

The Impact of the Environment on Quality of Life and Mediating Effects of Sleep and Stress

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Abstract

Purpose Environment is an independent factor affecting quality of life. Studies suggest that health practices consider having an impact on quality of life. The purpose of the present paper was to examine the association between environmental conditions and quality of life, and how individual health practices affected this association.

Methods Participants aged 20 or above were recruited from 11 tertiary planning units in the centre of Kowloon. These tertiary planning units were selected as they represent the overall living environment in Hong Kong, with older poorer urban areas alongside relatively affluent districts. A mediation analysis was implemented using multiple linear regressions to examine the effects of environmental conditions on quality of life. The predictor variables included sociodemographic and environmental conditions, health practices and health service utilisation.

Results Of the eligible 607 participants, 390 females and 217 males with a mean age of 47.4 were included for analysis. Physical, psychological and environmental factors were conducive and connected to quality of life. After adjusting for fruit and vegetable intake, gender, education level and chronic illness, perceived stress and sleep quality had significant mediating effects.

Conclusion Environment is an important factor that affects the overall well-being of individuals. The interaction of environmental quality with individual variables, specifically stress and sleep is extremely important when assessing its impact on the quality of life. The findings of this study support the importance of individual stress and sleep in mediating the relationship between the environment and quality of life.

Background

Quality of life (QoL) is a broad multidimensional concept that is significant as desired outcome of health effect. The concept represents the expectation and concern of one's own health and life, both positive and negative aspects of QoL in the context of the culture and value systems [1]. The short form 36 Health Survey (SF-36) is a widely used health-related QoL tool, which is aimed at detecting a subjective expression of health status on eight health concepts in the two main dimensions of physical and mental health [2]. However, these dimensions focus on a disease's effect on specific functional aspects, but do not address the QoL that is embedded in a cultural, social and environmental context [3]. The World Health Organization (WHO) thus initiated the development of the World Health Organization Quality of Life 100 (WHOQOL 100), to consider people's overall well-being. WHO Quality of Life Brief Scale (WHOQOL-BREF), a short form of WHOQOL100, was field tested and resulted in the identification of a four-domain structure: physical health, psychological health, social relationships and the environment in general. These four constructs were found to have moderate correlations but had adequate discriminant validity, reflecting the different measures they each represent [4].

The dimensions of QoL for health traditionally include physical, psychological and social aspects, but in recent years the environment has been identified as another important dimension of life [5]. Green space in urban areas constitutes an environmental determination to improve both physical and psychological health, enhance the quality of living and resilience in urban areas and promote sustainable lifestyles in the urban residents [6]. It provides access to nature and scenic beauty in urban areas, which may influence physical health [7], mental health [8,9] and environmental health [10]. The distance to green space has been emphasised as an important factor affecting health. A Danish study based on a national survey found that residents living closer than 1 km from green space had higher mean scores on all the eight subscales of SF36 than those living more than 1 km away [11]. A British study that included all residents appearing in the Census found that the percentage of green space was associated with better health in general, although the effects were not significant, among a group with a higher income and those living in suburban areas [12]. However, a German study did not find any association between green space and health-related QoL [13]. Other studies have revealed that the quantity of green space is associated with health. A greater expanse of forest in rural and urban green spaces was associated with fewer mental health issues [14]. A systematic review supported the positive association of the quantity of green space with mental health, although the evidence for the relationship between green spaces and general health is less strong [15].

Although green space is one of the key dimensions of environment contribute to QoL. Its influence may be attenuated by other factors including socioeconomic status and individual health practices [16–18]. Green spaces appear to have a stronger effect on health among lower socioeconomic classes among a Dutch population [19]. Mitchell and Popham [12] argued that the income-related inequality in health of the lower socioeconomic subpopulation could be reduced through greater exposure to green space. A sub-analysis was conducted among a Dutch data set from a population survey and found that the green space effect on health was stronger among the elderly and among homemakers [20]. These two groups were suggested to be more confined and thus more exposed to the local environment. Several mediator variables have been proposed that can clarify the environmental effect on QoL through individual health practices. Gong et al. [21] found that an increased percentage of green space within a 400-metre area was significantly associated with more participation in physical activity among a group of elderly men in the UK, but few differences in the levels of physical activity were found in a New Zealand population [22]. People who engaged in physical activity and who had greener households reported less stress [23] and improved physical and mental health [23–25]. Those who live closer to green spaces were also found to have lower odds of experiencing stress, as measured by the Perceived Stress Scale [11]. These results supported those found by Maas et al. [19]. Living closer to green space is associated with increased cortisol levels and decreased stress [26] and with better QoL [11]. Perceived stress may also serve as a mediator for health. Studies suggest that stress can mediate health outcomes by reinforcing individual health practices [20,27,28]. Sleep has also been associated with neighbourhoods that have green space. People who live in an environment that has 80% or more green space reported longer sleep duration at night [29]. Other individual health practices such as smoking, drinking [30,31] and fruit and vegetable consumption [32] are considered to have an impact on QoL [30].

Public spaces in neighbourhood with man-made recreational resources such as walking trails, cycle parts and swimming pools are more advantageous to physical activity [5] and contribute to overall feelings about the community [30] and QoL [34,35]. A survey was conducted among Australian adults and found that environmental attributes including access to parks, bicycle and walking trails and the presence of greenness were positively related to physical and mental health [35]. Similarly, a Dutch survey found that environmental quality from buildings, noise and traffic were strongly related to all four domains of QoL as measured by the WHOQOL-BREF [34]. Perception of the public open space and built environment are essential constituent in the evaluation of the neighbourhood, health [36] and QoL [37]. Our earlier study, however, found that satisfaction with the neighbourhood environment was only significantly related to psychological QoL [31]. Residents who reported perceived moderate satisfaction with the public space in neighbourhood had significantly higher psychological QoL.

According to Marans and Mohai's theoretical model [38] suggests how health and QoL may be linked not only with leisure resources but also environmental conditions [39]. The model hypothesized that the perceptions of environmental and urban amenities will influence peoples' satisfaction, physical health and their use of them. The aspect of environmental amenities include the quality of the ambient environment (air, water, noise, hazardous waste) and natural recreation resources. Urban amenities include man-made recreational resources (walking trails, swimming pools, and cycle parts), cultural resources (sports teams, cinemas, and galleries), health services and facilitates, public space and public transport [40]. The use or non-use of natural or man-made recreational resources by an individual is associated with physical health [40] and individual health practices such as physical activity [41]. The model provides opportunities to explore the relationship of environmental conditions and QoL. In this study, we proposed that the effect of the environment conditions is not only associate with but also interacts with individual health practice and QoL. These relationships have not previously been well studied, so the aim of this study is to examine environmental conditions and individual health practices as mediating factors affecting QoL.

Method

Participants were recruited from 11 tertiary planning units (TPU) in the centre of Kowloon. These TPUs were selected as they represent the overall living environment in Hong Kong, with older poorer urban areas alongside relatively affluent districts. A sample size of 598 can provide a precision range of 4% from the true values at a 95% confidence level [42,43]. Residents who had been living in the selected TPUs for at least 24 months, who were Chinese, aged 20 or above were invited to answer a questionnaire. Those who were cognitively impaired or unable to communicate effectively were excluded. Trained research assistants approached potential participants on the streets, in parks and outside the entrances of shopping malls in the TPUs. The participants were provided with an information sheet explaining the study and were reassured that their participation was voluntary, and that the information provided was anonymous. Their specific names would not be associated with the reporting of the findings.

The primary outcome of this study is QoL, which is measured by WHOQOL-BREF (Hong Kong version). There are 26 items, all items are rated using a 5-point Likert scale. The Cronbach's alpha (α) of the scale ranged from 0.66 in the social domain to 0.84 in the psychological domain [4]. Confirmatory analyses showed that the comparative fit indexes ranged from 0.837 for the environmental domain to 1.0 for the social domain, demonstrating that the four domains had acceptable construct validity. The domain scores were calculated and transformed into a linear scale between 0 and 100, following the scoring guidelines [4]. A higher score indicated a better QoL.

The predictor variables included sociodemographic and environmental conditions, individual health practices and health service utilisation. The internal consistency of the questions in the Chinese version was acceptable to good, with Cronbach's α values ranging from 0.77 to 0.86. Sociodemographic data included age, education level, occupation, marital status, monthly income, living location, housing types and others living in the same residence. For the socioeconomic status (SES), we categorised the participants based on their residential addresses, with reference to the 2014/15 household expenditure survey in Hong Kong [44]. The participants were asked to provide the street name and number of their address for the team to denote the percentage of green space within a 500 m radius of their residence, using a vegetation map of Hong Kong. This map was estimated based on an object-oriented classification with high resolution SPOT-6 satellite images. The images consisted of panchromatic wavelengths at 1.5 m spatial resolution and multispectral wavelengths at 6 m spatial resolution. A digital elevation model (DEM) and digital surface models (DSM) were used to separate vegetation structures from urban infrastructures and buildings. The vegetation map, derived by the project team through a contract from the Hong Kong Planning Department, displayed vegetation types (e.g., grassland, shrubland, woodland) and natural features (e.g., mangroves, badlands, rocky shores) [45,46].

The environmental conditions included environmental quality, green space percentage and public space satisfaction. Participants were asked to rate environmental quality based on the six parameters of air quality, heat island intensity, noise, vegetation density, building height, building density and overall environmental quality. Each parameter was illustrated with a local reference photograph. Participants were asked to rate how they perceived their neighbourhood environment for each parameter on a scale (ranging from 0 = *extremely low* to 100 = *high quality*). The parameters were validated as urban environmental quality indicators [47]. In addition, six questions on the satisfaction with public spaces including greening, parks and gardens, recreation and sports facilities, promenades and rest areas were rated using a five-point Likert scale (1 = *very unsatisfied*; 5 = *very satisfied*).

Individual health practices including healthy eating, physical activity, smoking, sleep and perceived stress were measured in the study. Healthy eating was measured by healthy eating practices and fruit and vegetable consumption. Fruit and vegetable consumption was defined as the WHO [48] recommendations of at least two portions of fruit and three of vegetables per day. Healthy eating practice was based on the recommendations of the Department of Health, Hong Kong [49] and defined as low fat, salt and sugar diets, measured using a 4-point Likert scale (1 = *never*; 4 = *always*). Physical activity (PA) attained in the last 7 days was measured using the Chinese version of the International Physical Activity

Questionnaire (IPAQ-C). PA was categorised into low, moderate or vigorous intensity activities, and the total MET-minutes per week were assessed. Metabolic Equivalent of Task (MET) is the energy expenditure of physical activities [50]. The concurrent validity of IPAQ-C and MET-minute/week (%CV ranged from 49–113) with a total %CV of 43% [51]. Each PA activity was calculated according to the IPAQ scoring guidelines [52]. Smoking habit was reported as never smoked or former/current smoker. The sleep quality of participants over the previous 3 months was measured by the 8-item Sleep Quality Index (SQI) [53]. Participants were asked to report time taken to fall asleep (≤ 10 mins; 11–30 mins, and > 30 mins), how often they had difficulty falling asleep, if they woke up during the night, woke up too early, had a disturbed night sleep or insomnia (no; < 3 days/week; and 3–7 days/week), morning tiredness (rather or very alert; don't know; and rather or very tired) and their use of hypnotics (no; occasionally; and at least 1 per week) [54]. The scores ranged from 0–16 with higher scores indicating more severe sleep disturbance. Perceived stress included the ability to cope with stressors and the degree of negative emotional reaction towards stressors in the past month were measured on a 10-item Perceived Stress Scale (PSS–10) using a 5-point Likert scale [55]. The total score ranged from 0 to 40 with higher scores indicating higher perceived stress [56]. For health utilisation, questions on regular use of western and Chinese medications, doctor's consultations in Western and Chinese medicine, hospitalisations, and sick leave taken in the past three months were assessed.

Data Analysis

Data analysis was conducted using SPSS version 25, and the mediation analysis was implemented using the SPSS macro PROCESS (version 3) model 4 [57]. PROCESS is a computational tool using the bootstrap resampling method to provide a bias-corrected indirect effect. We specified 5,000 bootstrap samples based on 95% confidence intervals (CIs). An indirect effect can be found if the 95% CIs do not include zero. The mediation analysis investigated if both path a (predictor to mediator) and path b (mediator to the outcome) were significant, even if path c (direct effect of predictor to outcome) was insignificant [58]. All alphas were set at 0.05, two-tailed.

Individual health practices regressed on environmental conditions, together estimated as path b. WHOQOL-BREF regressed on individual health practices, together estimated as path b. The direct effect of environment conditions on WHOQOL-BREF were together estimated as path c. To compare the influence of variables among different domains in WHOQOL, four separate models for four WHOQOL-BREF domains (physical—model 1, psychological—model 2, social—model 3, and environmental—model 4) were conducted in the study. Covariates to be included in the model were determined by the univariate linear regression. Only those variables reaching a significance level for the WHOQOL-BREF were included as covariates.

Results

We recruited 614 participants to take part in the study, and 7 questionnaires were incomplete and thus discarded. Of the eligible 607 participants, 390 were female and 217 male and their mean age was 47.4. Over 44% had attained university education and 59.8% were married. The percentage of CPI, in ascending order, was 48.6 (Grade A), 38.7 (Grade B) and 12.7 (Grade C). Over 63% of the participants said that their health was good or very good, and 35.3% reported living with chronic illnesses. In terms of their health utilisation over the past 3 months, 55% of participants sought doctor consultations, 41.8% took regular medication, 9.1% took sick leave and 2.8% had been hospitalised. In terms of individual health practices, over 90% of participants were non-smokers. The mean score for alcohol consumption was 1.0 ± 1.6 . The majority of them reported that they did not meet the guideline for fruit (84.7%) and vegetable (90.4%) consumption. Over the previous 3 months, the mean MET-minutes/week was 2406.5 ± 1709.4 , perceived stress was 15.9 ± 5.5 and sleep was 4.6 ± 3.4 . For environment conditions, the mean score of green space was 10.1 ± 7.9 . The perceived environmental quality was 57.7 ± 15.5 , and public space satisfaction was 3.3 ± 0.7 . For QoL, the mean score for the 4 domains were 60.5 ± 10.5 (physical), 62.8 ± 13.6 (psychological), 62.9 ± 12.5 (social) and 61.9 ± 13.5 (environmental). Table 1 gives the descriptive characteristics of the participants.

[Table 1]

The basic model for the demographic characteristics, individual health practices and environmental conditions contained all the covariates in the study. Those included in the model were determined by univariate linear regression. Only those variables reaching similar significant levels as the WHOQOL-BREF were included as covariates. Males ($p < 0.05$) and individuals with chronic illness ($p < 0.05$) were significantly negatively associated with social QoL. Higher environmental QoL was reported among those who had attained higher education ($p < 0.01$) and who met the guidelines for fruit and vegetable consumption ($p < 0.05$). Participants who met the guidelines for both fruit and vegetable consumption had higher QoL. Table 2 provides the covariates.

[Table 2]

The regression model for physical QoL was significant: $F(8, 598) = 41.08, p < .001, R^2 = 0.36$. The bootstrap result revealed that perceived stress is a mediator of environmental quality ($\beta = .046, 95\% \text{ CI}: .003, .072$) and public space satisfaction ($\beta = .056, 95\% \text{ CI}: .002, .112$) in model 1. Sleep quality only mediated environmental quality ($\beta = .033, 95\% \text{ CI}: .013, .055$). Fruit and vegetable consumption was adjusted to test whether physical QoL improved when environmental conditions were introduced after the mediators had been included. Figure 1 shows the mediation model for physical QoL.

[Figure 1]

The regression model for psychological QoL was significant: $F(8, 598) = 43.50, p < .001, R^2 = 0.37$. The bootstrap result revealed that perceived stress is a mediator of environmental quality ($\beta = .067, 95\% \text{ CI}: .034, .102$) and public space satisfaction ($\beta = .081, 95\% \text{ CI}: .004, .165$). Sleep quality only mediates

environmental quality ($\beta = .032$, 95% CI: .012, .057). Figure 2 shows the mediation model for psychological QoL.

[Figure 2]

After adjusting for fruit and vegetable consumption, gender and chronic illness, the overall regression model for social QoL was significant: $F(10, 596) = 12.77$, $p < .001$, $R^2 = 0.186$. The bootstrap result revealed that environmental quality is mediated by perceived stress ($\beta = .044$, 95% CI: .021, .071) and sleep quality ($\beta = .021$, 95% CI: .007, .040). Figure 3 shows the mediation model for social QoL.

[Figure 3]

After adjusting for fruit intake and education level, the regression model for environmental QoL was significant: $F(10, 596) = 38.54$, $p < .001$, $R^2 = 0.39$. The bootstrap result revealed that environmental is mediated by perceived stress ($\beta = .046$, 95% CI: .022, .075) and sleep quality ($\beta = .021$, 95% CI: .007, .039). Figure 4 shows the mediation model for environmental QoL.

[Figure 4]

Discussion

Quality of life models often focus on dimensions of physical and psychological health. Most literature investigating QoL does not specify the links between environment conditions and QoL domains of health. This study demonstrates that the conditions of environment does affect QoL, and as a core element of QoL, it is linked with different factors. In this study, both objective (green space percentage) and subjective (environmental quality, public space satisfaction) aspects of the environment conditions affecting QoL were analysed.

The studied population was a typical urban neighbourhood that covered by a limited green space. The level of green space in the study districts was low (mean 10.1 +/- 7.9, range 0–100), as in most urban areas of Hong Kong. The findings suggest that it positively affects physical activity and physical QoL, even if the space is limited, which is a characteristic of the urban area of Hong Kong. Previous studies suggest green space had a positive effect not only on physical health and activity [19, 24, 41, 59] but also on psychological health [22, 31, 60]. In our study, there were significant benefits of green space on physical activity and physical health but not on psychological health. It may due to factors such as perceived stress mediating the results. Studies suggested the exposure to green space is a major factor affecting perceived stress. Every 1% increase in exposure to green space is associated with an increased cortisol level and decreased self-reported stress [26]. Living less than 1000 m from a green space can lead to less stress and improve the QoL [11]. In our study, we measured the green space cover within a 500 m radius of their residence and found inadequate to benefit on psychological health and stress.

Although the objective value of green space in the study districts was low, the satisfaction with public space was moderate (mean 3.3 +/- 0.7, range 0–5) in our study. Public space satisfaction was positively associated with all domains of QoL. The result was similar to other studies on public space satisfaction [59, 61]. Public space satisfaction refers to leisure and recreation facilities. Although there is no standard for satisfactory public spaces, the requirements of the residents in the studied districts were met. On the contrary, people reported less satisfaction with public spaces were negatively affects both physical and psychological QoL by perceived stress. Perceived stress was related strongly to quality of public spaces than quantity [20]. A local study suggested that recreational and public spaces are important in Hong Kong for environmental satisfaction, in both private and public housing [18]. Housing environments in neighbourhood are fundamental to their overall life satisfaction [62], but the expectations for their housing environments are inconsistent. Those living in public housing were concerned about the accessibility of the housing location whereas those in private and subsidised housing were more concerned with the appearance of the housing environment. Types of housing and their locations associate with QoL should further be studied.

Besides green and public space satisfaction, the environmental quality also influence QoL and mediated with both stress and sleep. In this study, Environmental quality was negatively associated with QoL through perceived stress and poor sleep. Living in an urban neighbourhood can be stressful, and exposure to environmental risks such as a heavy traffic load and pollution can negatively influence general health [63]. A significant association has been found between perceived stress and physical exposure of noise, the safety of public spaces and QoL [64]. The detrimental effect of stress on health is evident. In our study, perceived stress has been shown to have a significantly negative effect on QoL ($\beta = 0.622-0.961$). Sleep is also a significant mediator of all four QoL domains in this study, and as a physiological process that restores and repairs body functions, good sleep is fundamental to health and quality of life. Like perceived stress, poor sleep quality has a significant negative effect on QoL ($\beta = 0.566-0.890$). LeBlanc et al [65] examined the mental and QOL to sleep. The findings suggested poor sleep is associated with perceived higher levels of stress and increased report of physical health discomfort and poor mental QOL. Strategies to improve environmental quality are essential to reduce stress and promote sleep, thus resulting in good QoL.

Urbanization contributes more than half of the world's population lives in cities [66]. There has been a growth research interest regarding the impact of urban environment has on health and QoL through its physical design, land use and service delivery [67]. Stress and poor sleep are common risk factors of non-communicable diseases. The local government launched a strategic plan for 2025, multi-sectoral actions including urban planning and the creation of health-supporting environments to enable people to make healthy choices, to enjoy healthy living and to fight against non-communicable diseases [68]. Various measures can be taken immediately to reduce the disease burden attributable to environmental determinants. The government should consider to take not only access to green space, quality of environment and public space into consideration in designing healthy community. These can support good neighbourhood environments and the livelihood of people.

Our study has several limitations. First, the limited sample size and homogenous culture of the participants may affect the generalisability of the results. More diverse culture and larger samples could be considered to further confirm the association between environment quality and QoL. Second, the outcomes of the study are based on subjective measures. Future studies could include objective measurements, such as those of cortisol levels for stress and physical fitness tests. Wider age ranges, associations by age category and different neighbourhood environments of the participants could be further explored in future studies.

Conclusion

WHOQOL-BREF serves as an important outcome of how residents and their neighbourhood environment by assessing environmental conditions and QoL. In this study, the influence of objective and subjective measures of environment conditions on QoL is mediated by stress and sleep. The findings suggest that access to green space is associated with physical QoL and physical activity. Individuals with a positive evaluation of public space satisfaction and environmental quality are more likely to perceive good quality of life. Previous studies have observed that the impact of environment on health, such as neighbourhood safety, pollution and traffic influence physical and psychological well-being. The findings of this study further support the importance of individual stress and sleep in mediating the relationship between the environment and, as a direct consequence of QoL. Environmental conditions and interventions should be considered whenever making public health policies in urban populations.

List Of Abbreviations

CIs

Confidence intervals

DEM

digital elevation model

DSM

Digital surface models

IPAQ-C

International Physical Activity Questionnaire

MET

Metabolic Equivalent of Task

PA

Physical activity

PSS–10

10-item Perceived Stress Scale

QoL

Quality of life

SF–36

The short form 36 Health Survey

SQI

Sleep Quality Index

TPU

Tertiary planning units

WHO

The World Health Organization

WHOQOL 100

World Health Organization Quality of Life 100

WHOQOL-BREF

WHO Quality of Life Brief Scale

Declarations

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Declarations

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Authors' contributions

FKYW is the project leader, KKPC and FKYW drafted the manuscript. KLC and FYW coordinated the data collection. HCH, MSW, JYSH, JWMY, JYS and LY involved in data interpretation. All authors have read the final manuscript.

Ethics approval and consent to participate

Ethical approval was obtained from the Human Subjects Ethics Sub-committee of The Hong Kong Polytechnic University. The participants were provided with an information sheet explaining the study and were reassured that their participation was voluntary, and that the information provided was anonymous. Their specific names would not be associated with the reporting of the findings.

Consent for publication

All authors have approved the manuscript for publication.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, FKY Wong, upon reasonable request.

Competing interests

There are no competing interests.

Tables

Table 1. Descriptive Characteristics

	n=607
Age, M±SD	47.4±21.1
Gender, n (%)	
Female	390 (64.3)
Male	217 (35.7)
Education, n (%)	
Primary	117 (19.3)
Secondary	2178 (29.3)
Diploma	42 (6.9)
University	270 (44.5)
Marital status, n (%)	
Single	192 (31.6)
Married	363 (59.8)
Widowed/Divorced/Separation	52 (8.6)
Occupation, n (%)	
Not working	202 (33.3)
Working	193 (31.8)
Homemaker & student	212 (34.9)
AUDIT-C (0-12) , M±SD	1.0±1.6
Smoking status	
Non-smoker	552 (90.9)
Someday	22 (3.6)
Everyday	33 (5.4)
Fruit intake, n (%)	
Not meet guideline	514 (84.7)
Meet guideline	93 (15.3)
Vegetable intake, n (%)	
Not meet guideline	549 (90.4)
Meet guideline	58 (9.6)
Chronic illness, n (%)	
No	393 (64.7)
Yes	214 (35.3)
CPI, n (%)	
Grade A (5500-24499)	295 (48.6)
Grade B (24500-44499)	235 (38.7)
Grade C (44500-89999)	77 (12.7)
Individual monthly income, n (%)	
0	259 (42.7)
< 10000	143 (23.6)
10000-14800	59 (9.7)
14800-23000	51 (8.4)
>23000	95 (15.7)

Note: CPI: Consumer Price Index; AUDIT-C: Alcohol Use Disorders Identification Test

Table 1. Descriptive Characteristics (Con't)

	n=607
Green space (0-100), M±SD	10.1±7.9
Environmental quality (0-100), M±SD	57.7±15.5
Public space satisfaction (0-5), M±SD	3.3±0.7
Sleep Quality Index (0-14), M±SD	4.6±3.4
IPAQ, M±SD	2406.5±1709.4
Perceived Stress Scale (0-40), M±SD	15.9±5.5
WHOQOL (0-100), M±SD	
Physical	60.5±10.5
Psychological	62.8±13.6
Social	62.9±12.5
Environmental	61.9±13.5
Doctor, n (%)	
No	273 (45.0)
Yes	334 (55.0)
On medication, n (%)	
No	353 (58.2)
Yes	254 (41.8)
Hospitalization, n (%)	
No	590 (97.2)
Yes	17 (2.8)
Sick leave, n (%)	
No	552 (90.9)
Yes	55 (9.1)

Note: IPAQ: The International Physical Activity Questionnaire - short form

Table 2. Univariate analysis (Linear regression)

	Physical QoL	Psychological QoL	Social QoL	Environmental QoL
Age	0.051	0.010	-0.047	0.060
Gender				
Female	Ref	Ref	Ref	Ref
Male	0.048	0.027	-0.090*	-0.13
Education				
Primary	Ref	Ref	Ref	Ref
Secondary	0.008	-0.494	-0.490	1.298**
Diploma	-0.098	-0.265	-0.326	0.792**
University	-0.014	-0.415	-0.419	1.510**
Marital status				
Single	Ref	Ref	Ref	Ref
Married	0.089	0.069	0.057	0.019
Widowed/Divorced/Separation	-0.006	-0.023	0.005	0.002
Occupation				
Not working	Ref	Ref	Ref	Ref
Working	-0.079	-0.024	-0.003	-0.132**
Homemaker & student	-0.037	0.023	0.036	-0.060
Alcohol Use Disorders Identification Test - Consumption (AUDIT-C) (0-12)	-0.006	-0.076	-0.009	-0.030
Smoking status				
Non-smoker	Ref	Ref	Ref	Ref
Someday	-0.059	-0.068	-0.071	-0.045
Everyday	-0.065	-0.045	-0.059	-0.062
Fruit intake				
Not meet guideline	Ref	Ref	Ref	Ref
Meet guideline	0.085*	0.130**	0.092*	0.087*
Vegetable intake				
Not meet guideline	Ref	Ref	Ref	Ref
Meet guideline	0.122**	0.089**	0.090*	0.039
Chronic illness				
No	Ref	Ref	Ref	Ref
Yes	-0.028	-0.055	-0.090*	-0.009
CPI				
Grade A (5500-24499)	Ref	Ref	Ref	Ref
Grade B (24500-44499)	0.036	0.072	0.070	0.190*
Grade C (44500-89999)	-0.063	-0.076	-0.006	0.074
Individual monthly income				
0	Ref	Ref	Ref	Ref
< 10000	-0.001	0.022	0.023	0.008
10000-14800	-0.050	-0.044	-0.035	-0.079
14800-23000	0.010	-0.001	0.022	0.019
>23000	-0.060	0.027	0.043	-0.006

*p < .05, **p < .01, *** p < .001.

Note: CPI: Consumer Price Index

Table 2. Univariate analysis (Linear regression) (Con't)

	Physical QoL	Psychological QoL	Social QoL	Environmental QoL
Greenspace (0-100)	0.062	-0.012	-0.048	-0.027
Environmental quality (0-100)	0.270***	0.318***	0.150***	0.451***
Public space satisfaction (0-5)	0.269***	0.291***	0.183***	0.449***
Sleep Quality Index (0-14)	-0.478***	-0.361***	-0.251***	-0.296***
IPAQ	0.116**	0.121**	0.034	0.034
Perceived Stress Scale (0-40)	-0.407***	-0.521***	-0.334***	-0.387***
Doctor				
No	Ref	Ref	Ref	Ref
Yes	-0.025	-0.025	-0.037	0.050
On medication				
No	Ref	Ref	Ref	Ref
Yes	-0.053	-0.058	-0.061	0.047
Hospitalization				
No	Ref	Ref	Ref	Ref
Yes	-0.075	-0.012	0.002	-0.028
Sick leave				
No	Ref	Ref	Ref	Ref
Yes	-0.028	0.021	0.082	-0.011

*p < .05, **p < .01, *** p < .001.

Note: IPAQ: The International Physical Activity Questionnaire – short form

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Figures

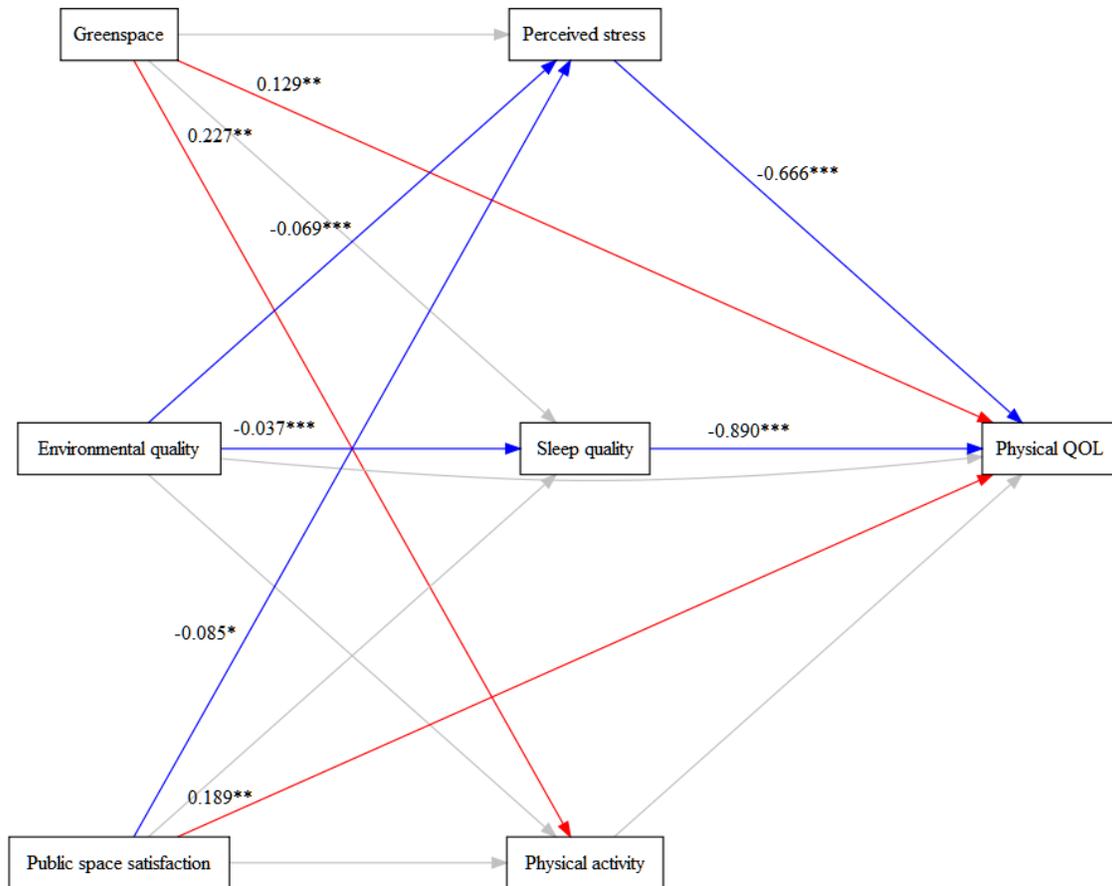


Figure 1

Mediation model for physical QoL. Analyses control for fruit intake and vegetable intake. Unstandardized coefficients are displayed. Red arrows depict positive relationships, blue arrows show negative relationships, grey arrows depict non-significant. * $p < .05$, ** $p < .01$, *** $p < .001$. Except for perceived stress and sleep quality, higher score indicate better.

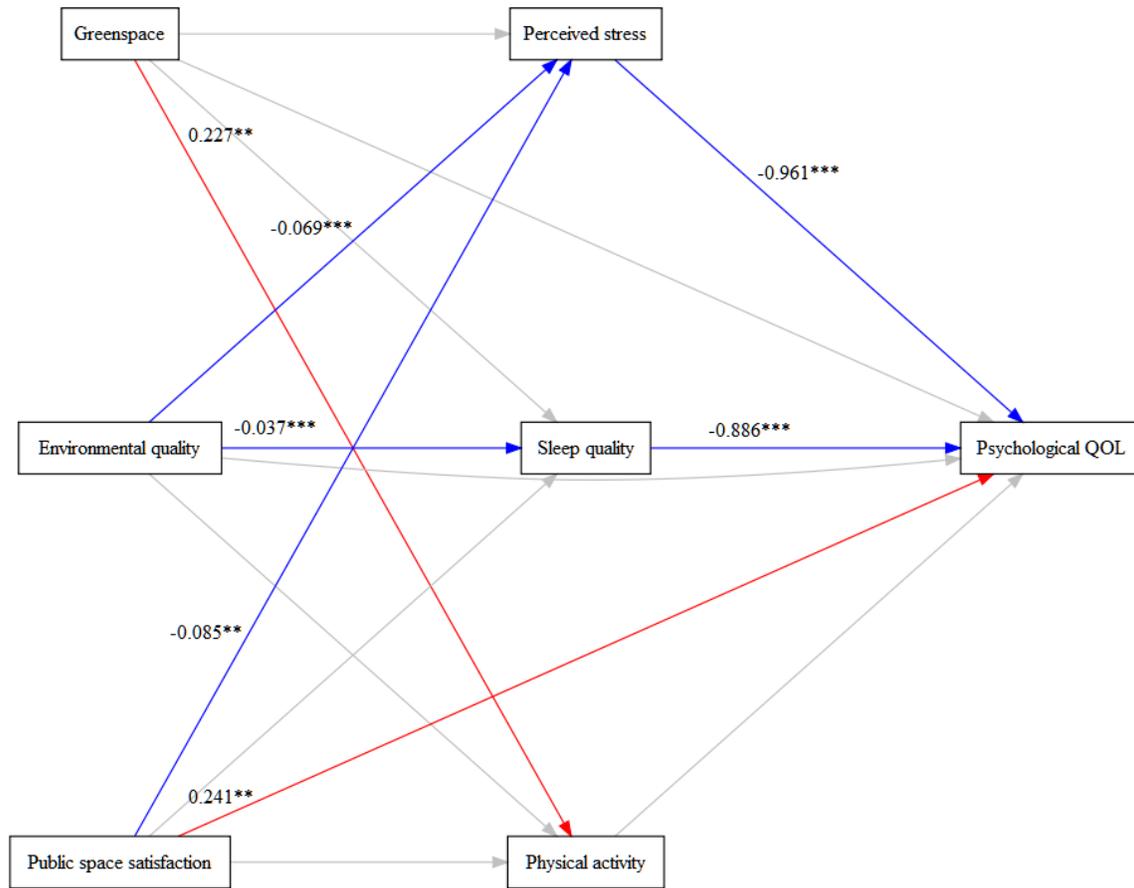


Figure 2

Mediation model for psychological QoL. Analyses control for fruit intake and vegetable intake. Unstandardized coefficients are displayed. Red arrows depict positive relationships, blue arrows show negative relationships, grey arrows depict non-significant. * $p < .05$, ** $p < .01$, *** $p < .001$. Except for perceived stress and sleep quality, higher score indicate better.

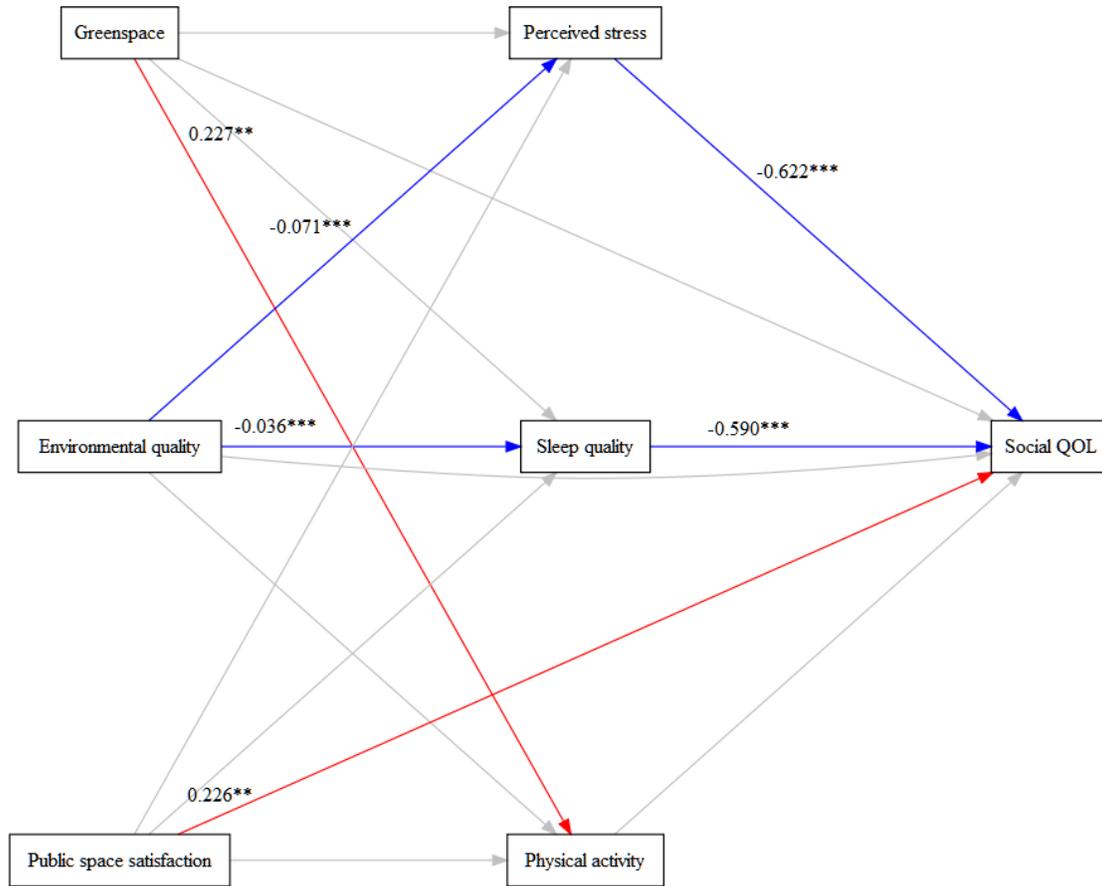


Figure 3

Mediation model for social QoL. Analyses control for fruit intake, vegetable intake, gender, and chronic illness. Unstandardized coefficients are displayed. Red arrows depict positive relationships, blue arrows show negative relationships, grey arrows depict non-significant. * $p < .05$, ** $p < .01$, *** $p < .001$. Except for perceived stress and sleep quality, higher score indicate better.

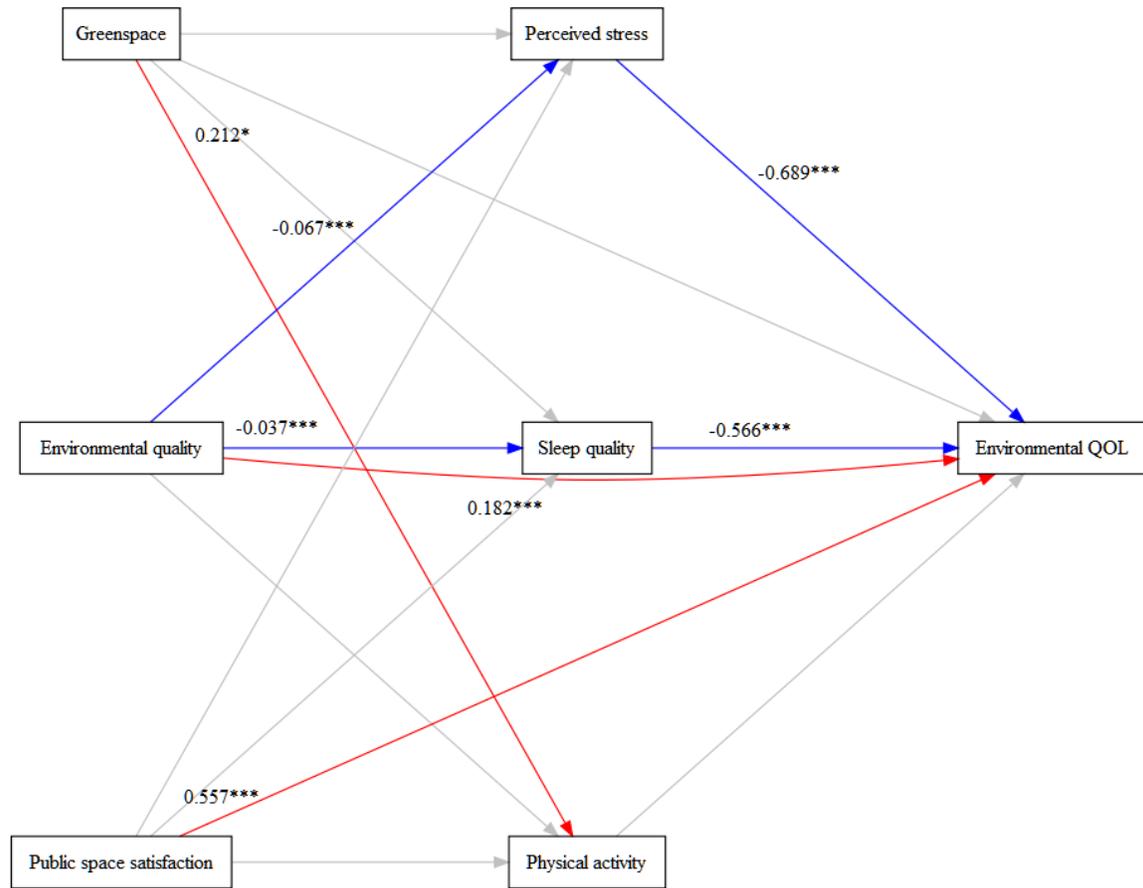


Figure 4

Mediation model for environmental QoL. Analyses control for fruit intake education level. Unstandardized coefficients are displayed. Red arrows depict positive relationships, blue arrows show negative relationships, grey arrows depict non-significant. * $p < .05$, ** $p < .01$, *** $p < .001$. Except for perceived stress and sleep quality, higher score indicate better.