fig. 2. The change and error bars denoting perceived stress and home gardening metrics from onset into stabilization stages.
free time significantly affected physiological (F = 10.03; p < .001) and psychological benefits (F = 5.30; p < .001). The group with 3.1–4.0 days of free time produced the highest benefits, indicating that higher free time may promote home gardening and obtaining benefits. Regarding residence type, rural residents had significantly higher physiological (F = -3.26; p < .01) and psychological benefits (F = -2.41; p < .05) than urban residents. Residence areas did not affect physiological (F = 1.72; p > .05) or psychological benefits (F = 1.16; p > .05), indicating that home gardening produced similar benefits in the entire population cohort surveyed across Taiwan.

4. Discussion

4.1. Pandemic peak caused highest perceived stress

To our knowledge, no case studies have explored the evidence of perceived stress and home gardening change over 1.5 months from the clear onset, peak, easing, and stabilization stages of the COVID-19 pandemic in Taiwan. This case study provides additional information on home gardening during short-term perceived stress events. The results showed that the peak period caused significantly higher perceived stress than the onset, easing, and stabilization stages. Perceived stress significantly increased from the onset to peak and decreased from the peak to stabilization stages. These results were consistent with previous studies that showed the COVID-19 epidemic caused serious perceived stress (e.g., Xu et al., 2021). The contribution of this study was to provide further evidence of stress reduction from the pandemic peak to decline stages. The uncontrolled COVID-19 pandemic may continuously produce long-term perceived stress that induces social problems. Conversely, reducing the number of cases reduced perceived stress. In this study, the government established a rapid community testing strategy with health, environmental, police, transportation, and fire departments with immediate isolation and medical services upon the detection of a positive case, and integrated mask-wearing and contact-tracing systems to reduce the spread of the virus (Liu et al., 2022).

When attempting to identify populations sensitive to pandemic stress, we found that male respondents, people with considerable gardening experience, and rural residents had higher pandemic stress. One study showed that COVID-19 pandemic stress is correlated with suicidality, loneliness, and self-efficacy (Wu et al., 2022). Furthermore, this study indicated that men had significantly higher perceived stress due to work requirements. Men’s perceived stress should be considered.

### Table 4
Quality criteria: Factor loading, cross loading, discriminant validity, construct reliability and validity.

| Variables                      | M (SD) | Factor loading and cross loading | Cronbach’s alpha | CR | AVE |
|-------------------------------|--------|---------------------------------|-----------------|----|-----|
|                               |        | A      | B      | C      | D      |     |     |
| Perceived stress              | 4.73 (1.21) | 1.00 | 0.21  | 0.01  | 0.13  | 1.00 | 1.00 |
| Gardening intention           |        |        |        |        |        | 0.88 | 0.91 |
| B1 : Planting vegetable       | 4.43 (1.53) | 0.20 | 0.80  | 0.28  | 0.45  |        |     |
| B2 : Planting flower          | 4.56 (1.43) | 0.17 | 0.79  | 0.26  | 0.46  |        |     |
| B3 : Planting fruit tree      | 3.64 (1.70) | 0.17 | 0.73  | 0.28  | 0.40  |        |     |
| B4 : Maintaining garden       | 4.71 (1.41) | 0.17 | 0.86  | 0.36  | 0.52  |        |     |
| B5 : All kinds of gardening   | 4.80 (1.36) | 0.17 | 0.88  | 0.38  | 0.57  |        |     |
| B6 : Online gardening classes | 4.65 (1.35) | 0.14 | 0.64  | 0.26  | 0.43  |        |     |
| B7 : Recommending friends/family participate | 4.18 (1.45) | 0.10 | 0.66  | 0.25  | 0.43  |        |     |
| Gardening behaviors           |        |        |        |        |        | 0.64 | 0.71 |
| C4 : Receiving plants through friends/relatives | 4.30 (1.16) | 0.01 | 0.18  | 0.52  | 0.28  |        |     |
| C5 : Self-propagating plants  | 4.23 (1.31) | 0.01 | 0.36  | 0.88  | 0.42  |        |     |
| C6 : Self-propagating from stored seeds | 4.07 (1.32) | 0.01 | 0.33  | 0.86  | 0.37  |        |     |
| Gardening benefits            |        |        |        |        |        | 0.89 | 0.91 |
| D1 : Stretching muscles       | 5.05 (0.90) | 0.09 | 0.43  | 0.32  | 0.79  |        |     |
| D2 : Relieving stress         | 5.25 (0.84) | 0.12 | 0.43  | 0.28  | 0.79  |        |     |
| D3 : Planting food for diet   | 4.92 (1.01) | 0.14 | 0.47  | 0.30  | 0.74  |        |     |
| D4 : Planting fruits and vegetables for diet | 4.74 (1.05) | 0.08 | 0.43  | 0.39  | 0.75  |        |     |
| D5 : Spending time            | 4.65 (1.05) | 0.08 | 0.29  | 0.23  | 0.62  |        |     |
| D6 : Developing a gardening hobby | 4.93 (1.03) | 0.06 | 0.58  | 0.50  | 0.76  |        |     |
| D7 : Strengthening family relationships | 4.56 (1.07) | 0.11 | 0.43  | 0.31  | 0.72  |        |     |
| D8 : Beautifying the garden   | 5.15 (0.89) | 0.10 | 0.47  | 0.31  | 0.79  |        |     |

### Table 5
Fornell-Larker criterion: The square root of AVE should be higher than the other construct’s correlation.

| Variables                      | M (SD) | Factor loading and cross loading | Cronbach’s alpha | CR | AVE |
|-------------------------------|--------|---------------------------------|-----------------|----|-----|
|                               |        | A      | B      | C      | D      |     |     |
| Perceived stress              | 1.00   | 0.21  | 0.77  |        |        | 0.89 | 0.91 |
| Gardening intention           |        | 0.01  | 0.39  | 0.77  |        | 0.56  |     |
| Gardening behaviors           |        | 0.13  | 0.61  | 0.46  | 0.75  |        |     |

### Table 6
Path coefficients of direct effects and specific indirect effects.

| Parameter                        | Coefficient | t-value | BC 95 %CI | Hypothesis |
|----------------------------------|-------------|---------|-----------|------------|
| Direct effect                    |             |         |           |            |
| Perceived stress → Gardening intention | 0.21a      | 7.66    | 0.15; 0.26 | Supporting |
| Gardening intention → Gardening behaviors | 0.39a     | 16.40   | 0.34; 0.43 | Supporting |
| Gardening behaviors → Gardening benefits | 0.46a   | 21.77   | 0.42; 0.51 | Supporting |
| Specific indirect effect         |             |         |           |            |
| Perceived stress → Gardening behaviors | 0.08a     | 7.12    | 0.06; 0.10 | Supporting |
| Perceived stress → Gardening intention → Gardening behaviors | 0.04a | 6.28 | 0.03; 0.05 | Supporting |
| Gardening intention → Gardening behaviors → Gardening benefits | 0.18a | 10.42 | 0.15; 0.22 |     |

*p < .001; BC CI: Bias-corrected confidence interval based on 5000 bootstrapped samples.
Interestingly, the easing and stabilization stages produced lower perceived stress during the pandemic (Lal, 2020; Mullins et al., 2021; Niles et al., 2021). Indeed, food supply and safety have been the reason for home gardening during the pandemic period. We showed that home gardening intentions significantly increased from the pandemic onset to peak stage, including planting vegetables and fruit trees, as well as maintaining gardens. Furthermore, home gardening intentions significantly decreased from the pandemic peak to easing stage. When high perceived stress is removed, the requirement for gardening may be reduced to produce lower gardening intentions and behaviors. Nevertheless, the peak of the pandemic motivated short-term demand for gardening. Small-scale gardening activities and spaces may be more appropriate as the demand for food (Lal, 2020; Mullins et al., 2021; Niles et al., 2021). Planting fruit trees had lower intentional activity due to the small home garden spaces (Schoen et al., 2021). Suitable spaces to obtain gardening benefits and avoid the potential problem of space abandonment after the pandemic (Schoen et al., 2021).

The demand for home gardening should be considered in severe pandemic events, especially if parks or natural places are prohibited. Our results also indicated that gardening and planting flowers and vegetables resulted in higher intentional activities during pandemic events. Vegetable planting is a suitable activity because of the demand for food (Lal, 2020; Mullins et al., 2021; Niles et al., 2021). Planting fruit trees had lower intentional activity due to the small home garden spaces in Taiwan. Therefore, providing flower and vegetable seeds, seedlings, tools, knowledge, and online programs can promote home gardening behaviors and obtain multiple benefits.

Interestingly, gardening intentions, behaviors, and benefits were reduced from the peak to stabilization stages. When high perceived stress is removed, the requirement for gardening may be reduced to produce lower gardening intentions and behaviors. Nevertheless, the peak of the pandemic motivated short-term demand for gardening. Small-scale gardening activities and spaces may be more appropriate as the demand for gardening may decrease after the epidemic. Small residential (Chalmin-Pui et al., 2021), therapeutic (Marsh et al., 2021; Marques et al., 2021), and food gardens (Sofo and Sofo, 2020) are suitable spaces to obtain gardening benefits and avoid the potential problem of space abandonment after the pandemic (Schoen et al., 2021).

This study indicated that both men and women obtained physiological and psychological benefits from home-gardening. One study showed that gardeners with less than ten years of experience spent more time gardening during the pandemic than those with more than ten years of experience (Egerer et al., 2022). This study further indicated that the group with higher experience obtained higher benefits. This condition may be associated with the effect of age because the more...
experienced group was the older age group (Egerer et al., 2022). In the present study, the middle-aged group had significantly higher benefits. This result was similar to that of Gerdes et al. (2022), showing that respondents with 15 years of experience had lower anxiety levels. Young respondents in their twenties consider gardening an investment, while the elderly consider gardening a health improvement and recreational function from growing fruits and vegetables (Janus et al., 2022). The group with 3–4 days of free time produced the highest benefits, which may also be associated with the effect of age. Rural residents had higher benefits from home gardening than did urban residents. First, rural residents may have more opportunities and space to engage in home gardening, which may produce higher benefits. Second, rural residents experience significantly higher stress than urban residents, which might promote gardening intentions, behaviors, and benefits.

4.4. Study strengths and limitations

This study has some limitations and strengths. The respondents were not the same in the four stages because we expected large follow-up respondents in the first stage to be difficult to obtain through a non-anonymous questionnaire and had a higher attrition rate from the first to fourth stages. In addition, the survey time is short, and it is more challenging to assign similar gender and age in the four stages due to the rapid change in the epidemic. Finally, this study used online snowball sampling because face-to-face investigation is impossible owing to strict social distancing regulations. The strength of this study was the clear onset, peak, easing, and stabilization stages during 1.5 months to evidence the effect of gardening on short-term severe stress events.

5. Conclusions

Home gardening is a helpful method for staying close to nature. This study explained the relationship between perceived COVID-19 pandemic stress and home gardening according to onset, peak, easing, and stabilization stages. We found that perceived stress increased from the pandemic onset to its peak, and decreased from the peak to stabilization stages. Home gardening intentions and behaviors also revealed similar trends. Our findings indicate that home gardening is one of the best ways to reduce perceived stress, even during short-term COVID-19 pandemic events. Finally, pandemic-perceived stress promotes gardening intentions, behaviors, and benefits. However, lower gardening intentions and behaviors were observed when the high perceived stress was removed. Future studies should explore whether long-term perceived stress affects gardening behavior after pandemic events. This study suggests that providing small-scale gardening activities and spaces is appropriate for obtaining gardening benefits and avoiding the potential problem of space abandonment after the pandemic. Providing seeds, seedlings, tools, knowledge, online home gardening programs, and small residential and food gardens is a valuable strategy for staying close to nature and obtaining multiple benefits during the pandemic. Future urban living environments should consider home gardening requirements with outdoor limitations to maintain health.

CRediT authorship contribution statement

Chen-Fa Wu: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. Li-Wei Chou: Validation, Writing – original draft, Writing – review & editing. Hsi-Chih Huang: Software, Formal analysis, Data curation. Hung-Ming Tu: Conceptualization, Methodology, Validation, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2022.127770.

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