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Evaluating urban public spaces from mental health point of view: Comparing pedestrian and car-dominated streets

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ABSTRACT

Introduction: So far, the planning and design of public urban spaces have not been specifically researched from the perspective of mental health. Only a few studies in the field of urban mental health have investigated the effect of different dimensions of public space design on mental health. Focusing on the street as a major type of public space in all cities around the world, the present study seeks to examine the effect of the dimensions and qualities of street design on mental health.

Methods: This experimental study evaluates the psychological results related to two types of urban streets with and without motor traffic. Using a mixed design and a cross-sectional study of the users of public spaces (n = 547), we have measured their level of mental health as well as environmental perception after facing one of the two types of environment. The data were experimentally analyzed via partial least square structural equation modeling (PLS-SEM) and SmartPLS 3.0 software package.

Results: The results show that mental health in pedestrian streets is greatly affected by micro-level physical features of the environment and more specifically by natural elements. Whereas, in car-dominated streets, the macro-level physical features of the environment have a stronger effect on mental health. From these features, pollution had the strongest effect on mental health in car-dominated streets. Three further factors are important to mental health in pedestrian streets which include social relationships, safety, and social surveillance. In both streets, factors such as mixed land use, public transportation, attractiveness, active edge, quality of the pedestrian path, soundscape, and air pollution have the closest association with mental health. Additionally, the dominance of cars not only affects mental health through air and noise pollution but also threatens it by limiting the social experience of space.

Conclusions: Although experimental and longitudinal evidence is needed to verify findings, The study illustrates those spaces with better public qualities (i.e., pedestrian streets) tend to have stronger effects on citizens' mental health.

1. Introduction

Psychological disorders are a remarkable part of diseases in the world (2008a), and urban inhabitants are at a higher risk of

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developing such disorders (2010a; Galea, 2011; Lederbogen et al., 2011). Given the increasing growth in urbanization and the estimation that 68% of the world population will be living in cities by 2050 (Nations, 2017), the contribution of cities to psychological disorders has received more attention. On the other hand, the designing and formation of urban areas determine people's choices in life (Field, 2011) and urban environments as the most important manifestation of urban life play a crucial role in recovering and boosting mental health in citizens.

As research has indicated that mental health is a major need of citizens (Riyahi et al., 2010) which should be met by urban designers and planners (WHO, 2011). Although the relationship between urban structure and mental health can be considered central to anthropological environmental studies (Kyttä et al., 2011), it has not yet received sufficient attention and is even unknown and unresolved in some areas (Saxena et al., 2006).

Recent studies have remarkably focused on the importance of public spaces and investigated the different aspects of these spaces. As Eyles and Litva put it (1998), public spaces are conducive to social relationships, place communities, and a sense of belonging. Social interaction in public spaces can ease the burden of routine everyday life, contribute to the sense of belonging in society, create opportunities to connect with other people and build morale by increasing people's tolerance (2008b). As a prominent component of urban structure and probably the most important public space, streets have a direct influence on citizens' life and determine their quality of life to a great extent. Small-scale environmental elements on the street may affect the symptoms of mental disorders and can be accounted for as risk factors for these disorders (Perkins and M.J.Taylor, 1992).

Although there has been a considerable rise in research into cities and mental health, only a few studies have focused on the role of streets. Streets are important public spaces (Appleyard and Lintell, 1972) that play a determining role in citizens' daily life as well as in their mental health. As a result, urban design research should be directed toward investigating streets and how they might be associated with mental health. Addressing environmental factors, particularly on a street scale, can help us to build paths that could enhance citizens' mental health.

The purpose of this article is to investigate the design features and qualities of urban public spaces that are related to mental health. Previous studies have examined this relationship mainly in the form of a single factor, such as green space, and this article tries to evaluate the sum of factors affecting the quality of public space. A comprehensive assessment of the effects of the elements of the urban environment on mental health, in addition to measuring the design attributes of public spaces, requires the measurement of daily life activities such as movement patterns, employment, recreation, shopping, etcetera. Nevertheless, evaluating the evaluation of urban public spaces from the point of view of users who spent most of their daily time for many years in the specific public space can provide a proper understanding of the relationship between mental health and the characteristics of space design.

We focus on four aspects of the environment. Furthermore, this study contributes to the literature by measuring individuals' satisfaction with 14 factors in two different streets to understand the potential relevance and importance of the urban environment to users' mental health. This study hypothesizes that 14 elements derived from these four aspects have a positive relationship with mental health.

2. Review of literature

This section explores the positive and negative effects of the built environment on people's mental health as well as the role of walking in the improvement of mental health. Research findings confirm that the built environment influences physical and mental health (2004; 2010b; 2013; 2014; Dreger et al., 2014; Kaplan, 2001). His environment can potentially enhance our health while it may also provoke stress and increase our anxiety (Moughtin et al., 2009). Following is a brief discussion of the numerous studies conducted on these positive and negative effects.

The literature is indicative of the direct and indirect effect of many environmental factors on citizen's mental health, namely, the diversity of species in green spaces (Azadeh et al., 2019a,b), the quality of green spaces (Houlden et al., 2017), access and proximity to green spaces (Riyahi et al., 2010; Zhang et al., 2019b; Duncan et al., 2013; Choosing restorative environments across the, 2004; Sturm, R.; Croucher et al., 2007), and the quantity of these spaces (Gascon et al., 2015a,b; Gong et al., 2016; Qiu et al., 2019). In addition to the studies on the relationship between urban green spaces and mental health, a number of studies have decisively confirmed the positive effects of using public spaces (Grahn and Stigsdotter, 2003; Hadavi et al., 2018; Macintyre et al., 2008; Shackleton and Blair, 2013; Wendel et al., 2012) and walking in public urban spaces (Leyden, 2003a) as well as its direct and indirect association with increased social connections (Coley et al., 1997; Maas et al., 2009; Sullivan et al., 2004), physical activity (Sugiyama et al., 2008), and sense of place(2008c; Dannenberg et al., 2011a). Samavati and Ranjbar (2017) indicated that environmental factors and pedestrian-orientedness along with variety, legibility, and place identity would not only boost mental health but also improve citizens' sense of happiness.

Recent research has suggested that the undesirable features of the built environment could lead to social crimes and disorders in neighborhoods which potentially affect stress levels and lack of self-control and increase the risk of depression by intensifying supportive social networks (Barton, 2016). A case in point is some environmental features of streets and buildings such as vacant streets and graffiti. Dreger and colleagues (Dreger et al., 2014) have indicated that, apart from the apparently positive psychosocial and socio-demographic features of neighborhoods, some physical factors (pollution, waste management, and road traffic) might have different effects on mental health. In this vein, the urban environment is a potential factor of health and well-being inequality which should be addressed in all approaches to health (Croucher et al., 2007; Scotland, 2007).

As with the effect of urban environmental factors on mental health, Duncan (Duncan et al., 2013) briefly explains the spatial distribution of the built environment's indicators related to depression among young people. Nevertheless, the small number of studies have limited statistical capability to measure the most significant effects (Araya et al., 2006; Mitchell, 2003; Surtees et al., 2003; Weich

et al., 2002, 2003). A wide range of people, and not only with a clinical diagnosis, may experience unpleasant feelings and anxiety when passing through the public spaces of their neighborhoods; therefore, the designers are responsible for how the design could aggravate or alleviate these feelings (Dillon, 2005).

So far, different types of anxiety have been investigated, ranging from clinical psychological anxiety through realistic anxiety to phobia due to a known trigger. However, the boundaries between these types are gradually fading. In the conditions of today's cities, various stressors can provoke clinical anxiety symptoms in public urban spaces, particularly in response to perceived violence, crime, and terrorism (Dillon, 2005). Attempting to reduce these stressful experiences is of great importance in a society where anxiety is a common sign of urban life (Space, 2005). Therefore, designing public spaces for all levels of social coherence requires thinking in architecture and urban design (Dillon, 2005). An appropriate response to these threats and moving towards an improved mental health state is a necessity in modern life. However, decisions concerning health and development will not immediately affect public health; instead, their effect is a gradual process that only begins with decision-making (Barton, 2016).

Halpern (2014) investigates stressors in built environments which can affect an individual's mental health. He divides environmental tensions into "social" and "classical" stressors. Classical tensions include elements such as weather, air pollution, noise, and water quality which are mainly physical stressors whereas social stressors include crime, fear of crime, crowding, and density (Moughtin et al., 2009). The latter are stressors that are directly created by humans.

In sum, the stated relations between mental health and the urban environment could be classified in Fig. 1. As the conceptual model of this study reveals, four prominent relations were considered from four groups of environmental variables and mental health. Also, six other relationships were considered among these four variables.

In the discussions of the factors of health in the field of public well-being, the focus has shifted from a vehicle-oriented lifestyle to the positive effects of walking as a method of urban transportation (Frank and Engelke, 2001). The development of transportation methods that require more physical activity brings about drastic changes to citizens' physical health. The positive effects of this approach on mental health have also been confirmed. For instance, the research of Peluso et al. (Peluso and Andrade, 2005) indicates that physical activity can reduce stress by secretion of certain hormones (such as dopamine), enhancement of the neurological system, and oxygen consumption.

Improvement of mental faculty through physical improvement is one of the ways proposed by many psychologists and sociologists to mitigate the burden of mental disorders. Those who are physically active are less likely to be diagnosed with brain diseases and exercise can be of great help in treating mood disorders such as depression (Ströhle, 2009). Physical exercise reduces the risk of many physical and mental diseases (Dannenberg et al., 2011a,b).

Places that encourage and support physical activity can not only prevent but also contribute to the treatment of depression. Many studies have confirmed the association between physical activities such as walking and cycling and the reduction of mental health disorders like depression (Ng et al., 2007).

Stephens and Craig indicated that those who prefer to walk to close destinations and are physically more active tend to have a better mood, higher self-confidence, and a more active mind (Stephens and Craig, 1990). Similarly, a study of 400 subjects in Canada concluded that those who have physical activity regularly usually have a more positive mood. An analysis of two studies in Canada and two studies in the United States which had been conducted between 1971 and 1981 disclosed that physical activity stands in a significant relationship with mental health problems such as anxiety, depression, and general disorders (Weich et al., 2002). According to WHO statistics, 60% of the world population does not perform the minimum daily physical activity required for physical and mental health (Lavin et al., 2006).

Research findings indicate that increased physical activity may reduce the risk of depression while lack of activity is a risk factor for depression. Planning and designing neighborhoods can have frequent effects on mental disorders. Urban planners and designers can improve mental health by creating places that have minimum levels of noise with enough exposure to sunlight and encourage people to walk, run, play, ride bikes, and engage in other physical activities (Sullivan et al., 2004). Within urban environments, streets and parks can be used for walking and cycling so that people would become less dependent on motor vehicles for transportation. In addition to promoting physical activity among citizens, this could reduce the hygienic and environmental risks of greenhouse gas emissions. Thus, a more satisfying physical and mental health status is achieved via decreased exposure to air pollution and increased physical activity

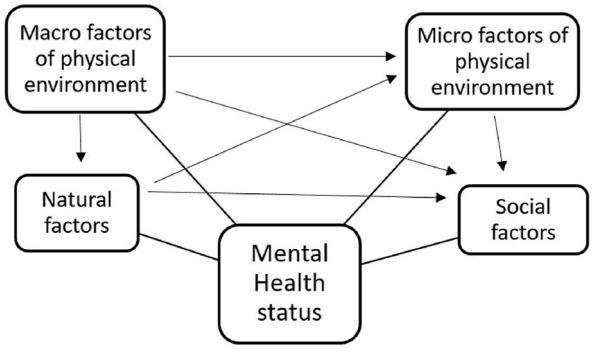

Fig. 1. Conceptual framework model.

(Dannenberg et al., 2003).

Moreover, places that support physical activity are significant stimuli in responding to therapeutic needs. Individuals will have more opportunities to communicate and establish friendly relationships during physical activity. Presence outside the home and physical activity will strengthen one's relationship with society. Also, many studies have indicated that physical activity can increase self-reliance and self-confidence, which are directly related to mental health. According to a study in Ireland, residents of communities that tend to walk have higher levels of social capital (Leyden, 2003b).

Neighborhood units with the capacity of walking on a human scale that provide safety and security as well as public and semi-public spaces such as parks, squares, and streets with trees can create more stable social interaction among citizens and enhance their mental health (Dannenberg et al., 2011a,b). As social networks and commitments have positive consequences for public health, people with high levels of social interaction tend to live a longer and healthier life, both physically and mentally. In communities with a strong sense of belonging and social life, quality of life and health are likely to be higher and more stable. Research shows that most people like to live in neighborhoods where they can live an active life. An active lifestyle achieved by increasing opportunities for social encounters, creating communication networks, and enhancing cultural identity will result in social cohesion (Berland, 2009).

Walking in the city prevents physical and mental illness. It also reinforces social networks due to people's presence and participation in public urban spaces (i.e., Streets) and brings about positive psychological effects which increase citizens' sense of satisfaction and acknowledge their health properly (Sullivan et al., 2004). Thereby, focusing on pedestrian urban streets opens an avenue toward enhancing public mental health in cities.

There are several classifications regarding indicators of mental health in the built environment. Considering the literature on the relationship between environment and mental health, we attempt in this study to propose a comprehensive model of the factors of mental health on the scale of public urban spaces with a particular emphasis on streets. A social-ecological approach is designated for recognizing the interrelationship between individuals and their social and physical environments (Stokols, 1996). This framework was used to investigate associations between two types of public spaces' indicators and mental health (as measured by positive mental health) independently of other demographic and individual correlates (Table 1). This study acknowledges that, apart from interpersonal and demographic features, the impact of the built environment on mental health could be identified through features that can be divided into four groups, namely macro- and micro-level, natural factors, and social factors. A conceptual model of the relationship between street indicators and mental health is considered with a careful review of previous studies based on a social-ecological approach (Fig. 1).

This model was re-conceptualized as a framework specifically for understanding the interactions between factors while helping us with identifying mental health status. Our focus in this study is to find the relationship of the factors to mental health and explain how these features could affect space users' mental health status.

3. Material and methods

Several studies have been conducted on the evaluation of the qualities of public spaces so far (references). However, few studies identify the qualities that are most associated with mental health. Therefore, based on the research background, this study identifies

Table 1
Environmental features affecting Mental Health.

Latent Valuables	Observed Valuables	Description/Statement	Reference
Macro factors	Mixed use	Mixed use and access to diversity of services	(Gong et al., 2016; Zhang et al., 2019b)
	Height	High-rise environments around	Kalantari and Shepley (2020a)
	Density	Density of buildings and population	(Bornioli et al., 2018a, b)
	Public transportation	Access to public transportation	(Litman, 2012; Melis et al., 2015; Zhang et al., 2019b)
Micro factors	Attractive	Attractive and aesthetics of spaces	(Bond et al., 2012; Burton, 2015b)
	Active frontages	Active frontages	(Bond et al., 2012; Burton, 2015b)
	Access to light	Daylighting and Natural received light	(Andersen et al., 2013; Azadeh et al., 2019)
	Walkability	Pedestrian-orientedness	(Azadeh et al., 2019; Bornioli et al., 2018b; Samavati and Ranjbar, 2017)
Natural factors	Green space	Access and quality of green spaces	(Croucher et al., 2007; Grahn and Stigsdotter, 2003)
	Quality of noise	Noise pollution and level of noise in environment	(Firdaus, 2017a; Guite et al., 2006b)
	Air pollution	Cleanness and air pollution	(Bullinger, 1989; James et al., 2017a,b)
Social factors	Social relationship	Social support and social interactions	(Gu, 2020; Spokane et al., 2007)
	Crime	Crime rates and fear of crime	(Firdaus, 2017a; Guite et al., 2006)
	Social security	Eyes on the street, and Sense of security	(Bornioli et al., 2018a; Burton, 2015b)
Mental Health	MH.1	have been feeling cheerful	
	MH.2	have been thinking clearly	
	MH.3	have been feeling close to other people	
	MH.4	have been able to make up my own mind about things	
	MH.5	have been feeling optimistic about the future	
	MH.6	have been feeling relaxed	
	MH.7	have been feeling useful	

the qualities and characteristics of design related to mental health and provides a more accurate assessment of how they are related to mental health.

3.1. Study area

The study examined two adjacent streets: a major car-dominated street and a street that had been a pedestrianized commercial street for 10 years. These two streets are work environments in the center of Tehran with great importance for the city.

Owing to the proximity of these two streets, we can easily compare their qualities of urban design as well as their users' mental health status. The area contains main sections such as the Jomhoori-Saadi Intersection, the Jomhoori-Lalehzar Intersection, Baharestan Square, and the historical edge of Jomhoori Street.

Jomhoori Street: The selected segment of Jomhoori street stretches from Hafez street to 30th-Tir street and is located in District 12 of Tehran (Fig. 2), which is one of the densest districts in the city. It covers more than three-fourths of the historical part of Tehran (the part which dates to the rule of Naser al-Din Shah). This area has been one of the busiest commercial hubs of the Iranian capital (Samavati and Ranjbar, 2017), which includes retail, office, and workshop activities not only for the region but also with a city-wide function.

Saff Pedestrian Street: Saf street (Sepahsalar Garden), the first pedestrian street in modern Tehran (Ranjbar and Rais Esmaili, 2010), is located within the commercial district of central Tehran, in Neighborhood 3, Zone 1, District 12 (Fig. 2). Geographically, it is delimited by Mesbah street (between Zahir al-Eslam Street and Hedayat Street) on the east, by Saadi street on the west (between Zahir al-Eslam street and Hedayat Street), by Hedayat Street on the north (between Saadi Street and Zahir al-Eslam Street), and by Jomhoori street on the south (between Saadi street and Zahir al-Eslam street). It is a major commercial street that functions on an urban and national scale (Ranjbar and Rais Esmaili, 2010). The dominant activities in the Saff pedestrian area are commercial-workshop (production of shoes and bags), whereas residential uses are also found in the street's alleys.

These two cases are not surrounded by the rich residential context, as they are in particular commercial zones. Therefore, it was necessary to choose participants with the highest time spent and more acquainted with each space. Thus, Participants were mainly salespeople and shopkeepers who visited each space at least four full-time (9 a.m.–9 p.m.) and two part-time days (9 a.m.–2 p.m.) during the last week of the study. The selected interviewees have been working in these streets for many years, and most of the participants have more than five-year of experience working in these sites. It was arranged to designate a convenience sample of more than 240 interviewees in each area to conduct a questionnaire designed by the research group with a face-to-face interview.

4. Methods

This study was conducted to evaluate better environmental factors affecting mental health using five main steps (Fig. 3). These steps have started with the classification of previous related research and then with the Delphi model for the Iranian context and field investigation to ensure its validity. In the next stage, in the form of field research, information was obtained using questionnaires and face-to-face interviews, and PLS-SEM was used to evaluate the results. Finally, we compared the results to investigate the effects of pedestrian-orientedness and car dominance in these two streets.

4.1. Evaluating factors

After a comprehensive review, we extract street quality and mental health indicators. Afterward, a particular classification model of factors is considered to compare the indicators.

As localized factors for evaluating citizens' mental health had not been utilized in the Iranian context, we decided to pursue expert opinion through the Delphi technique to localize the relevant criteria. For this purpose, we first developed a questionnaire containing selective questions for the Delphi procedure. In this stage, 21 extracted factors of the most recurrent and significant indicators were evaluated and validated via an expert survey and localized the criteria through the Delphi technique. This model was processed using 31 experts from four groups urban design and planning, sociology, psychology, and architecture (Appendix 1).

In the third stage of this study, the extracted factors were evaluated in the context of this research, using the field survey technique. Also, interviews were used to compile the most effective indicators in the Iranian context. These 14 criteria, taken from the mental health literature, are based on mental health factors and the quality of urban streets, which can be a beginning to improve mental health in the streets.

4.2. Questionnaire design and data collection

To understand the potential relevance and importance of the urban environment to users' mental health, we conducted a cross-sectional analysis to examine the associations between elements of the urban environment and the mental health of frequent users of two street types.

Given the importance of the identification of mental health indicators, the factors were surveyed through questionnaires administered to both people and experts. The questionnaires were then analyzed in SPSS and PLS Smart v3.0 software package using partial least square structural equation modeling (PLS-SEM) with other advanced analytical tests. We interviewed more than 550 respondents (salespeople, shopkeepers) in person between December 15th and 30th, 2018.

As expressed in our model, mental health can be affected by structural-physical (Micro and Macro), social, and natural contexts. For

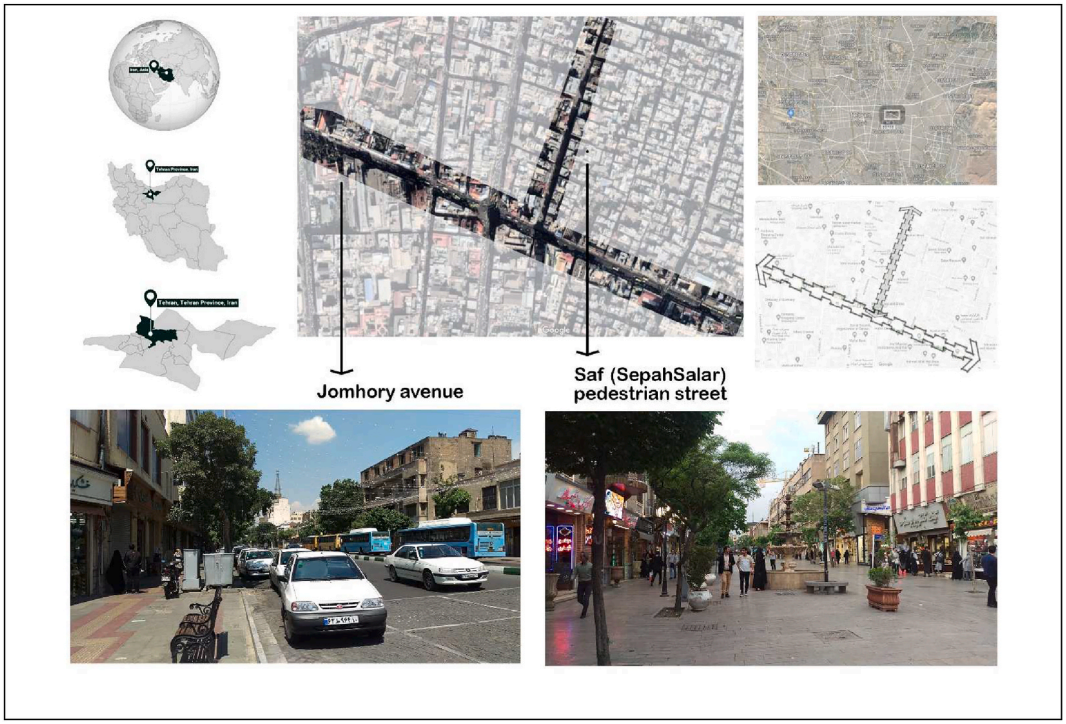

Fig. 2. The area of study (source: authors).

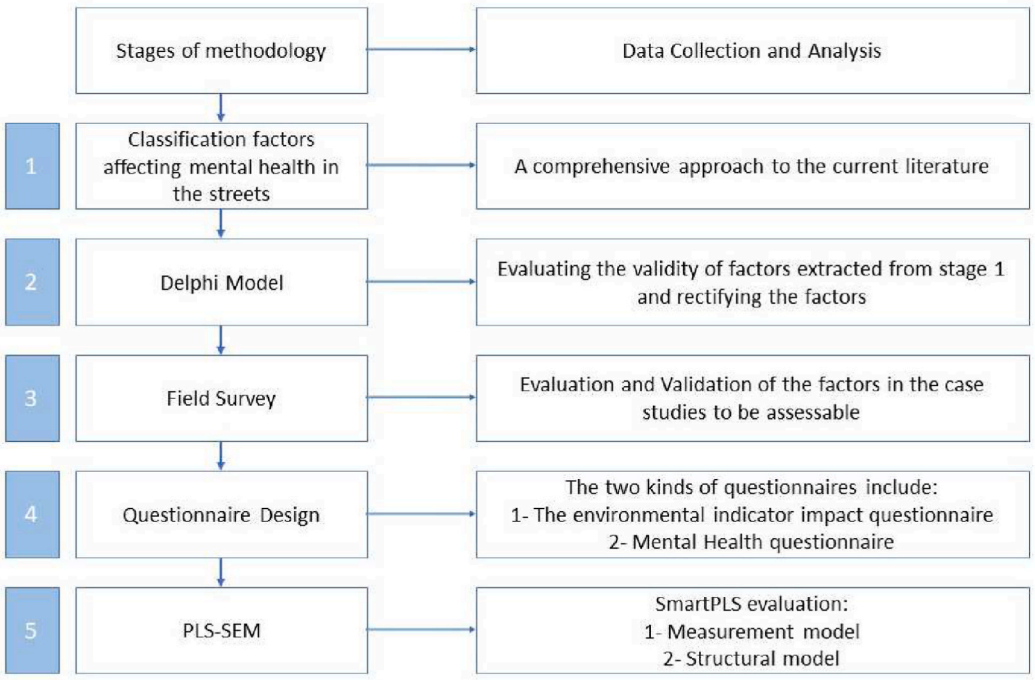

Fig. 3. Methodological flow diagram.

this reason, what is of primary importance here is which factor affects the study area most. Also, the solutions and strategies which could be selected in this situation, and the indicators that can be used for responding to each of these components.

The final questionnaire was divided into three subsections, each of which had strong validity. The first part aimed to collect general

information such as age, gender, level of education, etc. The second section aimed to evaluate the perceived Environmental Indicators, and the last part is designed to assess the positive mental health of the respondents.

4.2.1. Perceived Environmental Indicators

The second section of the questionnaire investigated the effects of the environmental features of each space. In making the questionnaire, Measures to assess satisfaction with the environment had been adopted from previous studies (e.g., Chu's model (Chu et al., 2004)) as well as Residential Environmental Assessment Tool (REAT[1]) items (Dunstan et al., 2005) were taken into consideration. Before preparing a final questionnaire, a trial survey was carried out to check the relevance of the questions and the comprehensibility of the questionnaire. Afterward, a pilot survey in both spaces was conducted, which indicated that the study areas would require distinctive sets of questions and minor alterations to the questions. Therefore, a necessary modification was performed to the questionnaire. In this part, the respondents expressed their opinion on any question using a 5-point Likert score (from 1 = 'Strongly Disagree' to 5 = 'Strongly agree).

The survey asked respondents to evaluate the 14 individual factors of their street based on how satisfied they were with each of the 14 elements by indicating how delighted they were with each feature. We adopted a Likert-type questionnaire approach to evaluating residents' satisfaction and the effects of environmental factors on their mental health. The questions were developed in consultation with the steering group.

4.2.2. Measuring mental health

Recognizing the multidimensional and subjective nature of mental health, we provide a seven-item composite statement about feelings and thoughts in the survey, to evaluate respondents' positive subjective wellbeing. This prominent part was measured by a questionnaire derived from our review of profound mental health assessment tools (GHQ-12, SRQ-20, SF-36, and WEMWBS[2]). We decided to use the seven-item statements, which evaluated components, that we believed would be appropriate and easy to understand for ordinary people in the Iranian cultural context (especially in Tehran).

This instrument provides multiple seven-item statements to evaluate respondents' positive subjective well-being. The selected items cover positive affect, satisfying interpersonal relationships, and positive functioning (Tennant et al., 2007). The mental health score is based on how often people have felt in the last month. This measurement is quite consistent with previous studies measuring positive mental health with the same method (e.g. (Anable and Gatersleben, 2005; Hadavi et al., 2018; Qiu et al., 2019),).

The respondents had to assess their perceived general health on a five-point scale from 'none of the time' to 'all of the time' (none of the time, rarely, some of the time, often, and all of the time). The Cronbach's alpha coefficient of the questionnaire is 0.903 and 0.861 in Saf street and Jomhoori street, respectively; therefore, the seven items demonstrate high internal consistency in both areas (reliability of 0.70 or higher is considered 'acceptable' in most social science research situations).

Table 2 demonstrates the loading of each item on the latent mental well-being factor. A higher score of the latent factor in the loadings indicates superior mental health status. The statistics from SPSS were also considered in the table for comparison and to ensure the data acceptability. The results from both methods demonstrate that, in general terms, visitors to Saf Street answered the mental health questionnaire more positively and gained a better mental health score. To be precise, the sum of data from mental health questions is noticeably higher in the Saf area in comparison with Jomhoori street (a mean loading of 0.765 in Saf and 0.693 in Jomhoori, and a mean answered a score of 3.207 in Saf and 2.074 in Jomhoori). This information shows that visitors to Saf street perceived better mental health status.

In the next step, we compare our survey results with previous surveys conducted in Iran to investigate subjective well-being in Iranian societies. After converting our standardized mental well-being scores on a scale of 0–100, the average score of our 547 respondents' mental well-being is 0.7252 (72.5%). The results from Estimated Mental Health status in Table 2 indicate that people in Saf pedestrian street significantly responded more positively (0.7645 or 76.4%) than those in Jomhoori street (0.6924 or 69.2%).

This information illustrates that approximately 27.5% of respondents might have mental health issues. This result is consistent with the personal well-being scores reported in previous studies in different parts of Iran, even though those studies used different survey questions and different statements to measure people's subjective well-being. For instance, according to Emami et al., 29.5% of the total sample (34.1% females and 23.7% males) was above the cut-off score. Also, another more recent study demonstrates that, similarly, 30.2% of the subjects (34.2% of females and 26.4% of males) were suspected of having mental disorders (Ng et al., 2007).

4.3. Data analysis using PLS-SEM

Participants scored the 14 indicators classified in the four groups of factors regarding the two streets. And the relationships between them were explained by careful research and related study. Concerning the validity of the analysis, two tests were performed on the

[1] Environmental features at the micro-scale level were measured using the Residential Environmental Assessment Tool, REAT is a validated and observational instrument designed for measuring the quality of the living environment. The REAT contains property and street level assessments by examining 28 items in four domains: physical incivilities (features of social disorder, such as graffiti, broken windows, and litter on the street); territorial functioning (maintenance and management of private areas, such as decorative features in gardens); defensible space (designs encouraging the control of local areas, such as walls and fences separating public and private areas) and natural elements (aesthetic and outlook of streets, such as trees and green space).

[2] Warwick-Edinburgh Mental Well-being Scale.

Table 2
Mental Health level of the population.

Factor	Saf area				Jomhory area			
	Loading 1*	Mean (1–5)	Std. Deviation	Variance	Loading 2*	Mean (1–5)	Std. Deviation	Variance
1- I have been feeling **optimistic about the future**	0.600	3.2450	.90,263	.815	0.624	2.4195	.96,847	.938
2- I have been feeling **useful**	0.727	2.8112	.82,337	.678	0.685	1.8960	.90,968	.828
3- I have been feeling **relaxed**	0.831	3.7751	.68,216	.465	0.782	1.4933	.72,587	.527
4- I've been **thinking clearly**	0.803	2.8996	1.01697	1.034	0.713	2.3289	.99,793	.996
5- I've been **feeling close to other people**	0.800	2.9719	.98,538	.971	0.718	2.3423	.93,400	.872
6- I've been **able to make up my own mind about things**	0.807	2.9880	.99,791	.996	0.665	2.3389	.95,834	.918
7- I've been **feeling cheerful**	0.784	3.7590	.62,069	.385	0.660	1.6980	.75,393	.568
Estimated Mental Health status (SUM)	0.7645	3.2071	.69,511	.483	0.6924	2.0738	.66,317	.440
variance	0.690				0.340			
Cronbach's Alpha	0.903				0.861			
Number of respondent	249				298			

Loadings* (1 and 2) are estimated with Smart PLS while other statistics presented in the table are provided with SPSS 26.

data: 1) KMO test: Determining the sufficiency of the number of samples for analysis. 2) Bartlett test: It measures the correlation between data.

Both the maximum likelihood structural equation model and partial least squares structural equation model (PLS-SEM) methods were analyzed. The reason for preferring PLS-SEM was that independent and dependent variables be formulated into a linear equation so that each variable could be classified by latent variables, measurement indicators, and measurement error. In this study, we use SmartPLS 3 (SmartPLS GmbH, Bönningstedt, Germany), which can simultaneously analyze the path coefficient of the latent variable and measurements. Unlike the covariance-based SEM methods, which require a multivariate normal distribution of the observed variables, PLS is based on the resampling procedures of bootstrapping, which does not make parametric assumptions. This software package has been used to analyze the hidden relationships between indicators and factors more accurately and correspondingly to introduce a model of environmental factors affecting health.

The PLS-SEM approach contains principal component analysis with ordinary least squares regression, to examine the association between manifest (observed) variables and latent (unobserved variables). In this study, Mental Health, MACRO factors, MICRO factors, NATURAL factors, and SOCIAL factors have been considered latent variables. Furthermore, the observed variables were mixed-use, height, density, transportation, attractiveness, active edge, lights, pedestrian, green, sound, pollution, relationship, crime, and surveillance.

There are two stages for the PLS-SEM analysis. In the first step, Discriminant validity (Fornell Larcker criteria), Convergent validity (AVE), and Internal consistency reliability (Cronbach's Alpha and Composite reliability) were used to evaluate the measurement model. Second, the structural model was evaluated using a bootstrapping procedure. The structural model specified the relationships between the latent variables, whereas the measurement model specified the relations between a latent variable and its observed variables Content validity was ascertained by experts before the pilot testing of the questionnaire items was carried out, which is specifically explained in the Delphi method section.

4.3.1. Measurement model

The measurement model specifies the relations between a latent variable and its observed variables. The reliability and validity were tested using Composite Reliability (CR) to evaluate internal consistency and Average Variance Extracted (AVE) to assess convergent validity (Mohamed and Azizan, 2015).

Internal Consistency: The reliability of an instrument's scale is determined by the internal consistency that exists between the items. In this context, one of the most widely used measures of internal consistency is Cronbach's alpha. In advanced studies, a measurement model has high internal consistency reliability of the composite reliability (CR) or Cronbach alpha (CA) value is 0.8 or 0.9, whereas the reliability is considered low if the value is less than 0.6. The consistency of items becomes higher as the composite reliability (CR) value gets higher.

Convergent Validity: For the convergence and discriminant validities, factor loadings, composite reliability, and average variance extracted (AVE) were assessed. Once there is an established correlation between all the items, convergent validity has already been established. To detect problems with any particular items, respective loadings and cross-loadings of the items are assessed. Convergent validity guarantees that a projected construct is measured by its items. Moreover, convergent validity is acceptable only when the AVE value is at least 0.50.

Discriminant Validity: Discriminant validity is described as an indication of the difference between constructs. Cross-loadings of the construct items and Frank and Engelke (2001) criterion are the two methods for measuring a construct's discriminant validity. In the cross-loading method, the value implies that the items' loadings in other constructs are lower than the loadings they have in their respective constructs. The value of Frank and Engelke (2001) criterion is obtained when a construct's correlation with other constructs is less than the square root of its AVE. These values are a reflection of a measurement model's discriminant validity.

4.3.2. Structural model evaluation

The structural model specifies the relationships between the latent variables. To evaluate the structural model, algebraic signs, magnitudes, and statistical significance of the structural path coefficients should be evaluated. Therefore, the path significance values and hypotheses of this study were calculated using a bootstrap re-sampling routine involving 547 cases and 500 subsamples (2015b). There were two objectives in this regard, examining the relationship between dependent and independent variables and testing the significance of path coefficients (β-values). The assessment of PLS-SEM includes path coefficients to evaluate the significance of structural model relationships, the R2 value estimates the model's accuracy, and f2 to assess the significant impact of the independent variable on a dependent variable (Mohamed and Azizan, 2015). In the next stage, the evaluation of the PLS-SEM structural model is processed. A bootstrap resampling technique was applied to 500 samples. The Path Coefficients (B), including the significance of the proposed relationship between factors, are determined via bootstrapping.

5. Results

5.1. General description

There were 547 completed samples (36.38% females vs. 63.62% males). The Cronbach's alpha value of the overall reliability and validity of the study was 0.947. As shown in Table 3, about 63.6% of the participants in the survey were men. Persons aged 36–45 years accounted for the majority of the sample (31.8%), followed by the younger middle-aged group (25–35 years), and the young and adolescent group (below 24 years). Nearly 44.6% of respondents had undergraduate education (bachelor's degree), over 34% had their high-school diploma or below, and 19.1% had a postgraduate degree (master's or above).

Around 47.9% of respondents claimed to have moderate general health, and about 33.82% reported that they were at a high level of general health. Only 18.28% reported poor health levels.

5.2. The evaluation of PLS-SEM analysis

Before we analyze the result, we should assess the model analysis of PLS-SEM. Model analysis of PLS-SEM proceeded in two steps (Blair et al., 2014; Wu et al., 2016b) (I- the assessment of the measurement model and II- the evaluation of the structural model) which are described below.

5.2.1. Measurement model

Tables 4 and 5 illustrate the reliability of the assessments applied in this model. The AVE of all latent variables was >0.5, indicating high convergent validity among constructs. Tables 4 and 5 illustrate that the lowest value of CR (Composite Reliability) was 0.782 (macro in Saf), which was statistically acceptable. It also indicates that the loadings of all indicators examined in the study ranged between the lowest of 0.630 (height factor in Saf) and the highest of 0.879 (crime factor in Jomhori), while the lowest threshold value of AVE of this study was 0.474 (macro in Saff) that was slightly lower than the common threshold value of 0.5 (Frank and Engelke, 2001). The values of Cronbach's alpha that measured the internal consistency reliability exceeded 0.60 for the latent variable. The square root values of AVE of the study, which are displayed in Tables 5 and 6, indicate that the values were highly different from the values of other constructs, ranging from 0.700 (macro) to 0.842 (social) in Jomhoori and ranging from 0.689 (macro) to 0.814 (natural) in Saf. Overall, the results manifest that the model quality of the study is statistically valid and reliable (see Table 7).

The results of VIF illustrated in the table also indicate no collinearity issue, showing all formative indicators (VIF) < 5 (Ranjbar and Rais Esmaili, 2010), which was no bias for the path coefficients. The highest value of VIF among every environmental measurement indicator in this research is 2.196. So, it may be possible to run the model with no multicollinearity.

Evaluating the outer weight can confirm the adherence, which is the relative importance of each indicator, and the outer loading,

Table 3
Characteristics of the study population.

Demographic variables		Total		Jomhori (298 sample)					Saf (249 sample)				
547 Total samples		n	%	n	%	median	mean	SD	n	%	median	mean	SD
Gender	Men	348	63.62	195	65.4	1.00	1.34	0.47	153	61.4	1.00	1.38	0.48
	Women	199	36.38	103	34.6				96	38.6			
Age group	≤ 24 years	125	22.85	73	24.5	3.00	2.55	1.18	52	20.9	3.00	2.57	1.12
	25–35 years	134	24.49	70	23.5				64	25.7			
	36–45 years	174	31.80	89	29.9				85	34.1			
	46–55 years	85	15.53	50	16.8				35	14.1			
	≥ 56 years	29	5.30	16	5.4				13	5.2			
Education	College or bellow	186	34.00	104	34.9	2.00	1.86	0.76	82	32.9	2.00	1.94	0.81
	undergraduate	244	44.60	137	46.0				107	43			
	Masters or higher	117	21.39	57	19.1				60	24.1			
General health level	Poor	100	18.28	67	22.5	2.00	2.06	0.71	33	13.3	2.00	2.26	0.67
	moderate	262	47.90	145	48.7				117	47			
	Very well	185	33.82	86	28.9				99	39.8			
Cronbach's Alpha from 26 Item						0.947							

Table 4
Reliability and validity of latent variables and observed variables in Jomhory Street.

Latent variable	Fornell-Larcker Criterion					R^2	α	CR	AVE	Q^2	observed variables	VIF	Outer loadings	Outer Weights
	Mental Health	MACRO	MICRO	NATURAL	SOCIAL									
Mental Health rho_A: 0.868	**0.745**					0.804	0.866	0.897	0.555	0.437	MH.1	2.265	0.754	0.186
											MH.2	1.785	0.748	0.194
											MH.3	1.770	0.752	0.197
											MH.4	1.825	0.714	0.185
											MH.5	1.620	0.698	0.176
											MH.6	2.513	0.805	0.212
											MH.7	1.846	0.740	0.190
MACRO factors	0.759	**0.700**					0.653	0.793	0.490		mixed use	1.276	0.714	0.375
											height	1.209	0.651	0.334
											density	1.360	0.722	0.324
											transportation	1.202	0.710	0.395
MICRO factors	0.819	0.644	**0.719**			0.613	0.689	0.811	0.517	0.312	attractiveness	1.334	0.728	0.336
											active edge	1.325	0.720	0.334
											lights	1.219	0.672	0.340
											pedestrian	1.369	0.756	0.380
NATURAL factors	0.797	0.619	0.748	**0.762**		0.383	0.639	0.806	0.581	0.219	green	1.267	0.733	0.431
											sound	1.332	0.735	0.394
											pollution	1.199	0.814	0.484
SOCIAL factors	0.534	0.477	0.580	0.539	**0.842**	0.371	0.797	0.879	0.709	0.250	relationship	1.712	0.787	0.336
											crime	2.196	0.879	0.368
											surveillance	1.616	0.857	0.481

MH1.Cheerful-MH2.clear-MH3.Close to other-MH4.concentration-MH5.optimistic-MH6.relaxed-MH7.useful.

Table 5
Reliability and validity of latent variables and observed variables in Saf Pedestrian street.

Latent variable	Fornell-Larcker Criterion					R^2	α	CR	AVE	Q^2	observed variables	VIF	Outer loadings	Outer Weights
	Mental Health	MACRO	MICRO	NATURAL	SOCIAL									
Mental Health rho_A:0.910	**0.797**					0.856	0.903	0.924	0.636	0.537	MH.1	2.980	0.741	0.167
											MH.2	2.744	0.851	0.190
											MH.3	2.745	0.851	0.191
											MH.4	2.844	0.865	0.192
											MH.5	1.740	0.668	0.142
											MH.6	3.760	0.816	0.194
											MH.7	2.164	0.771	0.173
MACRO factors	0.822	**0.689**					0.629	0.782	0.474		mixed use	1.291	0.724	0.378
											height	1.158	0.630	0.337
											density	1.223	0.663	0.333
											transportation	1.250	0.731	0.401
MICRO factors	0.824	0.734	**0.748**			0.650	0.737	0.835	0.559	0,356	attractiveness	1.352	0.707	0.295
											active edge	1.335	0.722	0.325
											lights	1.504	0.803	0.382
											pedestrian	1.417	0.754	0.331
NATURAL factors	0.881	0.788	0.784	**0.814**		0.622	0.746	0.855	0.663	0,408	green	1.454	0.811	0.410
											sound	1.544	0.795	0.387
											pollution	1.475	0.836	0.431
SOCIAL factors	0.767	0.686	0.648	0.741	**0.773**	0.580	0.667	0.816	0.598	0,330	relationship	1.271	0.727	0.370
											crime	1.284	0.734	0.373
											surveillance	1.359	0.851	0.537

MH1.Cheerful-MH2.clear-MH3.Close to other-MH4.concentration-MH5.optimistic-MH6.relaxed-MH7.useful.

Table 6
Significant testing results of the structural model path coefficients.

Hypotheses	Jomhory street								Inference
	Sample Mean (M)	Standard Deviation(SD)	T Statistics (T-value)	P Values (sig.)	F2	Effects Direct (PC):β	Indirect	Total	
Macro - > MH	0.322	0.035	9.257	0.000	0.286	0.323	0.436	0.759	Supported
Macro - > Micro	0.290	0.051	5.704	0.000	0.136	0.292	0.351	0.644	Supported
Macro - > Natural	0.622	0.038	16.161	0.000	0.622	0.619	–	0.619	Supported
Macro - > Social	0.128	0.066	1.975	0.049	0.015	0.130	0.347	0.477	NS
Micro - > MH	0.381	0.043	8.727	0.000	0.264	0.379	−0.004	0.375	Supported
Micro - > Social	0.346	0.075	4.674	0.000	0.075	0.349	–	0.349	Supported
Natural - > MH	0.319	0.041	7.794	0.000	0.206	0.319	0.211	0.529	Supported
Natural - > Micro	0.568	0.046	12.412	0.000	0.513	0.568	–	0.568	Supported
Natural - > Social	0.203	0.076	2.579	0.010	0.025	0.197	0.198	0.395	Supported
Social - > MH	−0.013	0.032	0.366	0.715	0.000	−0.012	–	−0.012	NS
	Saf pedestrian street								
Hypotheses	**Sample Mean (M)**	**Standard Deviation (SD)**	**T Statistics (T-value)**	**P Values (sig.)**	**F2**	**Effects Direct (PC):β**	**Indirect**	**Total**	**Inference**
Macro - > MH	0.216	0.041	5.169	0.000	0.104	0.213	0.608	0.822	Supported
Macro - > Micro	0.309	0.063	4.884	0.000	0.101	0.306	0.428	0.734	Supported
Macro - > Natural	0.789	0.022	35.709	0.000	1.642	0.788	–	0.788	Supported
Macro - > Social	0.231	0.070	3.380*	0.001	0.046	0.236	0.449	0.686	Supported
Micro - > MH	0.254	0.049	5.136	0.000	0.154	0.253	0.017	0.270	Supported
Micro - > Social	0.108	0.086	1.214	0.225	0.009	0.104	–	0.104	NS
Natural - > MH	0.389	0.051	7.655	0.000	0.265	0.391	0.225	0.617	Supported
Natural - > Micro	0.542	0.063	8.661	0.000	0.318	0.542	–	0.542	Supported
Natural - > Social	0.473	0.094	5.037	0.000	0.153	0.473	0.057	0.530	Supported
Social - > MH	0.166	0.041	4.042	0.000	0.081	0.167	–	0.167	Supported

All: t-value is sig. at $p < 0.001$ - *: t-value is sig. at $p < 0.01$ – β = path coefficient.

Table 7
The relations among environmental variables and mental health.

Variables	Jomhory street				Saff pedestrian street			
	Path Coefficients (β)	T-value	F^2	remarks	Path Coefficients (β)	T-value	F^2	remarks
MACRO	0.323	9.257	0.286	accepted	0.213	5.169	0.104	accepted
MICRO	0.379	8.727	0.264	accepted	0.253	5.136	0.154	accepted
NATURAL	0.319	7.794	0.206	accepted	0.391	7.655	0.265	accepted
SOCIAL	−0.012	0.366	0.000	Not Supported	0.167	4.042	0.081	accepted

t-value is sig. at $p < 0.001$.

which implies its absolute importance (Hair et al., 2016). The outer weight is more than 0.1 (Andreev et al., 2009), and the outer loading is more than 0.7 (excluding four indicators slightly lower than 0.7). The analysis shows that all the criteria mentioned above are satisfied, and the formative measurement model is appropriate. The table presents the results concerning the measurement model in this research.

5.2.2. The structural models

The findings of the path model are displayed in Tables 4 and 5 It is suggested that the R-square values of 0.19–0.33 mean low, 0.33–0.67 mean moderate, and values higher than 0.67 mean strong explanatory power (Wu et al., 2016b). According to Tables 4 and 5, the value of R2 in both Jomhoori street and Saf pedestrian street are indicative of very high determination coefficients. The results in the table indicate that, in Jomhoori street, mental health is evaluated to have strong explanatory power while micro-features, natural features, and social features have moderate explanatory power. Similarly, the same figures were found in Saf street, although with higher coefficients of determination. These data indicate that mental health has strong explanatory power whereas micro-features, natural features, and social features (R2 = 0.580) have moderate explanatory power. Thus, the results in the table demonstrate that mental health in both areas has high explanatory powers whereas other predictors indicate moderate except for the micro-features in Saf street.

The difference in R^2 indicates the overall effect size f^2 for each interaction effect. f^2 coefficients lower than 0.02 are considered small, values between 0.02 and 0.15 are medium, and values higher than 0.15 are considered large effects (Hair et al., 2016). The value of f^2 in Jomhoori shows that macro-on-social features and social-on-mental health are estimated as small whereas macro-on-micro features, micro-on-social features, and natural-on-social features are medium. The values of f^2 in other hypotheses were large. These statistics in the Saf pedestrian street indicate that the effect size of micro-on-social features was small while macro-on-mental health, macro-on-micro features, macro-on-social features, and social-on-mental health are estimated to have medium effects. The other five hypotheses have large effects.

5.3. Analysis results

According to Table 4, in the car-dominated street (Jomhoori street), the relationship between mixed-use, density, public transportation, attractiveness, active edge, quality of the pedestrian section, green space, soundscape, air pollution, social relationships, security, and social surveillance with the respondents' mental health was found to be significant. Only two factors turned out to be insignificant, i.e., the height of surrounding buildings (loading = 0.672) and the natural lights (loading = 0.651). The strongest effects belonged to air pollution, crime, fear of crime, and social surveillance over the space (loading>0.800).

Table 5 illustrates that in the pedestrian-oriented street (Saf), the relationship of mixed-use, public transportation, attractiveness, active edge, quality of the pedestrian section, green space, soundscape, air pollution, social relationships, security, and social surveillance with the respondents' mental health was found to be significant. The figures suggest that the height of surrounding buildings (loading = 0.630) and population density (loading = 0.663) were not significant (Table 5). In the pedestrian street, the strongest effects belonged to natural lights, quality of green space, air pollution, and social surveillance (loading>0.800).

The analysis of PLS-SEM revealed that 8 out of 10 relations among variables in the study of Jomhoori and 9 out of 10 in the study of Saf were significant at $p < 0.001$ (Table 6) except for macro-on-social features in Saf which were significant at $p < 0.01$. Only one of the four main variables toward mental health in Jomhoori was not strongly and positively related to mental health (social features). However, all other variables in Jomhoori and all variables in Saf had strong and positive relations with mental health.

These results suggest that, in Jomhoori, the positive association between mental health and macro-features, micro-features and mental health, and natural features and mental health are acceptable. Furthermore, in Saf street, the positive relations between mental

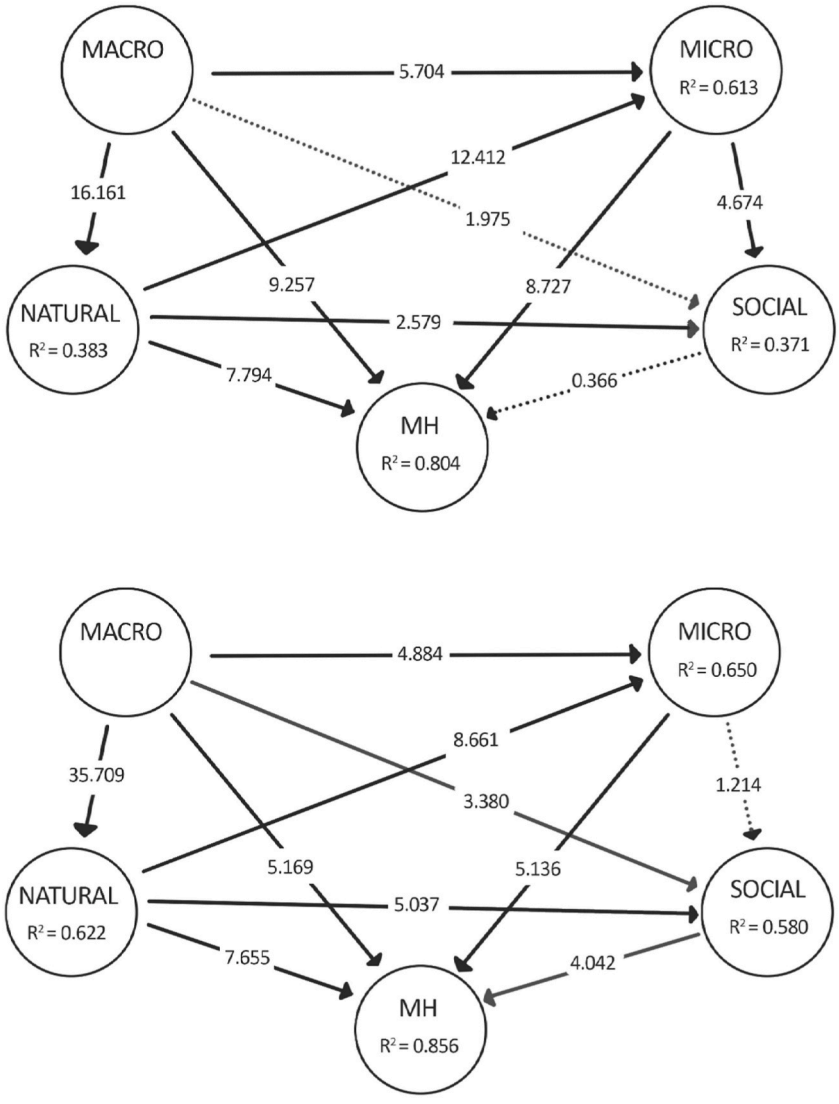

Fig. 4. Structural-equation modeling diagram of mental health and associated factors.

health and macro-features, micro-features and mental health, natural features and mental health, also social features and mental health are acceptable.

Thus, this finding confirmed the following relationships among variables: J: Macro→MH, J: Macro→Micro, J: Macro→Natural, J: Micro→MH, J: Micro→Social, J: Natural→MH, J: Natural→Micro and J: Natural→Social; and also S: Social→MH, S: Macro→Micro, S: Macro→Natural, S: Macro→Social, S: Micro→MH, S: Natural→MH, S: Natural→Micro, S: Natural→Social, and S: Social →MH. Conversely, three hypotheses were not accepted as significant. In this regard, these results rejected the following variables' relations: J: Macro→Social (f^2 not valid), J: Social→MH (P and f^2 not valid), and S: Micro→Social (P and f^2 not valid).

The results demonstrate that the connection between macro-on social features and social features affecting mental health was not supported in Jomhoori street. In the Saf pedestrian area, the association between micro and social features was also not acceptable. The table shows the relationship between environmental factors and mental health. The results indicate that, among all four mentioned features in each study, only social indicators in Jomhoori street were not acceptable, while other variables were acceptable and had a possible relation with mental health.

As shown in the diagrams (Fig. 4), In both streets, there is a significant relationship between all the main features and mental health, except for the social features that were not significant in any of our case studies, although it has been claimed that the social aspects of the urban environment have a strong relationship with mental health (Barton, 2016; Dannenberg et al., 2011a). This non-significant effect of the social aspects of the environment on mental health might be due to the lack of social characteristics and relationships and the absence of social interactions in these spaces.

Among the features observed in Jomhoori street, macro, micro, and natural indicators seem more significant, indicating that small physical factors could be more effective on a large scale in car-dominated streets. People tend to be more influenced by physical rather than social features. However, social aspects were also significant in Saf pedestrian street, indicating that these features could be more attractive in places with slower actions since people could be more relaxed and benefit from these indicators. Regarding the coefficient of determination (R2), all features in both Jomhoori and Saf streets have moderate explanatory power, while mental health level estimation has strong explanatory power.

Furthermore, statistics demonstrate different behaviors in the interaction among features, indicating different levels of impact on each other in each space. In Jomhoori, there are non-significant relationships between macro and social factors. In Saf, however, macro-social relations are significantly stronger. In addition, micro-natural relations with a value of 12,412 in Jomhoori and 8661 in Saf showed the most significant relationship among all features in both areas, demonstrating the importance of natural factors influencing micro-features and their indirect effect on mental health.

6. Discussion

The results suggest that, in general, spaces that have received more positive evaluations in terms of public qualities (i.e., pedestrian streets) tend to have more significant effects on citizens' mental health. The direct association between spaces with more positive perceived quality and positive mental health is consistent with previous findings (Bornioli et al., 2018; Francis et al., 2012a; Francis et al., 2012a,b; Wu et al., 2016b). The qualities of the public space for those who use the space for a long time are mixed with their daily life. Thus, if these qualities are considered positive in their daily life, they will affect their mental health. These qualities in people's daily life will have a long-term effect, especially when they last for a long time. According to our results, people's average score on mental health on Saf pedestrian street is 76.45% which is remarkably higher than the average score on Jomhoori street.

Our data analysis identified the most important indicators of public urban spaces which could affect mental health. We also evaluated and compared the direct and indirect effects of environmental components on each other and mental health in both study areas. The results of this study suggest that in the car-dominated Jomhoori street, from among the environmental factors, the social component does not have a strong relationship with mental health and the social dimension of the existing elements is not significant. These findings are in contrast to many other studies, which have confirmed the effect of social components on mental health (Barton, 2016). It was shown that the proposed framework for testing the hypothesis was appropriate and mental health was affected by environmental factors such as micro-, macro-, and natural factors. Also, the assumption of the relationship between macro-factors and social factors was not significant in both study areas. In addition, the hypothesis of the effect of natural factors on social factors was not significant in Jomhoori street. This shows that, despite the claim in the literature that social factors might affect environmental factors and mental health (Dannenberg et al., 2011a), in our study area (Tehran city) only micro-factors and small-scale design policies could influence social components. The reason may be the lack of certain social relationships in the space in question or the type of structure of the streets or the district. Nevertheless, it was demonstrated that, in Saf pedestrian street, the effect of social factors on mental health was significantly stronger than in Jomhoori street.

From the relationships among the proposed categories of the factors affecting mental health, all categories except for social factors had a significant relationship with mental health in the car-dominated street (Jomhoori). The strongest effect belonged to macro-scale components. The situation in terms of the relationship between social factors and mental health was quite different in Saf pedestrian street, and all four factors had a significant relationship with mental health. In Saf street, the components of natural factors had the strongest effect on mental health. In other words, we discovered that the effect of social factors in Jomhoori street could not be evaluated by the used method, and their significance has not been observed in the study area. Also, the most significant factors in the car-dominated street were micro-scale design factors that could be perceived by citizens whereas, in the pedestrian street, natural factors proved to have the strongest relationship with the users' mental health. This might be due to an easier perception of space in areas without motor vehicles.

In the car-dominated street (Jomhoori), all of the factors investigated through SEM, except for the height of surrounding buildings

(loading = 0.672) and streetlights (loading = 0.651), were determined as significant. This indicates the higher possibility of the effect of these factors on people's mental health and their direct relationship with mental health. Similarly, in Saf street, two components were found to have no significant relationship with the respondents' mental health. These two components are building height (loading = 0.630) and population density (loading = 0.663). The figures are indicative of the low importance of the height of surrounding buildings to citizens' mental health. In Jomhoori street, the relationship between lights and mental health was evaluated as trivial and less significant than in Saf street. Although the relationship between density and mental health in Jomhoori street was of great importance, this relationship was much less significant on Saf street. These results show that, despite previous studies concerning the relationship between buildings' height and people's mental health (Kalantari and Shepley, 2020b), this relationship is not remarkable in our study area. In the pedestrian area, population density did not significantly affect mental health. This has also been confirmed previously in several studies (Evans, 2001; Zhang et al., 2019b).

The air pollution component was of great importance and weight in both areas of study. It shows that, in both cases, air pollution was one of the most influential factors in mental health (1989; James et al., 2017a). More specifically, air pollution has the most significant effect on mental health in car-dominated streets. Similarly, social surveillance over the space was one of the most effective environmental factors which had a high significance in both spaces. This is indicative of the importance of this component in citizens' mental health. This issue has also been pointed out by Burton (2015a). However, PLS test results rejected the relationship between social factors and mental health, also this relationship can only be evaluated in pedestrian areas rather than in car-dominated streets.

As in the car-dominated street, the height of surrounding buildings (loading = 0.672) and street daylights (loading = 0.651) was insignificant. Also, the three factors of the social dimension of space (i.e., social relationships, crime and fear of crime, and social surveillance over space) were insignificant. The only factors to be considered as affecting citizens' mental health include mixed uses, density, public transportation, attractiveness, active edge, quality of the pedestrian path, green space, soundscape, and air pollution. The figures suggest that, in the pedestrian street, the height of surrounding buildings (loading = 0.630) and population density (loading = 0.663) were insignificant. Therefore, the factors which were associated with mental health in the pedestrian street include mixed uses, public transportation, attractiveness, active edge, lights, quality of the pedestrian path, green space, soundscape, air pollution, social relationships, security, and social surveillance over space.

Other factors have also been mentioned in the literature. For example, the theoretical literature has discussed the relationship of mental health to mixed uses, access to public transportation(2015a), crime and fear of crime(Firdaus, 2017b; Guite et al., 2006a), quality of the pedestrian path(Azadeh et al., 2019a; Francis et al., 2012a), green space(Gascon et al., 2015b), and soundscape (Firdaus, 2017b) as well as the importance of these factors.

This shows that all the significant factors listed for car-dominated streets are also effective in pedestrian streets. Importantly, however, lights were found to be significant only in pedestrian streets. As a result, the relationship between lights and mental health in pedestrian streets in the Iranian context is a direct one that appears not to exist in other environments such as car-dominated streets.

As with the direct relationships between the components, this study indicated that, in car-dominated Jomhoori street, the hypothesis concerning the effect of macro-factors on natural factors and micro-factors could be accepted, but they do not seem to have a strong, direct effect on social factors. The effect of natural factors on micro-factors, the impact of natural factors on social factors, and the impact of micro-factors on social factors have been confirmed. In Saf pedestrian street, the effect of macro-factors on natural factors, micro-factors, and social factors, also the impact of natural factors on social factors and micro-factors have been accepted. Only the effect of micro-factors on social factors was rejected, which indicates that the influence of this component is only direct, and it does not bear any indirect impact on mental health in the pedestrian street. As a result, walking in quality urban spaces (pedestrian areas) has a positive effect on the mental health of citizens, whereas motor vehicle traffic harms the potential advantages of social elements in experiencing the space of the street.

In Jomhoori street, the most important relationship was between macro-factors and natural factors. It was also the most important relationship in Saf pedestrian street. It shows that macro-factors exert the most significant indirect effect on mental health through the desirable results of natural factors.

Although SEM using PLS has been widely used in the literature on information systems and strategic management (Hair et al., 2012; Marcoulides and Saunders, 2006), few studies have used it to investigate people's feelings and experiences of space. A study showed that the quality of services perceived by the patient in healthcare settings has a strong effect on behavioral adjustment (Mohamed and Azizan, 2015). The present study contributes to the theoretical literature by adding to the knowledge of the relationship between the different components and dimensions of environmental factors in car-dominated and pedestrian streets and citizens' mental health with the help of this method. The PLS method allows the verification of structural hypotheses regarding the relationship between the outcome variable and other latent variables, as well as the ranking of latent variables according to their effect on the outcome variable (Occelli P et al., 2013). As the outcome variable in this study (i.e., mental health) is a multi-dimensional variable and the relationship between citizens' general satisfaction and their experiences and feelings about different environmental aspects (social, personality-related, etc.) is not specified, PLS seems to be an appropriate method for testing structural hypotheses.

However, there are several limitations to this study. In the initial step, convenience sampling was used in our survey, which may not be free from bias. Also, further longitudinal studies with larger populations need to be conducted if we seek to generalize and validating the findings. In addition, the study was performed in the central district of Tehran and, given the time and budget limitations as well as legal permissions, we could manage to examine only two spaces. Thus, it is also necessary to study other districts in Tehran as well as other cities to be able to verify and generalize the results. Although such findings indicate a significant relationship between mental health and environmental factors, there may be still other components that are not covered in our conceptual model.

7. Conclusion

Nowadays, many researchers consider public health as a result of access to green spaces, activities, and physical and visual access to open spaces, as well as the possibility of people's social interaction. Proper design of the street can also support the structure of the environment. In general, to achieve healthier and more active cities, there is a need to focus on pedestrians and develop urban design policies and guidelines that support physical activity and improved health. Well-being and health are effective stimuli for development and economic productivity. In addition to guaranteeing the health of citizens, the promotion of active life can bring about many economic and social benefits. The design and form of living environments determine to a large extent whether or not people are encouraged to perform physical activity and live a healthy life. Therefore, authorities have a crucial role in creating environments with sufficient green spaces, which could increase physical activity opportunities. Although these findings seem adequate, there is still a knowledge gap in the existing field. While previous studies have examined this subject in a single-factor manner, the current study has measured the effect of different factors simultaneously on mental health. Therefore, in this research, various qualities that include the criteria of previous studies have been comprehensively investigated.

The results of this research are based on the use of methods such as PLS-SEM, which can simultaneously observe the subject of mental health and urban design, which is one of the innovations of current research. The results of this study demonstrate that streets with more positive perceived public quality (i.e., pedestrianized streets) have stronger effects on citizens' mental health. Regarding the research aim, by classifying the built environment into physical (macro and micro), social and natural dimensions, we sought to create a framework to define a psychologically healthy street.

What we learn for practice from this research would be summarized in the following items: Pedestrians should be prioritized as far as possible in places where commercial activities are concentrated, and on streets that are of interest to people in their daily lives. In practice, the factors of pollution and social monitoring of space are considered very influential. Therefore, actions are required to reduce the pollution of the area and increase the opportunities for social monitoring of space. The solutions to the pollution will include limiting the access and unnecessary uses of cars, increasing the width of sidewalks, and amending laws to reduce vehicle emissions. The next priority includes increasing mixed uses and creating a diversity of activities. Also, active edges and the possibility of engaging the street with activities in land use are essential. Access to well-planned public transportation should also be considered. Improving the attractiveness of the space and the aesthetics of facades hand-in-hand with natural and green spaces could help the better experience of the space. But without a suitable path for pedestrians, a positive perception of the space's attributes is not achievable. Last but not least is the importance of the soundscape, which, if not properly planned, can cease a satisfactory perception of the space.

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Author statement

Dear editors of the Journal of Transport and Health, We highly appreciate the comments on our paper, which helped us improve the quality. We have listed two reviewer comments and our response and amendments applied to the text.

We appreciate the inspiring responses on our paper, which give us the confidence to do more research in urban design and mental health. Based on the practical remarks of both reviewers' words, we have prepared a new edition which is attached along with commented response to reviewers.

We hope to cover the reviewer's expectations and are eagerly ready to hear the following effective comments.

Credit author statement

Hooman Hematian: Literature review, data analysis, discussion, and writing Ehsan Ranjbar: conceptualization, Supervision, Methodology, review, and editing.

Declaration of competing interest

The authors have no conflicts of interest to declare.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2022.101532.

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