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The effects of personal green spaces on human's mental health and anxiety symptoms during COVID-19: The case of apartment residents in Tehran

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The governments implemented social distancing and isolation with the spread of COVID-19. However, these ways efficiently prevent coronavirus transmission, but they caused unprecedented changes in most people's day-to-day lives. One of the concerns is mental health, and many experts are concerned about the tsunami of mental illnesses during and after coronavirus. Being exposed to nature has an efficient role in mental health. Under pandemic conditions, people reduced their outdoor activities, but personal green spaces are still available. This research assessed the impact of these spaces as an alternative to public green spaces and their benefits during COVID-19 on mental health and generalized anxiety disorder. Accordingly, by designing an online self-administered questionnaire, a total of 700 residents of Tehran apartments were evaluated. A structural equation model was created. The results demonstrate that using personal green spaces has a negative correlation and significant impact on general mental health and generalized anxiety disorder. It also plays a more substantial role in reducing depression than its role in reducing anxiety among individuals. Therefore, maximum land use policies should be reviewed. Also, green spaces should be given more attention in post-COVID designs on a macro-scale to a small scale.

KEYWORDS

COVID-19, personal green space, mental health, anxiety symptom, apartment residents

1 Introduction

The coronavirus disease 2019 (COVID-19) outbreak raised a public health emergency on 30 January 2020 and a global pandemic on 11 March 2020 (World Health Organization, 2020). This pandemic has impacted all aspects of human lives (Lu et al., 2021), such as the global market, economy, agriculture, industries, health care,

and human health þ(Kumar and Nayar, 2021). The WHO is concerned about the pandemic's psychosocial consequences and mental health þ(World Health Organization, 2020). Also, the global community is worried about COVID-19 and its long-term outcomes þ(Kumar and Nayar, 2021), and many experts have predicted a "tsunami of psychiatric illnesses" as the aftermath of the COVID pandemic þ(Tandon, 2020). Most governments worldwide issued stay-at-home orders (Gostin and Wiley, 2020; Petersen et al., 2020) for an unprecedented time þ(Brooks et al., 2020). Also, they have implemented various social distancing measures as the most effective way to control the spread of this virus þ(Gu et al., 2020; Tian et al., 2020; Wilder-Smith and Freedman, 2020), forbidding visiting parks, playgrounds, community gardens, and all outdoor activity spaces (Shoari et al., 2020). These strategies are essential to break the transmission, but it has also created lots of problems for humans, even for children, who become restless and, in some cases, violent þ(Kumar and Nayar, 2021). These social distancing measures may keep people away from nature þ(Lu et al., 2021). Quarantine, self-isolation, and the concern and uncertainty instilled by the perceived health risk and economic ramifications of the pandemic have increased insomnia, loneliness, drug use, harmful alcohol, depression, anxiety, suicidal behavior, self-harm, and suicide rates þ(Huang and Zhao, 2020; Rajkumar, 2020; Wang et al., 2020; World Health Organization, 2020; Zhu et al., 2020). Furthermore, it is expected that well-being and mental health effects are likely to be profound and long-lasting þ(Holmes et al., 2020; Hotopf et al., 2020). There are various available pathways for mitigating the stress of this pandemic, which seems that connecting with nature is one of these ways. Connecting with greenery in public outdoor spaces benefits human physical and mental health þ(Barton and Pretty, 2010; Hartig et al., 2014; Gascon et al., 2015; Triguero-Mas et al., 2015; WHO, 2016; Douglas et al., 2017; Van den Bosch and Sang, 2017; Callaghan et al., 2021). However, with quarantine, impeding the outdoor interaction with green spaces, and spending almost all of the time at home, most of these ways toward improving mental health are not available þ(Dzhambov et al., 2021).

Many studies have been concerned with measuring public green spaces in different dimensions and their impact on humans, and fewer studies have examined the different dimensions of the effects of personal green spaces. On the other hand, new conditions were created due to the coronavirus outbreak. It became necessary to create suitable alternatives to improve the mental conditions of humans that were previously available. One of the suitable alternatives is personal green spaces that were created which can affect mental health and anxiety levels. However, this study seeks to assess the impact of personal green spaces on mental health, anxiety levels, and the relationship between demographic characteristics and mental health and anxiety symptoms by eliminating activities that were previously helpful for mental health and anxiety levels. This study was conducted during the fifth wave of coronavirus in Iran, which was more dangerous than previous waves, and the country was under an emergency. This article aims to target the corona era when quarantine orders were enforced throughout the country, and people were denied access to urban green spaces to examine the relationship between personal green space utilization, mental health, general anxiety symptoms, and demographic characteristics to provide solutions for designing apartments in Tehran for the post-COVID period. Therefore, this research seeks to answer three questions: 1) what is the impact of personal green spaces on mental health? 2) What is the effect of personal green spaces on anxiety symptoms? Also, 3) what is the relationship between demographic characteristics and mental health and anxiety symptoms? Based on the literature, visible greenery, both outdoors and indoors, reduces stress and increases concentration (Duijn et al., 2011; Alker et al., 2014). Also, connecting with greenery in public outdoor spaces benefits human physical and mental health (Barton and Pretty, 2010; Hartig et al., 2014; Gascon et al., 2015; Triguero-Mas et al., 2015; WHO, 2016; Douglas et al., 2017; Van den Bosch and Sang, 2017; Callaghan et al., 2021). The authors hypothesized the following: (H1) personal green space has positive effects on the level of human general mental health; (H2) personal green space has positive effects on reducing symptoms of generalized anxiety disorder; (H3) there is a relationship between demographic characteristics and mental health and the symptoms of generalized anxiety disorder. Overall, the authors expect that these pathways of private green spaces are an efficient alternative for outdoor green spaces; also, through these ways, humans demonstrate lower symptoms of anxiety or depression. The hypotheses are shown in Figure 1. Moreover, it needs to mention that the authors refer to the personal green space, a natural space that is physically accessible. Therefore, there have not been examples such as the existence of a painting of nature that is mounted on the wall.

2 Materials and methods

2.1 Connecting with greenery in quarantine

With the widespread coronavirus and the application of quarantine and stay-at-home orders, humans' connection with nature becomes limited. However, there are still some alternative forms to connect with nature as an element of improving mental health. First, the plant symbolizes nature (Smardon, 1988; Bringslimark et al., 2009). Also, each green environment could improve mood and self-esteem, improve general psychological well-being, reduce anger, and positively affect emotions or behavior. On the other hand, the presence of water generated more significant effects (Barton and Pretty, 2010; Windhager et al., 2011; Keniger et al., 2013; Wolf and

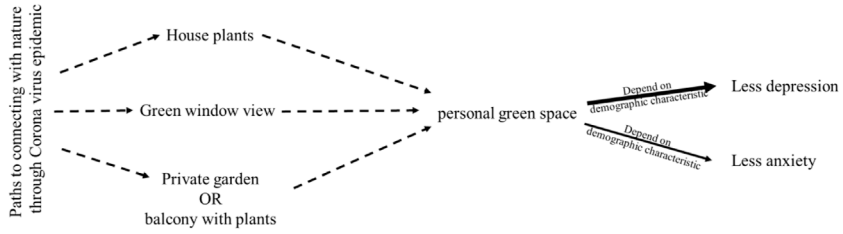

FIGURE 1
Conceptual framework showing the authors' hypotheses. * Line widths represent hypothesized pathway strength and thicker lines denoting stronger associations. Moreover, dashed lines are for introducing selected variables of personal green spaces in this research.

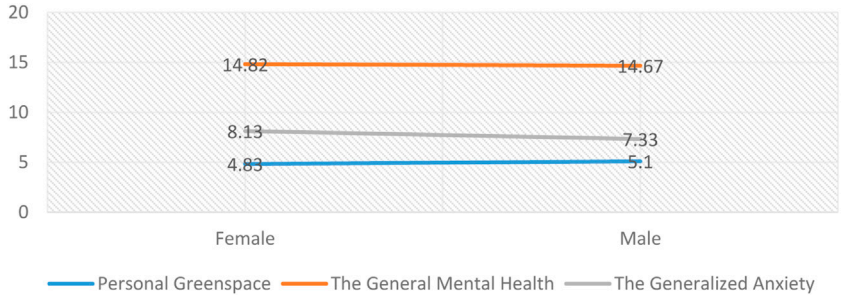

FIGURE 2
Mean personal green spaces, general mental health, and generalized anxiety disorder at gender levels.

Housley, 2014; Mensah et al., 2016). Moreover, visible greenery, both outdoors and indoors, reduces stress and increases concentration (Duijn et al., 2011; Alker et al., 2014). Many people place plants indoors such as in the living area or their workspaces (Dravigne et al., 2008), where research and empirical studies demonstrated that potted plants could reduce physical discomfort, stress, depressive symptoms, anxiety, and mental health (Fjeld, 2000; Chang and Chen, 2005; Doxey et al., 2009; Han, 2018; Hall and Knuth, 2019; Han and Ruan, 2019). In a study, interior plants can lead to healthy and productive workplaces through decreased stress levels, enhanced attention capacity, and higher job satisfaction (Raanaas et al., 2011; Hartig et al., 2014; Gilchrist et al., 2015). Moreover, placing plants in the classroom can increase children's performance, and it was shown they were progressing through the school curriculum 20%–26% faster (Duijn et al., 2011). Therefore, indoor vegetation at home is an effective way to engage with greenery and benefit from its positive effects. Second, based on empirical research, green window views can provide micro-restorative episodes over the days or a few hours, which promote healing (Ulrich, 1984; Kaplan, 2001; Jo et al., 2019). This way recovery from stressful events (Li and Sullivan, 2016) and psychological restoration (Lee et al., 2015) can be achieved. If it expends to several months, a person's ability to complete complex cognitive tasks such as earning high grades will increase (Benfield et al., 2015). When people observe plants, oxy-Hb (oxyhemoglobin) concentrations in the right prefrontal cortex are significantly lower, indicating a physiological state of relaxation (Park et al., 2017). Biophilic workplaces with views of nature and daylight can lead to greater employee attention and productivity (Elzeyadi, 2011; Windhager et al., 2011); for instance, studies showed that offices in Great Britain and the Netherlands with plants had an increase of 15% in worker's productivity (Nieuwenhuis et al., 2014; Korpela et al., 2017). Employees exposed to views of nature, such as trees or flowers, are less stressed and more satisfied in comparison with those who lack window views entirely or see only buildings outside (Kaplan, 1995). Even the views of artificial nature can help with anxiety and stress relief (Ulrich and Dimberg, 1991). Therefore, greenery views through windows effectively connect relationships with nature and benefit their positive impact. Third, mental fatigue recovery, stress reduction, and improved concentration levels happen when individuals spend time on natural spaces (Entrix, 2010; Kjellgren and Buhrkall, 2010; Keniger et al., 2013; White et al., 2017) live near green environments, or view greenery and vegetation (Abraham et al., 2010; Carrus et al., 2015; Watts, 2017). The

benefits of gardening and gardening to well-being are considered adequate for human mental health. The design of "healing" gardens becomes a topic of study in itself and as a credible ingredient for convalescent patients in health care situations (Marcus and Sachs, 2013). Also, a domestic garden can reduce anxiety and depression (Dennis and James, 2017; Soga et al., 2017; de Bell et al., 2020). A research on participants involved in outside horticultural therapy activities such as landscaping or gardening demonstrated that people have reduced incidents of aggressive behavior, have improved cognitive capacity, and are more actively engaged (Gigliotti and Jarrott, 2005). So, having a private garden or balcony with greenery is one of these ways. These three alternatives for engaging humans with greenery have rarely been compared, even much less directly (Akpinar et al., 2016; Korpela et al., 2017; Dzhambov et al., 2018). Most previous research on indoor greenery was related to workplaces, especially classrooms or office spaces (Raanaas et al., 2011; Han and Ruan, 2019).

2.2 Study design

This research was conducted during the COVID-19 pandemic with the aim of evaluating the effects of personal green spaces on human mental health and the level of anxiety symptoms. Between 20 August and 1 September 2021, the authors conducted an online self-administered survey among 700 apartment residents in Tehran. Severities of anxiety and depression symptoms over the past 2 weeks were measured by the Patient Health Questionnaire 12-item and the Generalized Anxiety Disorder 7-item Scale comparing two indoor measures (number of houseplants and the proportion of visible exterior from inside the home through windows, balcony, or terrace). Sampling was performed using the nonprobability (simple random sampling) method. The questionnaire was developed on a site, and its link was delivered to the respondents through the social media platform. At first, the questionnaire had questions such as the area of residence and the number of apartment floors. Given that these two factors seem to affect the results, the authors only analyzed the responses of middle-class (middle-income) residents living in mid-rise buildings. Table 1 shows the scale range of personal green space components used in the questionnaire.

2.3 Greenery assessment

For assessing all greenery variables, a self-reported analysis was performed. Moreover, questions such as the amount of change in the number and frequency of public green spaces were measured to control the impact of this variable on the research outcome. Accordingly, cases, where quarantine did not affect the use of green spaces, were removed.

2.4 Mental health assessment

In this research, for evaluating the symptom of depression and anxiety over the past 2 weeks, two widely used and valid screening instruments were used. Since 1970, when Goldberg developed the General Health Questionnaire (GHQ), it has been extensively used in different cultures and settings (Goldberg and Blackwell, 1970; Goldberg, 1988; Jacob et al., 1997; Schrnitz et al., 1999; Donath, 2001) for measuring mental health and determining the risk of developing a psychiatric disorder (Goldberg, 1988). The 12-item General Health Questionnaire (GHQ-12) was translated into Iranian language. The Iranian version of GHQ-12 has a valid and reliable instrument and a good factor structure to measure minor psychological distress (Montazeri et al., 2003). It has 12 items in which each question has four response options based on Likert style. The total score could range from 0 to 36, in which a higher score indicates more symptoms of depression and anxiety.

Also, the Generalized Anxiety Disorder 7-item (GAD-7) Scale was used, which was generated by Spitzer et al. (2006) to measure generalized anxiety disorders. A systematic review and diagnostic meta-analysis have demonstrated that this test has acceptable psychometric properties in adults (Plummer et al., 2016). Moreover, this test has become a widely used measure in adults in different cultures and an efficient screening tool for detecting the generalized anxiety disorder in primary care patients (Delgadillo et al., 2012; Parkerson et al., 2015). The response options of each item, based on Likert style, include 0 (not at all), 1 (sometimes), 2 (often), and 3 (nearly every day). The total score could range from 0 to 21; the higher score demonstrates more anxiety symptoms.

3 Results

3.1 Reliability and validity

The estimation of the reliability of the questionnaire using Cronbach's alpha index and the combined reliability performed using SmartPLS software to check the internal consistency were assessed. Cronbach's alpha index (generalized anxiety disorder: 0.92, general mental health: 0.92, personal green space: 0.74, and total questionnaire: 0.82) and combined reliability (generalized anxiety disorder: 0.93, general mental health: 0.93, and personal green space: 0.85) for all questionnaire variables were greater than 0.7, so the questionnaire has suitable reliability. Also, the average variance extracted (AVE) criterion showed that the extracted variance for all structures was more than 0.5 (generalized anxiety disorder: 0.67, general mental health: 0.54, and personal green space: 0.66), so their convergent validity is confirmed. In addition, the divergent validity of the research variables was examined using Fornell and Larker methods. The results of Table 2 demonstrate that except for

TABLE 1 Scale range of personal green space components.

Selected variables of personal green spaces	Scale (a 5-point scale)	
The existence of apartment plants	0	Without houseplants
	1	Less than 5 plants
	2	Between 6 and 15 plants
	3	Between 16 and 25 plants
	4	26 plants or more
The view of windows	0	100% built-up view
	1	A larger share (60%–70%) of built space and a smaller share (40%–30%) of green space
	2	Half (50%) is built space and half (50%) is green space
	3	A smaller share (30%–40%) of built space and a larger share (60%–70%) of green space
	4	100% green view
Private garden or balcony with flowers or green cover	0	No private garden or balcony with plants
	1	At least one of these two spaces with a total of less than 5 square meters
	2	At least one of these two spaces with a total area of more than 5 square meters and less than 10 square meters
	3	At least one of these two spaces with a total area of more than 10 square meters and less than 20 square meters
	4	At least one of these two spaces with a total area of more than 20 square meters

TABLE 2 Divergent validity matrix using Fornell and Larker methods for research variables.

Variable	Generalized anxiety disorder	General mental health	Personal green space
Generalized anxiety disorder	0.81		
General mental health	0.79	0.73	
Personal green space	−0.31	−0.38	0.81

the variable of general mental health, the correlation of other variables with their items is more than the correlation of that variable with other variables. Therefore, it has a relatively suitable divergent narrative model.

3.2 Descriptive statistics of research

The authors recruited a nonprobability sample from apartment residents in Tehran, and their mental health related to the amount of connection with greenery was evaluated. Demographic characteristics of the participants (n = 700) are presented in Table 3.

Table 4 shows the descriptive statistics indicators including mean, median, standard deviation, skewness, kurtosis, and minimum and maximum scores related to research variables.

According to the questionnaire, the average score for private green spaces, general mental health, and generalized anxiety disorder equals 6, 18, and 10.5, respectively. According to the results obtained from Table 5, the personal green space use is less than desirable. In addition, the level of anxiety and depression among the participants in this study is less than average, so they are at an acceptable level in terms of mental health and anxiety disorder.

3.3 Inferential statistics of research

To test the hypotheses of this research, first, the normality of the research variables is measured, and then the correlation between them is calculated. Finally, the research hypotheses are tested based on the partial least squares method.

The results of Table 6 show that the significance level of the test for all variables is less than the test error level (0.000). Therefore, the hypothesis of normality of variables is rejected using the Kolmogorov–Smirnov test. Nevertheless, the values of skewness and kurtosis of variables are in the range between 2 and -2. Therefore, the normality of the research variables is accepted. In this way, parametric tests can be used to analyze the data.

The results of the correlation table show that the significance level of the test between all variables in the model is less than 0.01.

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TABLE 3 Demographic variables.

Category	Subcategory	Frequency	Frequency percentage
Gender	Female	558	79.7
	Male	142	20.3
	Total	700	100
Marital status	Married	461	65.9
	Single	239	34.1
	Total	700	100
Age	Under 18 years old	7	1
	Between 18 and 28	123	17.6
	Between 29 and 39	162	23.1
	Between 40 and 50	157	22.4
	Between 51 and 60	192	27.4
	Between 61 and 71	49	7
	Over 72 years old	10	1.4
	Total	700	100
Monthly income (in Iranian rial)	Without income	129	18.4
	20.000.000 and less	67	9.6
	20.000.001–30.500.000	52	7.4
	30.500.001–50.000.000	124	17.7
	50.000.001–10.000.000	255	36.4
	10.000.001 or above	73	10.4
	Total	700	100
Education	Diploma or less	98	14.0
	Bachelor degree	327	46.7
	Master degree	249	35.6
	Ph.D. or above	26	3.7
	Total	700	100

TABLE 4 Indicators of descriptive statistics of research variables.

Variable	Number	Mean	Median	Standard deviation	Skewness	Kurtosis	Lowest score	Highest score
Personal green space	700	4.88	4.00	3.22	0.52	−0.71	0	12
The General Health Questionnaire (GHQ)	700	14.79	14.00	7.07	0.44	−0.37	0	36
The Generalized Anxiety Disorder 7-item (GAD-7)	700	7.97	7.00	5.52	0.47	−0.77	0	21

So there is a correlation between the variables. Among these, the highest correlation is observed between generalized anxiety disorder and general mental health (0.800), and the lowest correlation is observed between generalized anxiety disorder and personal green spaces (−0.309).

The amount of personal green spaces, general mental health, and generalized anxiety in the levels of demographic variables were examined using parametric tests. To investigate this issue at different levels of demographic characteristics, a *t*-test of two independent communities with an error level of 0.05 was used.

TABLE 5 Correlation of model variables.

Variable	Personal green space	The General Health Questionnaire (GHQ)	The Generalized Anxiety Disorder 7-item (GAD-7)
Personal green space	1.00		
The General Health Questionnaire (GHQ)	−0.374**	1.00	
The Generalized Anxiety Disorder 7-item (GAD-7)	−0.309**	0.800**	1.00

p-value < 0.01.

TABLE 6 Evaluation of normality of research variables using the Kolmogorov–Smirnov test.

Variable	Significance level of the test	Skewness	Kurtosis
Personal green space	0.000	0.52	−0.71
The General Health Questionnaire (GHQ)	0.000	0.44	−0.37
The Generalized Anxiety Disorder 7-item (GAD-7)	0.000	0.47	−0.77

TABLE 7 *t*-test at the gender level.

			Equality of variance test		Mean comparison test	
Variable	Gender	Mean	F-statistic	Significance level	t-statistic	Significance level
Personal green space	Female	4.83	8.77	0.00	−0.90	0.37
	Male	5.10				
The General Health Questionnaire (GHQ)	Female	14.82	17.32	0.00	0.23	0.81
	Male	14.67				
The Generalized Anxiety Disorder 7-item (GAD-7)	Female	8.13	2.92	0.09	1.55	0.12
	Male	7.33				

3.3.1 Gender

The results of Table 7 show that the significance level of the test for the variables of personal green spaces, general mental health, and generalized anxiety disorder is more than 0.05, so the use of green spaces and the rate of depression and anxiety are the same among males and females. The graph of the relationship between personal green space, mental health, and generalized anxiety disorder at gender levels is shown in Figure 2.

3.3.2 Marital status

The results demonstrate that the significance level of the test for the personal green space variable is more than 0.05, so the amount of green spaces used is the same among single and married people. Also, the significance level of the test for general mental health variables and generalized anxiety disorder is less than 0.05, so the assumption of the equality of means is rejected with 95% confidence. In other words, the rate of general mental health and generalized anxiety disorder varies between married and single people, and based on the average values of each group, single people are more anxious and depressed than married people.

3.3.3 Age

This factor was used based on the ANOVA test at an error level of 0.05. According to the results, the significance level of the test for the personal green space variable is more than 0.05, so the amount of green space used is the same among different age groups. Also, the significance level of the test for general mental health variables and generalized anxiety disorder is less than 0.05, so the assumption of the equality of means is rejected with 95% confidence. In other words, the rate of general mental health and generalized anxiety disorder varies between different age groups. Based on the mean values of each group, people between 18 and 28 years have the highest rate of depression, and people under 18 years have the highest level of anxiety. The rate of depression and anxiety decreases and the rate of green space use increases with age.

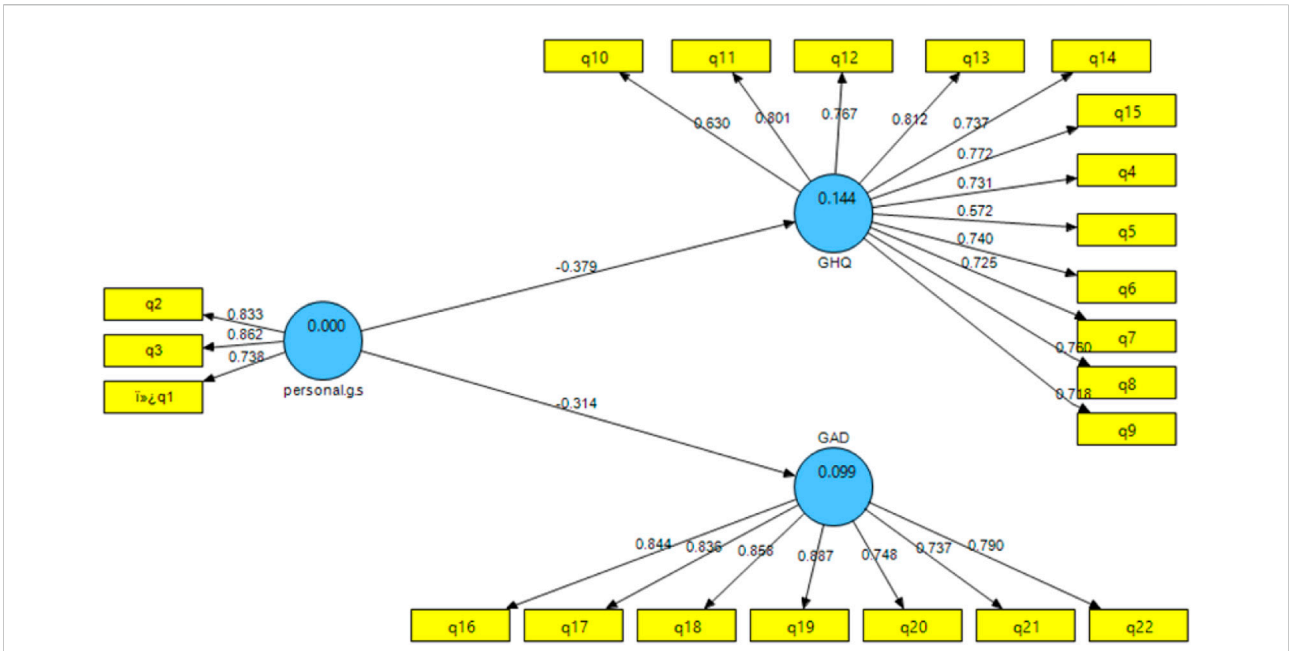

FIGURE 3
Standard path coefficient of the structural model.

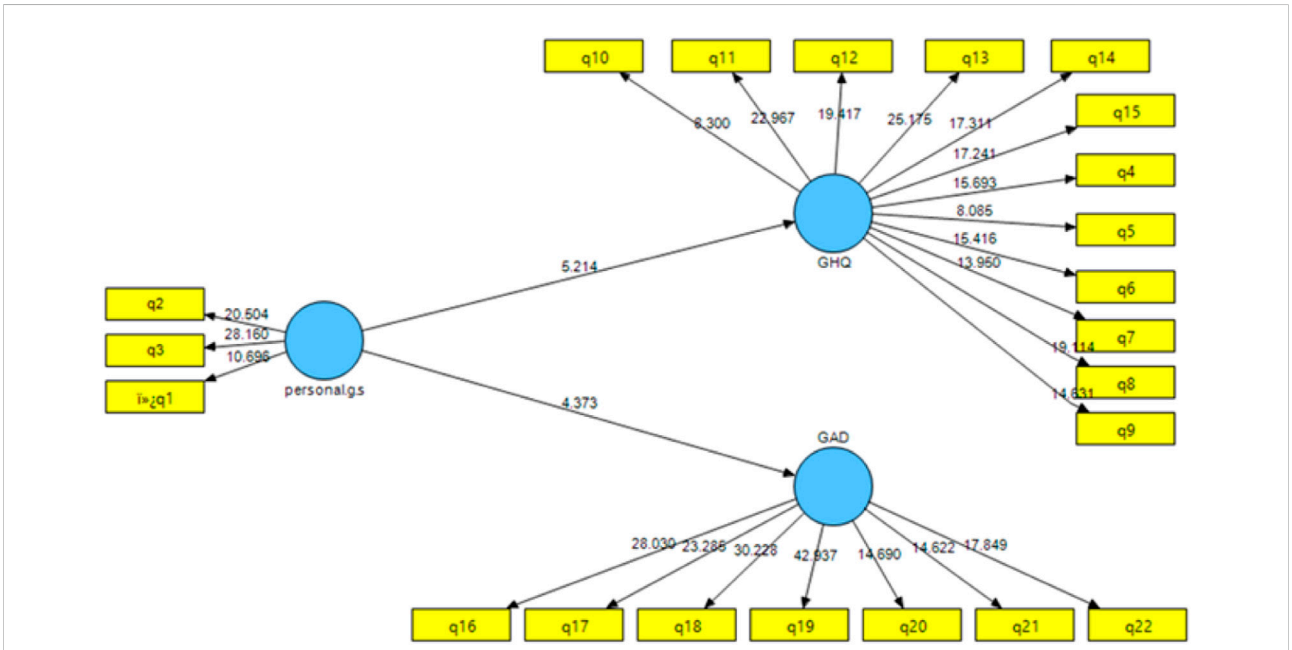

FIGURE 4
Significance level of the path in the structural model.

3.3.4 Monthly income

According to the results, the significance level of the test for the variables of general mental health, personal green space, and generalized anxiety disorder is less than 0.05, so the assumption of mean equivalence is rejected with 95% confidence. In other words, the level of general mental health, personal green space, and generalized anxiety disorder varies between people with different income levels and based on the average values of

each group. People with incomes over 100,000,001 million rial have the most use of personal green spaces. People with a revenue of 20,000,000 million rial or less have the highest rate of depression and anxiety. Also, with increasing income, the rate of anxiety and depression has a decreasing trend. The average use of personal green space is not much different among people who earn less than 100,000,000 million rial.

3.3.5 Education

According to the results, the significance level of the test for the variable of personal green space and generalized anxiety disorder is more than 0.05, so the use of green space and the level of anxiety are the same among people with different levels of education. Also, the significance level of the test for general mental health variables is less than 0.05, so the assumption of the equality of means is rejected with 95% confidence. In other words, the rate of general mental health and generalized anxiety disorder varies among people with different education levels. Based on the average values of each group, people with a master's degree have the highest rate of depression. The results show that as the level of education increases, the rate of depression increases.

3.3.6 Structural equation modeling

Figure 3 demonstrates the Standard path coefficient of the structural model. The structural model is a part of the model that shows the relationships between the latent variables of the research. After the quality of the measurement model was confirmed, the authors evaluated the structural fit of the model. For this purpose, the t-statistic and R^2 index were used. The value of t-statistic between the variable of personal green space and general mental health and personal green space on generalized anxiety disorder is more than 1.96. Therefore, the personal green space affects general mental health and generalized anxiety disorder. The significance level of the path in the structural model is shown in Figure 4.

3.3.7 Determination coefficient (R square)

The overall fit using the GOF criterion for the comprehensive research model is 0.272, which indicates the average fit of the general research model. After reviewing the fit criteria of the model and ensuring the suitability of the model, the authors analyzed the research hypotheses.

3.3.8 Evaluation of hypothesis (1): The personal green space has positive effects on the level of human general mental health

The *t*-test (statistics T: 5.21) and the standard coefficient of the path (standard path coefficient: −0.38) between personal green space and general mental health were assessed. Based on this evaluation, it was evaluated that the personal green space has a negative correlation and significant effect on general mental health. In other words, increasing the use of personal green spaces in residence reduces depression.

3.3.9 Evaluation of hypothesis (2): The personal green space has positive effects on reducing symptoms of generalized anxiety disorder

The *t*-test (statistics T: 4.37) and the standard coefficient of the path (standard path coefficient: −0.31) between personal green space and generalized anxiety disorder were assessed. This assessment indicates a negative correlation and significant impact of personal green space on generalized anxiety disorder. In other words, increasing the use of personal green spaces reduces anxiety.

3.3.10 Evaluation of hypothesis (3): There is a relationship between demographic characteristics and the level of human general mental health and symptoms of generalized anxiety disorder.

According to the analysis, there is a relationship between demographic characteristics of people with their level of mental health and the degree of symptoms of general anxiety. Therefore, personal green spaces are not the same for all age groups, gender, education, marital status, and income levels.

Moreover, by comparing the results of the first and second hypotheses, it can be concluded that the personal green space in reducing the rate of depression is more significant than its role in reducing anxiety among individuals.

4 Discussion

With the outbreak of the corona pandemic and government orders for social isolation, reduced outdoor activities, and people spending more time at home, more symptoms of depression and anxiety among people in the community were seen. One way to reduce the symptoms of depression and anxiety is to be exposed to green spaces, which has decreased during the corona epidemic. This research considers three methods of personal green spaces, including having houseplants, a view of the green space through windows, and having a private garden or balcony with flowers and plants, as alternatives to the green space outside the house, through a questionnaire. Among 700 residents of apartments in Tehran, this study assessed the incidence of symptoms of depression and anxiety. Also, a structural equation model was developed.

This study examined the effects of demographic characteristics concerning personal green space on mental health, depression, and anxiety separately. Gender differences in the effects of environmental factors on different dimensions of health are beginning to emerge (Roe et al., 2013). The results of research on students in India during COVID-19 to evaluate built environment attributes with anxiety and depression risk demonstrated that gender has no significant associations with anxiety and depression risk (Asim et al., 2021). Another study showed a significant interaction effect between gender and

percentage green space on mean cortisol concentrations, demonstrating a positive effect of higher green space concerning cortisol measures in women but not in men (Roe et al., 2013). In the current research, there was no significant difference, and the rate of green space use and the rate of depression and anxiety were the same between men and women. Moreover, the marital status is another demographic variable, which was evaluated in this study. The result showed that personal green space used by married people is slightly higher than that used by single people. Moreover, single people are more anxious and depressed than married people. Also, there are many research studies conducted on the positive effects of nature on the elderly. For instance, research on older adults demonstrated that green space characteristics are linked to their mental health status (Zhifeng and Yin, 2021) although some studies have not found significant differences between different age groups. For example, a study in the COVID-19 era for assessing garden use and mental well-being in the elderly showed no significant differences between gardeners and non-gardeners in some demographic variables such as gender (Corley et al., 2021). In this study, there was a difference between the uses of personal green spaces. According to this, the rate of green space use increases while depression and anxiety decrease with age. Also, people between 18 and 28 years have the highest rate of depression, and people under 18 years have the highest level of anxiety. Moreover, income is another demographic variable in this study. The results showed that people with incomes over 100,000,001 million rial have the most use of personal green space. With increasing income, the rate of anxiety and depression has a decreasing trend. This factor may be due to housing policies in Tehran, where people with higher income levels have larger apartments, generally with a more favorable and spacious view, and in most cases people have green balconies, courtyards, or roof gardens. In comparison, people with low-income levels have fewer of these facilities. The education level is another variable. However, a study conducted in the COVID-19 era assessing garden use and mental well-being in the elderly showed no significant differences between gardeners and non-gardeners at the education level (Corley et al., 2021). Also, the results of a study on students in India during the corona pandemic for assessing built environment attributes with anxiety and depression risk demonstrated that gender has no significant associations with anxiety and depression risk, and the effect on productivity showed that. Although the educational level was linked to anxiety level and productivity, the educational level has no associations with depression risk (Asim et al., 2021). In this research, as the level of education increases, the rate of depression increases, and people with a master's degree have the highest rate of depression.

This study showed that personal green spaces affected depression and anxiety of apartment residents in Tehran during the COVID-19 pandemic and that green spaces can be introduced as an appropriate alternative solution during quarantine at home. The findings are in line with earlier studies. The research was carried out on the general mental health of Plovdiv students and demonstrated that spending more time on the greenery and having a green view were associated with a higher level of general mental health (Dzhambov et al., 2018). Moreover, the research on prisoners visually exposed to natural sceneries through watching videos of natural settings reported higher restoration and affective state (Nadkarni et al., 2017; Moran, 2019). Numerous studies in various situations have shown that the presence of plants indoors can be effective. For instance, placing plants in the classroom can increase children's performance (Duijn et al., 2011). In addition, the studies on hospitalized patients demonstrated that patients staying in a room with a view of green landscapes or having plants in the room reported less fatigue and anxiety, and they ultimately had faster recovery after their surgical interventions (Ulrich, 1984; Park and Mattson, 2009; Aslam et al., 2016). The research showed that interior plants could lead to productive workplaces and health by decreasing stress levels, enhancing attention capacity, and achieving higher job satisfaction (Raanaas et al., 2011; Hartig et al., 2014; Gilchrist et al., 2015). A greenery view through windows can help recover from stressful events (Li and Sullivan, 2016) and psychological restoration (Lee et al., 2015). Also, there is increasing evidence that gardening provides substantial health benefits for humans (Soga et al., 2017). Moreover, many researchers reported that gardening during COVID-19 positively affects human mood (Carvalho and Gois, 2020; Lades et al., 2020). Overall, the findings of this research support the hypotheses that personal green spaces have a significant and negative correlation impact on mental health and anxiety. These findings support the hypothesis that the personal green space can be a suitable alternative for the public green space during COVID-19 for apartment residents in Tehran. However, no causal interpretation of these associations is possible.

5 Conclusion

This study investigated the effects of personal green spaces as an alternative to public green spaces unavailable during the COVID-19 pandemic. For this purpose, information was collected from 700 apartment residents in Tehran through surveys and questionnaires. The results demonstrated that personal green spaces affected depression and anxiety levels of apartment residents in Tehran during the COVID-19 pandemic, and that green spaces can be introduced as an appropriate alternative solution during quarantine at home.

Based on the results, in future designs, the connection between the house and green spaces should be maintained as much as possible, and green space should be drawn into the house as much as possible so that individuals' connection with

nature remains at its maximum. As a result, architects in their future designs need to have a patio where there are conditions for keeping houseplants, designing semi-open spaces, and space hierarchy. Also, urban planners, in comprehensive plans, should consider the relationship between buildings and construction permits in terms of height (a building should not obstruct the view of the occupants of another building in green and blue). Also, the distance between the blocks in front of each other should be calculated accurately. In the design of buildings, it should be considered that in addition to the balcony, windows are the primary communication with the view and landscape outside the building. In terms of number and quantity, logical calculations should be applied to maintain sufficient visibility of green and blue spaces. Finally, it should not be forgotten that according to what the literature has shown, nature is the source of human peace. Also, this study showed that the current approaches to the apartment building in Tehran, which are based on the maximum use of land without considering the visual space, could severely threaten residents' mental health. Urban designs consider the presence of green spaces among building blocks, the creation of pocket parks, and green spaces in general at different scales. In order, it is recommended in future residential plans to create a suitable space to maintain the view of the green space, allocate a part of the land area for a private garden, or create suitable conditions for creating a roof garden for residents to communicate with nature.

The current research has some limitations. First, this study only analyzed the responses of middle-class (middle-income) residents who live in medium-sized buildings. Because these two factors can affect the results, future researchers can investigate these factors at other levels. On the other hand, each personal green space can have different effects that can be analyzed in future research. Also, mental health consists of different dimensions, and the effects of personal green spaces on each of these dimensions can be investigated.

On the other hand, the findings showed that personal green spaces have a significant and negative correlation impact on mental health and anxiety. However, no causal interpretation of these associations is possible. Therefore, future studies can examine the reasons for this. Also, the research on the effect of different dimensions of green spaces on other psychological and physical dimensions of human beings can be among future studies. Moreover, examining the effects of these spaces on spatial functions and individuals' satisfaction with the space is one of the concerns that should be studied.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Materials; further inquiries can be directed to the corresponding authors.

Author contributions

The authors confirm contribution to the manuscript as follows: study conception and design: MK and MF; data collection: HK; analysis and interpretation of results: HK and MK; and draft manuscript preparation: HK, MF, and MK. All authors reviewed the results and approved the final version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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