

Article

# Study on the Impact of Residential Outdoor Environments on Mood in the Elderly in Guangzhou, China

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Received: 24 March 2020; Accepted: 8 May 2020; Published: 11 May 2020



**Abstract:** Understanding the relationship between mood and the environment among the elderly is important for the healthy aging agenda. This study aimed to investigate the relationship between residential outdoor environments of different qualities and mood in the elderly. Nine residential neighborhoods across three different quality levels of the outdoor environment in Guangzhou, China, were surveyed. Measures included demographic characteristics, assessment of the residential outdoor environment, and mood status of the elderly. We constructed a group of multiple regression models to investigate influencing environmental factors of participants' mood. Results revealed that the environmental factors influencing mood in the elderly are different across the three types of residential outdoor environments: function and cleanliness of the site showed a significant correlation with mood in high-quality residences, while pavement was significantly correlated with mood in medium-quality residences. In contrast, transparency, enclosure, greenness, temperature, and humidity were significantly correlated with mood in poor-quality residences. To promote mental health in the elderly, we recommend that different qualities of residential outdoor environments should be considered individually rather than aggregated as simply "outdoor space." The findings of this study are expected to contribute to create age-friendly communities for an aging society.

**Keywords:** mood; the elderly; residential outdoor environment

## 1. Introduction

An aging population is one of the greatest global challenges, and it is estimated that the world's population over the age of 60 years will reach nearly 2 billion by 2050 [1]. In particular, China's population is aging dramatically, and mental health in old age has become an important social concern. In China, the number of so-called empty-nest elderly families is increasing, and has shown links to negative emotions related to aging, such as disappointment, loneliness, anxiety, and depression [2]. Moreover, mood disorders are significantly associated with the development of dementia and could lead to higher morbidity and mortality in old age [3,4].

Residential outdoor environments may matter for the emotional health of elderly residents, especially in cities. In China, the home-based care model has been the dominant model in the pension system [5], placing great significance on the need for support of the residential outdoor environment. Furthermore, residential outdoor environments can provide places for the elderly to exercise and socialize [6,7], and it plays a vital role in reducing isolation and loneliness [8], thus preventing poor

emotional health [9]. Given these findings, identifying the relationship between the residential outdoor environments and mood in the elderly has become an aging health priority.

A growing body of epidemiological evidence has revealed that the outdoor environment is associated with many factors of mental health, including general mental health [10–12], stress [13–15], anxiety [16], depression [17–19], and affective response [20–22]. Much of the available evidence on the psychological effects of outdoor environments has focused overwhelmingly on green spaces [10,13,15,18,19,23]. However, the potential role of the residential outdoor environment in promoting people's emotional well-being has been less well-studied. It has been argued that the immediate residential environment could directly or indirectly impact mental health [24]. For instance, some features of the residential environment, such as high housing density, can be environmental stressors residents are exposed to, which could affect their mental health by causing greater stress, depression, and mental fatigue [25,26]. In contrast, providing residents with access to pleasant landscaping elements, such as greenness, can improve positive emotional states through stress recovery and psychological arousal [27]. However, there is still little research that examines changes in mood as a result of exposure to residential outdoor environments [28,29], especially for older people who spend much of their time in outdoor spaces.

Moreover, spatial composition varies in different qualities of residential areas. The linkage between residential outdoor environment and mood in the elderly might differ by the type of residence with various material qualities and conditions. However, there is little understanding of whether residential outdoor environments with different qualities have different effects on residents' psychological health. Finally, most of the existing research has been conducted in Europe and the United States [27–29], and the published studies related to the association between mood and residential outdoor environments remain very scant in China.

This study aims to explore the link between residential outdoor environments and mood in the elderly within a Chinese context. Using community-dwelling older adults as participants, we surveyed nine communities in Guangzhou, China, including three different qualities of residential outdoor environments. Specifically, we intended to (1) compare mood in older people among the three types of residential outdoor environments, and (2) examine the outdoor environmental factors affecting mood. This study contributes to the literature in studying associations between mental health and the outdoor environment and could provide public policy implications for creating age-friendly residential environments in China.

## 2. Literature Review

### 2.1. Residential Outdoor Environments and Mental Health

Residential outdoor environments are open and exterior areas surrounding the residential buildings and serve as spaces for social interaction, entertainment, exercise, and other activities [30]. An accumulating body of literature has shown that the quality of the residential environment can have either a positive or negative impact on the health and well-being of its residents [31–33]. Dunstan, Fone, Glickman, and Palmer used the Residential Environment Assessment Tool (REAT) to measure and sort the neighborhood environment into three types (i.e., highest quality, middle quality, and lowest quality) and found that there were differences in health outcomes between environments with different qualities [34]. There is strong evidence that individuals living in the high-quality residential environment tend to have better physical and mental health [35–37]. For instance, Takano, Nakamura and Watanabe found that living in residential areas with walkable green space positively influenced the longevity of senior citizens [38]. Some researchers suggested that neighborhoods with high-quality public open space were positively associated with a sense of community, thus affecting residents' overall well-being [39]. In contrast, some studies have shown that communities characterized by poor environment quality are related to negative mood, depression, and low subjective well-being [24,40–42]. The Broken Windows Theory (BWT) postulates that there is a linkage between the disorder (i.e., public incivilities and deterioration) in urban neighborhoods and fear and actual occurrence of crime [43].

Furthermore, recent studies on public health have suggested that the disorder of the residential environment can be a stressor deleterious to mental health [44–46]. For example, regarding health status, a cross-sectional study of 30,000 residents living in South Wales revealed that respondents in the areas of poorest neighborhood quality were more likely to report poor health compared to those living in highest-quality environments [34]. In addition, McKenzie et al. investigated 5605 European adults and found that poor neighborhood quality can contribute to lower psychological well-being [47]. Although the literature concerning the effect of the residential environment on mental health is accumulating, there are much fewer studies exploring the mood effect of different quality residential outdoor environments on older people.

Furthermore, the design of the residential outdoor environment may influence how residents interact with the space and further affect their mental health. Some aspects of the residential outdoor environment may play a vital role in enhancing mental health, including landscape quality, spatial form, and microclimate environment. For example, Gandelman, Piani, and Ferre found that the difference in overall happiness can partly be explained by access to public facilities in residential communities, including street lighting, sidewalks in good condition, trees in the street, and the absence of air or noise pollution [48]. Chen et al. examined the relationship between residents' affective appraisal and the community environment and found that green space, layout, aesthetics and recreational service were correlated with affective appraisal [49]. It has also been suggested that high-rise housing is inimical to the psychological well-being of women with young children, and insufficient daylight is reliably associated with increased depressive symptoms [24]. Thus, sufficient and safe open space in the residential areas may impact mental health by promoting an active lifestyle and community cohesion [50,51]. Moreover, there is evidence to suggest that mechanisms underpinning the maintenance of body temperature suggest that mental health may be affected by ambient temperature [52], and research has demonstrated that exposure to high temperatures leads to a more negative affect, in comparison to exposure to comfortable temperatures [53]. However, existing studies on environmental factors affecting the mood of the elderly in different qualities of residential outdoor environments remain relatively deficient.

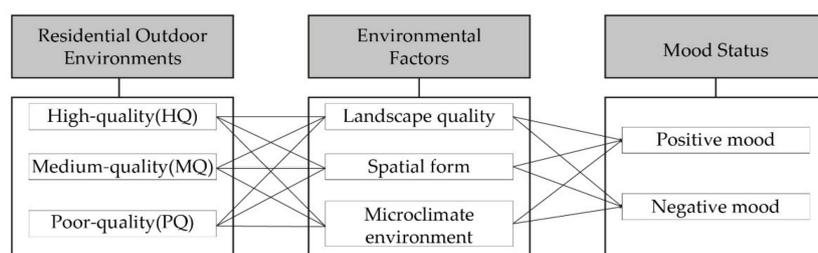
## 2.2. Outdoor Environments and Mood Measurement

Moods can be described to have as either a positive or negative affect, and have demonstrated a strong link with personal health [54,55]. Lane and Terry defined mood as a set of feelings that are ephemeral in nature, vary in intensity, and contain more than one emotion [56]. Many researchers have investigated the factors influencing mood, including the environment [57,58], social interaction [59,60] and physical activity [61,62]. Recently, researchers have focused on the association between outdoor environments and one's mood and mental health [16,63]. Generally, these studies have found that exposure to natural outdoor environments is significantly related to better mental health and less stress [13,57]. In contrast, lack of green areas, noise, and poor quality of the living environment are clearly associated with a depressed mood [63]. Several scales have been used to measure the mood effect of outdoor environments, such as Profile of Mood States-Short Form and the Scale of Positive and Negative Experience [57,64].

The Positive and Negative Affect Schedule (PANAS), developed by Watson, Clark, and Tellegen [65], is one of the most widely used affect scales in previous studies to investigate the link between environment and mood [66,67]. The PANAS consists of two subscales, with 10 positive affect (PA) items and 10 negative affect (NA) items in the original full form scales. The PA and NA scores describe one's positive and negative moods, respectively. Several short forms of the PANAS have also been translated into many languages and administered internationally [68–71]. For example, one study used a 20-item PANAS scale to measure mood scores across season and type of nature contact in Canada and found that both actual and pictorial nature contact benefited mood in both winter and warmer seasons [22]. Another study found that neighborhood environment was positively associated with a positive mood, but negatively to a negative mood, in residents by using a short version of PANAS [72]. The Chinese version of PANAS has been widely used and has shown high reliability,

validity, and ease in administration [73,74]. However, PANAS scales have not been used widely in residential outdoor environment and mood of the elderly research.

Based on the literature review, we attempt to compare mood in older people among the three types of residential outdoor environments and examine outdoor environmental factors affecting mood in this study. Therefore, we proposed a framework as shown in Figure 1; three different qualities of residential outdoor environments were constructed: high quality (HQ), medium quality (MQ), and poor quality (PQ). Environmental factors of landscape quality, spatial form, and microclimate environment were included in the research. Positive and negative mood were used to assess the mood status of the elderly. We hypothesized that residential outdoor environments have an impact on mood in the elderly and that this relationship differs with the types of outdoor residential environments.



**Figure 1.** Potential association between mood status of the elderly and residential outdoor environments with different quality.

### 3. Materials and Methods

#### 3.1. Study Settings and Survey Design

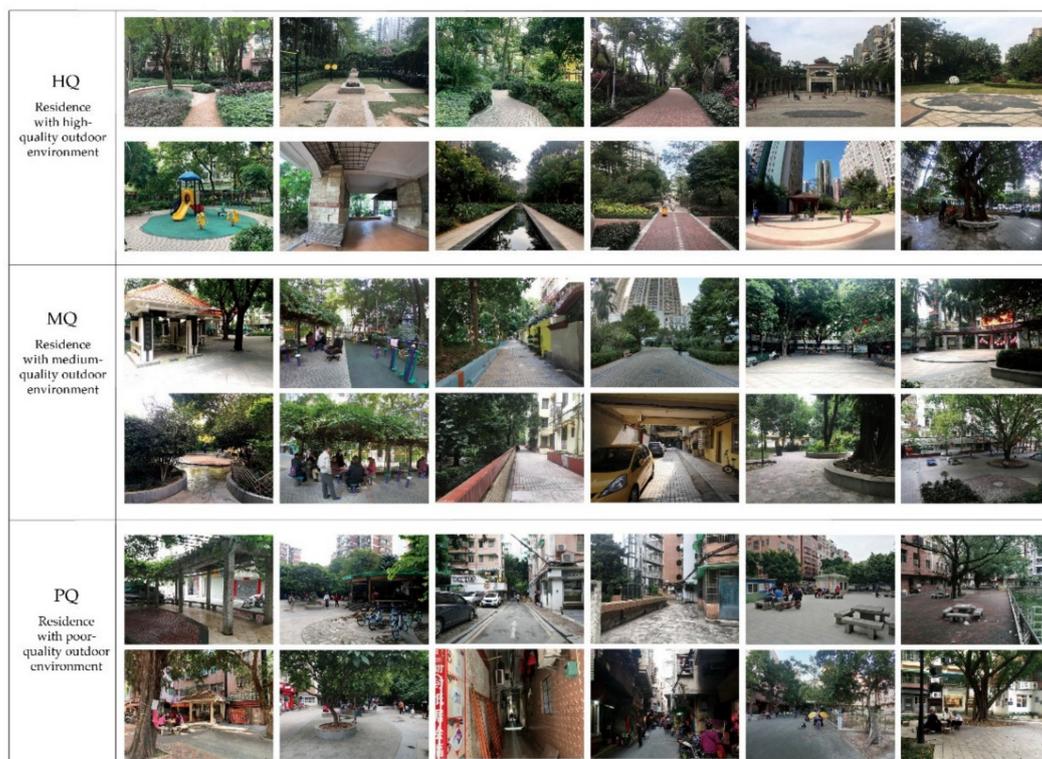
Guangzhou is the capital of Guangdong Province, and it is the largest industrial and commercial city in South China. It has a total of more than 13 million residents and land area of 7434 km<sup>2</sup>. In 2018, 18% population of Guangzhou was over 60 years of age, and it was sometimes more than 20% in older neighborhoods [75].

Attributes of residential outdoor environment that affect health outcomes include landscape quality, spatial form quality, and microclimate. Thus, we developed a scale assessing 14 environmental factors in three dimensions based on previous research [20,76–80]. We first carried out the field investigation across 37 residences in Guangzhou, and the scale was used by the trained researchers to rate the residential outdoor environments. Based on the results, we classified the environments into three different quality levels: (1) high quality (HQ), (2) medium quality (MQ), and (3) poor quality (PQ). Finally, nine representative residential locations with three different quality levels of outdoor environments were selected as study sites.

HQ residences were built during the 2000–10s, with pleasant landscapes and large public areas. The outdoor environments of HQ residences have a high ratio of greenness, a well-designed layout, abundant facilities, and good maintenance, with high scores on all the factors in general. MQ residences were established during the 1990–2000s, with outdoor environment quality ratings in between HQ and PQ residences. The outdoor environments of MQ residences have a relatively high proportion of green space and some recreational facilities with old-fashioned design. PQ residences were built during the 1980–90s and characterized by a lack of public area and high building density. The outdoor environments of PQ residences have a low ratio of greenness, their spatial layout is inappropriate, and functions of the site are not in harmony with the land use structure. Pictures of residential outdoor environments are shown in Figure 2.

A cross-sectional study was designed to investigate the relationship between residential outdoor environments and mood in the elderly in Guangzhou. Prior to the survey, we obtained the consent of the property management of residences to conduct the investigation. We obtained the approval of

each participant at the start of the interview and assured that their private information would not be divulged and all the data would only be used for academic purposes.



**Figure 2.** Three types of residential outdoor environments with different qualities.

### 3.2. Participants

Residents who were aged 60 years and over, living in the study area for more than half a year, able to understand the survey questionnaires, and provide responses, were invited to participate. During the survey, we randomly intercepted the residents in the study areas to introduce the survey purpose, and we asked some simple questions about their age and length of residence to identify whether they were eligible to participate. We used a convenience sampling method for recruiting. The interview was conducted anonymously, and verbal informed consent was obtained from each participant prior to the study. We invited 472 older adults to participate in the questionnaire survey and eventually received 435 responses. The overall response rate was 92.1% (non-response rate, 7.9%). Of the completed questionnaires, 32 were invalid due to incompleteness. Thus, the final sample consisted of 403 participants, with a valid response rate of 85.3%. Table 1 shows the demographic characteristics of the participants.

**Table 1.** Participant demographic characteristics ( $N = 403$ ).

Characteristic	Category	N (%)
Sex	Male	148 (36.7%)
	Female	255 (63.4%)
Age (years)	60–69	160 (39.7%)
	70–79	111 (27.5%)
	≥80	132 (32.8%)
Education	High school or below	328 (81.4%)
	Bachelor's Degree	66 (16.4%)
	Master's degree	7 (1.7%)
	Doctorate	2 (0.5%)
Occupation (before retirement)	Professional and technical personnel	117 (29.0%)
	Business and service personnel	34 (8.4%)
	Agricultural production personnel	72 (17.9%)
	Production and transportation workers	90 (22.3%)
	Others	90 (22.3%)

### 3.3. Data Collection

Before the extensive field investigation, the instruments were pilot-tested in a small group of elderly people, and we made minor changes to the questionnaire based on feedback to make it more comprehensible. The questionnaires were administered by the interviewers, who received a half-day of intensive training regarding data collection. Participants were interviewed in the outdoor environment of the residential areas between 7 a.m. and 8 p.m. during weekdays and weekends. The trained investigators administered the questionnaire verbally to participants, in which the researchers read each question to the participants and recorded their responses. Participants were given as much time as they needed to answer and most questionnaires took approximately 20 min to complete. On completion of the questionnaire, participants were given a small gift to thank them for taking part in the survey. All of the questionnaire surveys were carried out from 20 November 2019, to 26 December 2019.

We selected 14 specific factors for inclusion in the questionnaire survey for assessment of the quality of residential outdoor environments based on previous studies [20,76–80]. The environmental factors were as follows: (1) Landscape quality (e.g., cleanliness, function of the site, road pattern, accessibility, pavement, greenness, facilities, and building facade), (2) Spatial form (e.g., spatial scale, enclosure, and transparency), and (3) Microclimate (e.g., temperature, humidity, and wind environment). The scale has a unidimensional structure and includes items such as “The function of the site can meet my demand” and “It is easy to access to the outdoor environment.” Participants were required to rate their agreement on a five-point scale ranging from 1-strongly disagree to 5-totally agree. Higher scores indicate higher levels of assessment on the environment quality.

Mood was assessed using the PANAS [65]. The Chinese version of PANAS with 18 items was used in this study and consists of two subscales that describe positive and negative moods [81]. Positive affect and negative affect have been previously confirmed to be two relatively independent dimensions in the structure of PANAS [72], and we therefore calculated the score of positive affect and negative affect separately in this study. Participants indicated the extent of their feelings of positive affect (e.g., enthusiastic or excited) and negative affect (e.g., afraid or depressed) using a 5-point Likert scale (1 = very slightly or not at all, 2 = a little, 3 = moderately, 4 = quiet, and 5 = very much), during the past two weeks when they were in the outdoor residential environments.

### 3.4. Statistical Analyses

Data analyses were conducted using SPSS (version 25.0, IBM, Armonk, NY, USA). Graphs and figures were generated using GraphPad Prism version 6 (GraphPad Software, San Diego, CA, USA). The Kruskal–Wallis test was used to determine whether there were differences in the assessment of environmental quality and mood among the three types of residential outdoor environments. We then used Spearman’s rank correlation coefficient to understand the association between environmental factors and mood. A set of multiple linear regression models (Table 2) were also constructed to understand the main variable affecting the mood of the elderly. Each model represents the stepwise addition of each environmental factor.

**Table 2.** Summary of the independent categories in the regression models.

Categories	Model 1	Model 2	Model 3	Model 4
Landscape quality	√	√	√	√
Space form		√		√
Microclimate environment			√	√

## 4. Results

### 4.1. Reliability and Study Model Verification

Cronbach’s  $\alpha$  was used to confirm the reliability and validity of each type of residential outdoor environment, where a value of 0.6 or higher was regarded as reliable. Table 3 shows the number of

items in each type of residence and their reliability values. The variables of each type of residence were composed of 39 items, and each of their  $\alpha$  values was considered satisfactory at 0.6 or higher. Factor analysis was used to confirm the study's validity, and all of the loading values from the types of residential outdoor environments were higher than 0.8 and were subsequently included in the analyses.

**Table 3.** Reliability verification.

Types of Residential Outdoor Environment	Items	Construct Reliability (Cronbach's $\alpha$ )
High quality (HQ)	39	0.855
Medium quality (MQ)	39	0.891
Poor quality (PQ)	39	0.849

#### 4.2. Differences in Assessments of Environmental Factors and Mood Effect of Older People among Three Types of the Residential Outdoor Environment

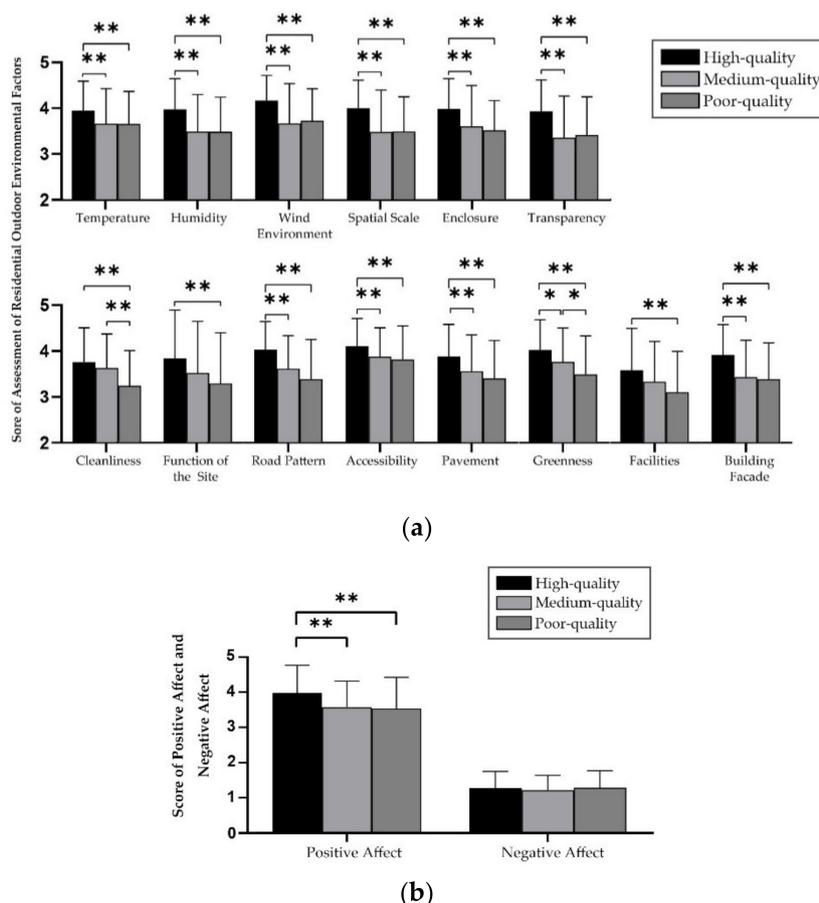
The assessments of 14 residential outdoor environmental factors and positive and negative mood effects among three types of residence are shown in Figure 3. The results show large variability among the three types of residences. The score of environmental assessments tended to be high for HQ residences and low for MQ and PQ residences. Kruskal–Wallis test was performed on all 14 environmental factors, and all the hypotheses of the equal medians across three types of residence were rejected ( $p \leq 0.01$ ). We also conducted a Dunn test, which revealed that the assessment of greenness had significant differences in three types of residences. There were significant differences in most of the factors between HQ and MQ residences, while no significant difference was found across 12 factors between MQ and PQ.

HQ residences showed the highest score on positive affect, followed by MQ residences and PQ residences. Kruskal–Wallis test for positive mood effects showed that the hypothesis of equal medians among three types of residence was rejected ( $p \leq 0.01$ ), and the Dunn test showed that HQ residences showed a significantly higher score of positive affect than MQ and PQ residences ( $p < 0.01$ ), while no significant difference was found in MQ or PQ residences. We found no significant difference in negative affect between the three residence types.

#### 4.3. The Effects of Different Factors on the Mood of Older People and Their Relative Importance

As shown in Table 4, the results of Spearman's correlation analysis among the three types of residential areas were highly variable. For HQ residences, the results showed that all of the environmental factors were correlated with positive affect (PA), while only seven environmental factors were correlated with negative affect (NA), including cleanliness, enclosure, temperature, function of the site, greenness, spatial scale, and humidity. For MQ residences, PA was positively related to all other 11 environmental factors, except for function of the site, greenness, and facilities, while only one factor (wind environment) was significantly correlated with NA. This analysis showed that the influence factors of NA could not be determined from the environmental factors of medium-quality residences. In PQ residences, PA was significantly correlated with all of the factors except greenness, while NA was significantly correlated with most environmental factors except function of the site, accessibility, and facilities.

To analyze the main factors that impacted mood in the elderly across the three residential types, we constructed several multiple linear regression models (Table 5; Table 6). The independent variable in Model 1 includes landscape quality factors, whereas that in Model 2 includes both landscape quality and spatial form quality factors. The independent variable in Model 3 includes both landscape quality and microclimate environment factors, while all of the selected factors were simulated in Model 4. Multiple models were estimated partly to ensure the stability of the observed relationship. All of the results in Model 4 were generally consistent with those in Models 1–3. The result showed that all of the variance inflation factor (VIF) values in the regression models were less than 3, suggesting no collinearity issues between the selected variables.



**Figure 3.** (a) Assessments of residential outdoor environmental factors among the three types of residence; (b) Positive and negative mood effect among three types of residence. \*\*  $p < 0.01$ .

**Table 4.** Spearman’s correlations between mood effect and the selected factors in regression models of three types of the residential outdoor environment.

Categories	Factors	High Quality		Medium Quality		Poor Quality	
		PA (positive affect)	NA (negative affect)	PA (positive affect)	NA (negative affect)	PA (positive affect)	NA (negative affect)
Landscape quality	Cleanliness	0.427 *	-0.288 *	0.238 *	-0.070	0.214 **	-0.275 *
	Function of the site	0.348 **	-0.192 *	0.135	-0.850	0.189 *	-0.098
	Road pattern	0.297 **	-0.146	0.339 **	-0.135	0.200 *	-0.187 *
	Accessibility	0.280 **	-0.054	0.257 **	-0.009	0.297 **	-0.166
	Pavement	0.369 **	-0.240	0.361 **	0.020	0.330 **	-0.247 **
	Greenness	0.268 **	-0.181 *	0.177	-0.040	0.116	-0.245 **
	Facilities	0.169 *	-0.032	0.149	-0.071	0.296 **	-0.132
Spatial form	Building facade	0.297 **	-0.182 *	0.244 **	-0.086	0.369 **	-0.222 **
	Spatial scale	0.398 **	-0.210 *	0.377 **	0.002	0.365 **	-0.293 **
	Enclosure	0.357 **	-0.237 **	0.294 **	-0.010	0.196 *	-0.288 **
Microclimate environment	Transparency	0.224 **	-0.097	0.332 **	-0.090	0.411 **	-0.342 **
	Temperature	0.264 **	-0.233 **	0.306 **	-0.173	0.385 **	-0.234 **
	Humidity	0.236 **	-0.196 *	0.300 **	-0.105	0.259 **	-0.361 **
	Wind environment	0.306 **	-0.238	0.257 **	-0.193 *	0.349 **	-0.271 **

\* Coefficient is significant at the  $p < 0.05$  level. \*\* Coefficient is significant at the  $p < 0.01$  level.

For HQ residences, the results showed that the cleanliness and function of the site were positively associated with PA in Model 1 (Table 5). Of the two factors, cleanliness had a stronger relationship with PA than the function of the site. Cleanliness was positively associated with NA (Table 6). Comparing Models 2 and 3 with Model 1, the adjusted R-squared values increased by 0.015 and 0.004 in PA, respectively, while they both decreased by 0.008 in NA. The results showed that the positive mood effect of space form was more pronounced than that of the microclimate environment, while neither

space form nor microclimate environment had any significant association with NA. In Model 4, the adjusted R-squared values were 0.252 and 0.172, respectively, in PA and NA, which meant that approximately 25.2% and 17.2% of the variation in the elderly population mood was explained by the model. After including both space form and microclimate environment in Model 4, cleanliness showed no significant association with PA, indicating that the effect of cleanliness on PA was mediated by space form and microclimate environment. The results showed that the function of the site was positively associated with PA, and cleanliness was negatively associated with NA in the high-quality residential outdoor environment.

For MQ residences, regression analysis showed that pavement was positively associated with PA in Model 1 (Table 5). Comparing Models 2 and 3 with Model 1, the adjusted R-square values increased by 0.026 and 0.005, respectively. The results indicated that the associations were stronger between PA and space form than between PA and microclimate environment. In Model 4, the adjusted R-squared value was 0.150, which meant approximately 15.0% of the variation in the elderly population mood was explained jointly by 11 environmental variables. The results indicated that pavement was significantly associated with PA, which was similar to the results of other models.

For PQ residences, the results of the regression analysis showed that, in Model 1, building facade was positively associated with PA (Table 5), while greenness was negatively associated with NA (Table 6). Comparing Models 2 and 3 with Model 1, the adjusted R-squared values increased by 0.074 and 0.042, respectively, in PA, while they decreased by 0.109 and 0.114, respectively, in NA. The results established that spatial form had a stronger relationship with PA, while microclimate was relatively weakly related to PA, and the negative mood effect of the microclimate environment was more obvious than the effect of spatial form. In Model 4, the adjusted R-squared value was 0.222 in PA, while it was 0.260 in NA, which meant that approximately 22.2% and 26.0% of the variation in the elderly's mood, respectively, was explained by the model. The results showed transparency to be positively associated with PA, and four factors (greenness, enclosure, transparency, and humidity) to be negatively associated with NA. Among the four factors, humidity was the most significant variable in predicting NA, followed by transparency, enclosure, and greenness. However, temperature was positively associated with NA.

**Table 5.** Multiple regression results with positive affect (PA) as the dependent variable across each type of residential outdoor environment.

Categories	Factors	High-Quality				Medium-Quality				Poor-Quality			
		Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Landscape quality	Cleanliness	0.239 **	0.180 *	0.221 *	0.174	-0.060	-0.043	-0.118	-0.070	0.024	-0.012	-0.009	-0.027
	Function of the site	0.186 *	0.175 *	0.182 *	0.177 *					-0.026	0.018	0.007	0.028
	Road form	-0.003	-0.005	0.001	0.002	0.174	0.080	0.144	0.100	-0.047	-0.125	-0.092	-0.136
	Accessibility	0.130	0.143	0.113	0.130	0.056	0.006	0.044	0.013	0.140	0.087	0.097	0.068
	Pavement	0.119	0.116	0.096	0.098	0.234 *	0.225 *	0.246 *	0.233 *	0.101	0.085	0.081	0.076
	Greenness	0.051	0.028	0.057	0.038								
Space form	Facilities	-0.124	-0.156	-0.123	-0.152					0.167	0.168	0.204 *	0.195
	Building facade	0.139	0.007	0.140	0.034	0.103	0.006	0.103	0.037	0.215 *	0.153	0.127	0.121
	Spatial scales		0.101		0.089		0.139		0.136		0.157		0.099
	Enclosure		0.156		0.141		0.017		0.008		-0.094		-0.107
Microclimate environment	Transparency		0.050		0.031		0.168		0.151		0.264 **		0.231 *
	Temperature			0.037	0.015			-0.118	-0.134			0.093	0.072
	Humidity			-0.101	-0.083			0.160	0.101			0.056	0.039
	Wind environment			0.147	0.115			0.111	0.034			0.180	0.103
	R <sup>2</sup>	0.283	0.312	0.302	0.323	0.173	0.221	0.200	0.230	0.191	0.279	0.249	0.297
	Adj R <sup>2</sup>	0.242	0.257	0.246	0.252	0.137	0.163	0.142	0.150	0.147	0.221	0.189	0.222
	Mean VIF	1.495	1.683	1.734	1.855	1.571	1.790	1.846	1.989	1.546	1.580	1.671	1.726

\**p* < 0.05. \*\**p* < 0.01.

**Table 6.** Multiple regression results with negative affect (NA) as the dependent variable across each type of residential outdoor environment.

Categories	Factors	High-quality (HQ)				Poor-quality (PQ)			
		Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Landscape quality	Cleanliness	-0.332 **	-0.312 **	-0.326 **	-0.309 **	-0.059	-0.031	-0.032	-0.024
	Function of the site	-0.131	-0.126	-0.111	-0.106				
	Road form					0.016	0.070	0.038	0.050
	Pavement					-0.010	0.064	-0.034	0.049
	Greenness	-0.028	-0.026	-0.025	-0.025	-0.201 *	-0.157	-0.245 **	-0.199 *
	Building facade	-0.111	-0.076	-0.089	-0.057	-0.124	0.000	-0.037	0.021
Space form	Spatial scales		0.000		0.007		-0.105		0.010
	Enclosure		-0.075		-0.075		-0.183 *		-0.212 *
	Transparency						-0.246 *		-0.281 **
Microclimate environment	Temperature			-0.041	-0.028			0.220 **	0.317 **
	Humidity			-0.033	-0.044			-0.386 **	-0.396 **
	Wind environment							-0.122	-0.036
	R <sup>2</sup>	0.211	0.214	0.214	0.217	0.090	0.213	0.219	0.320
	Adj R <sup>2</sup>	0.189	0.181	0.181	0.172	0.055	0.164	0.169	0.260
	Mean VIF	1.291	1.537	1.766	1.848	1.399	1.480	1.550	1.643

\**p* < 0.05. \*\**p* < 0.01.

## 5. Discussion

### 5.1. Factors Influencing Mood in the Elderly across Various Residential Outdoor Environments

The results of this study supported our hypothesis, indicating that residential outdoor environments have an impact on mood in the elderly, and the relationship varies with the different qualities of residential outdoor environments. Specifically, the elderly demonstrated greater positive affect in higher-quality residential outdoor environments in Guangzhou. This is consistent with previous studies that found that perceptions of high-quality environmental characteristics in neighborhoods may contribute to positive mental well-being [11,37]. However, there were no differences in negative mood among the three types of residences. This could indicate that positive mood and negative mood respond to the outdoor environment in different ways among older people. Generally, some factors may have different degrees of impact on the elderly's mood in different qualities of residential outdoor environments and may be related to residents' individual differences and the environmental characteristics of the residential area.

In HQ residential outdoor environments, the function of the site was strongly related to positive mood, while cleanliness of the site was significantly associated with negative mood. It might be the case that residential outdoor environments that serve as multiple functional places can trigger positive emotional responses in the elderly by providing opportunities for them to choose activities they like and by promoting social relationships. Our findings align with previous studies that have found that neighborhood can influence residents' well-being by providing a setting in which to foster social connections and subsequent positive mood [82]. Furthermore, the findings that site cleanliness was associated with mood is consistent with a previous study that found neighborhood uncleanness (e.g., presence of litter and dog dirt) was associated with lower levels of neighborhood satisfaction and mental health [83]. Moreover, participants living in HQ residential environments with higher socioeconomic status (SES) may prefer to have more places for physical exercise and pay more attention to sanitation issues [84]; thus, the function and cleanliness of the site are more important for their outdoor experience compared with other factors [85].

In MQ residential outdoor environments, our analyses showed that among the 11 environmental factors, pavement quality was the only one to have a significant effect on positive mood. Our finding aligns with previously-established findings that older adults with more positive perceptions of pavements have better mental health and affective appraisal [20,86]. Previous studies have found that good pavement conditions (e.g., no cracks, curbs, and potholes) in residential areas were conducive to walking for the elderly [87–89]. Walking was found to be the main mode of transportation among the elderly [86,90]. Pavement conditions may be crucial in order for the elderly to participate in outdoor activities, subsequently affecting their positive mood [91]. It is possible that poor conditions may decrease the sense of safety for older people and, in turn, lead to a diminished sense of positive affect due to the threat of tripping. Walking, therefore, may partially explain the association between better pavement conditions and higher positive mood.

In the PQ residential outdoor environments, two interesting findings are notable. First, transparency was associated with a positive mood. Transparency refers to how well residents can see and perceive the space outside of their environment, and previous research found that transparency was a significant predictor of walking [92]. Outdoor environments that exhibit some transparency contribute to the perception of other people's activities beyond the site, which would attract the elderly to participate in outdoor activities, thereby reducing their pressure and promoting a positive mood.

Furthermore, greenness, enclosure, transparency, humidity, and temperature were significant predictors of negative mood. Greenness was negatively associated with negative mood, suggesting that viewing vegetation can ameliorate negative moods (i.e., stress, depression, and anxiety). This finding is consistent with the effect of greenness on mental health found in various kinds of environments [93–96]. Moreover, enclosure and transparency were found to be negatively associated with negative mood, also confirming the findings of previous studies [20,76,97]. Older people living in PQ residences with

high building density may experience negative moods, likely due to the perception of enclosure and vistas without open views, leading to feelings of depression. However, our findings on the emotional effects of the microclimate environment were inconsistent with prior work [98], and this topic merits further research.

### *5.2. Implications for Residential Planning and Management*

Based on the above findings, community planners, designers, and stakeholders could benefit from knowing what environmental features will enhance the positive emotional response of elderly residents. These environmental features may contribute to the design and building of an aging-friendly community and ultimately enhancing older people's well-being and quality of life. Our findings suggest that the good design of specific environmental features in the residential outdoor environment is an important pivot of positive mood, and the factors impact on the mood among residential environments is different. Thus, the types of residential outdoor environments should be considered individually rather than aggregated simply as "outdoor space".

According to the results in this study, significant environmental predictors should be improved to build a pleasant environment that would exert a positive effect on the mental health of elderly residents. For instance, "function" and "cleanliness" are associated with the mood of the elderly living in high-quality residences. This suggests that for this type of residences, designers should pay extra attention to these two landscape quality factors in the construction of livable residences to enhance the elderly's mental health. Specifically, landscape architects should consider creating various functional spaces, such as spaces for fitness, chess-playing, chatting, and dancing, to promote recreational and social activities for the elderly and, in turn, enhance positive mood. Additionally, maintaining the cleanness of environmental and utilizing vegetation or microtopography to get rid of eyesores are highly effective means for enhancing the positive emotion of residents. In addition, "pavement" should be given higher priority than other elements in the design of medium-quality residences, while "greenness," "spatial form," and "microclimate environment" should be highlighted in the renovation of the poor-quality residences. Equipped with information about the impact of residential outdoor environment on the mood effect, policymakers and designers can make better decisions for residence design and promote the effectiveness and quality of construction in the residential environment.

### *5.3. Limitation and Future Research*

Several limitations of this study should be acknowledged. First, our study is based on a cross-sectional survey in which causality between residential outdoor environments and mood of the elderly residents is not clear. Although some findings coincide with previous studies, we cannot uncover the direction of the causal effect by this survey-based evidence alone. Therefore, longitudinal or experimental research is required for future investigation. Second, the study relied on convenience sampling and therefore provides a limited understanding of the links between residential outdoor environments and mood, and the results may not be representative of the population at large. Future studies should adopt a more stringent sampling method and increase the sample size. Third, another limitation of this study is that we were unable to assess whether the mood varies among older adults of different ages. Previous research has demonstrated that people tend to have a deeper attachment to the neighborhood when aging [99–101], which may impact their emotional response to the environment. In the future research, it will be important to examine more fully the role of the participant characteristics. Finally, the physical health condition and preference of the elderly are not emphasized in this study. It would be promising for future research to examine more individual physical and psychological factors that have been shown to play a role in the interaction with the outdoor environment. The dynamic of the elderly's psychology and behavior associated with the environment should also be studied.

## 6. Conclusions

This study investigated the links between residential outdoor environments of different qualities and the mood of the elderly in Guangzhou. Specifically, we investigated various factors associated with residential outdoor environments and how they may be linked to positive and negative affect.

The result suggested that the elderly tend to perceive more positive emotions in higher-quality residential outdoor environments and that effects of mood can vary as a function of different types of residential outdoor environments. More specifically, the results showed that the function and cleanliness of the site were significantly correlated with mood in high-quality residences, while pavement was significantly correlated with mood in medium-quality residences. In contrast, transparency, enclosure, greenness, temperature, and humidity were significantly correlated with mood in poor-quality residences. The results shed light on the need to promote mental health in the elderly and provide preliminary guidance for planners and designers to consider differences between types of residential outdoor environment that may affect mood and quality of life for elderly residents.

**Author Contributions:** Conceptualization, Y.X. and C.C.; methodology, C.C. and Y.X.; validation, C.C., W.L., and Y.X.; formal analysis, W.L., H.L., and X.Y.; investigation, W.L., H.L., and X.Y.; resources, C.C. and Y.X.; data curation, W.L., H.L., and X.Y.; writing—original draft preparation, W.L., H.L., and C.C.; writing—review and editing, C.C., Y.X., N.K., and W.L.; visualization, N.K. and W.L.; supervision, Y.X.; project administration, C.C.; funding acquisition, Y.X. and C.C. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by the National Natural Science Foundation of China, grant numbers: 51808229 and 51908310, and by the 2019 Philosophy and Social Science Foundation of Guangzhou, grant number: 2019GZGJ53, and by the 2017 Innovative Talents Project of Education Department of Guangdong Province, grant number: 2017WQNCX010.

**Acknowledgments:** We would like to thank Danyang Lei, Wangying Liang, Aiting Chen and Zhushen Cen for their help in undertaking the survey and collecting the data.

**Conflicts of Interest:** The authors declare there are no conflicts of interest.

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