A Study on the Relationship between Residential Environment Space and Residents' Health in Hefei

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Abstract. The quantitative relationship between residential environment and residents' health has been studied by taking the residential districts in Hefei new district of government administration as the research target. Data and information related to residential environment and residents' health were obtained through field investigation and questionnaire survey. The correlation of each factor was tested by single factor variance analysis, and the multiple regression model was used to analyse residential areas. The richness of plant species was negatively correlated with the health of residents, the appreciation of plants was positively correlated with the health of residents, and the air quality was negatively correlated with the health of residents. In the design of residential area, we should strengthen the appreciation of plants, avoid overuse of plant varieties, and pay attention to the role of plants in improving air quality.

1. Introduction

Health preservation has become one of the topics widely discussed by all the people, and its importance is self-evident. With the improvement of living standards in urban development, the number of sub-healthy, obese and chronic disease patients has increased year by year. According to Report on Health and Population Health in Beijing (2014), the prevalence of hypertension, diabetes and obesity in Beijing residents aged 18-79 was increased about 3.3%, 1.1% and 3.8% in 2014 compared with 2011[1]. The rate of overweight and obesity in Anhui Province ranked tenth in the country. Secondly, the hypertensive, hyperlipidemia and hyperglycemia patients are becoming younger and younger from old people originally, therefore, the health problems of residents should not be underestimated.

As the natural environment in which human beings live is very important to their health, the quality and quantity of urban environment which is a natural factor in urban artificial space, affect the physical and mental health of urban residents [2]. In urban green space system, one of the green space with the highest contact rate among urban residents is the residential environment, whose spatial layout form plays a great role in people's perception and use. People can produce corresponding physiological and psychological changes by feeling different audiovisual environment, light environment, spatial scale perception and using different spatial functions, which have an impact on human health [3].

Two residential districts with different residential environmental characteristics in Hefei have been chosen to study the relationship between environment and residents' health quantitatively, in order to explore the impact of residential environment on residents' health. It could be concluded the meaning of
promoting environmental design and balanced developing human health benefits to drive the improvement of related design and provide more optimized environmental design strategies.

2. Objects and Methods

2.1. Study Site
In this study, Xiangxieshiudu District (X district) and Yiyuanshijia District (Y district) in Hefei new district of government administration are taken as the study sites as there are differences in the internal environmental forms between X district and Y district, such as the differences of water areas, plant richness and appreciation, public facilities and so on. Therefore, it is of great significance to study the relationship between environment and residents’ health in Hefei residential areas. The X district and Y district are adjacent to the Swan Lake Sports Park. X district covers an area of 96,570 m², green ratio of 52%, and plot ratio of 1.82. There are 6,000 m² water area surrounding the residential buildings, complete public facilities, subtropical swimming pools, tennis courts and seven bottom overhead activity areas that could meet the needs of residents for leisure and health, neighborhood communication and parent-child activities. It locates 800 meters away from the south of Swan Lake Sports Park of Y district, which covers an area of 11,516 m², green ratio of 41%, and plot ratio of 2.0. The construction of green space and fitness facilities in the community cannot meet the needs of residents. Within the limited area of the main entrance of the residential area, landscape elements such as squares, fountains, inner streets, environment and gardens are laid out; the residential area adopts the layout mode of gradually rising from south to North and from east to west to meet the requirements of sunshine and ventilation, as well as the penetration of landscape, that could basically represent the typical community with below average level of green environment community in Hefei. In order to exclude the influence of the surrounding environment and the quantity of survey data to keep the scientific rigor, the residential area near Swan Lake was selected to control the variable factors of the surrounding environment. The two residential areas can represent different environmental quality levels of communities, which are satisfied with the representativeness of samples and the certain reliability and validity of study results in followed promoting stage basically.

2.1.1. Green Space Status. There are 6,000 m² water area in X district, where the internal water flows circuitously pass around the buildings with both equality of excellence and beauty of water landscape as there are abundant revetment plant. The green ratio of this district is 52% with 49 families and 75 genera of plants, including 37 species of trees, 33 species of shrubs, 20 species of grass cover and 1 species of bamboo. Total plants are properly trimmed and grow well from ground cover, herbs, shrubs, small to large trees, which makes various vegetation layers and high coverage.

2.1.2. Public Facilities. Meanwhile, there is an artificial pool of about 800 m² without water storage in the Square in Y district, which is equivalent to a sinking hard square. There are about 200 square meters of small curved ponds in the central activity area, where some aquatic plants, such as water lilies and scallions, are planted along the coast of the pond. The green ratio of Y district is 41% and there are 46 families and 73 genera of plants, including 32 species of trees, 31 species of shrubs, 16 species of grass cover and 1 species of bamboo. Compared with X district, the plant layer, coverage rate and appreciation are lower. The ground cover plants in front of the house are trampled, neglected in management, which causes shrubs grow badly, makes the plant level and appreciation worse.

2.2. Study Object
The survey was conducted by random sampling and the subjects selected were permanent residents in two districts. From May 2018 to January 2019, 163 people were selected to conduct a questionnaire survey. The questionnaire was sent out by the investigators. The respondents volunteered to fill in the questionnaire, which have been finished and collected on the spot. The effective recovery rate was 96.32%, among which here are 60 valid questionnaires collected from X district while 97 from Y district.
According to the inclusion exclusion criteria, 120 people were finally included as the study subjects, 60 from each district. All the respondents had informed consent and conducted the investigation according to ethical requirements.

2.3. Inclusion and Exclusion Criteria
Inclusion criteria: The subjects were young and elderly permanent residents living in two residential areas for more than half a year and those who volunteered to participate in and fill in the questionnaire. Exclusion criteria: residents who are unwilling to participate in the survey, permanent residents in non-two residential areas and residents with severe cognitive impairment.

2.4. Survey Project
The contents of the survey include the basic personal information, physical and mental health status, and their subjective evaluation of the residential environment.

2.4.1. Health Survey. This study designed questionnaires based on the SF-36 scale to assess the physical and mental health of community residents. The corresponding scores of physical and mental health status were obtained according to SF-36 formula calculation method, it shows that the higher the scores, the better the physical and mental health status.

2.4.2. Variable survey. The general situation of the subjects (age, sex, height, weight, etc.) and the community environmental assessment are investigated and quantified by self-designed questionnaires.

2.5. Analysis Method and Variable Assignment
Multiple linear regression analysis is used in this study. Physiological and psychological health scores of community residents are used as variables, while plant richness perception, ornamental perception and air quality perception as independent variables. At the same time, gender, age, height, weight and occupation are included as control variables. The variable assignment table is shown in Table 1.

| Variable                          | Code | Assignment Statement                                      |
|-----------------------------------|------|----------------------------------------------------------|
| Gender                            | X1   | 0=Male, 1=Female                                         |
| Age (year)                        | X2   | 1=>50 years old, 2=31~50 years old, 3=24~30 years old, 4=18~23 years old, 5=<18 years old |
| Height (cm)                       | X3   | 1=<150 cm, 2=150~160 cm, 3=161~170 cm, 4=171~180 cm, 5=>180 cm |
| Weight                            | X4   | 1=<45 kg, 2=45~55 kg, 3=56~65 kg, 4=66~75 kg, 5=>75 kg |
| Vocation                          | X5   | 1=Indoor, 2=Others, 3=Retire, 4=Student, 5=Outdoor |
| Regional environmental perception | X6   | 1=Low, 2=Relatively Low, 3=Middle, 4=Relatively High, 5=High |
| Plant Richness                    | X7   | 1=Low, 2=Relatively Low, 3=Middle, 4=Relatively High, 5=High |
| Plant Appreciation                | X8   | 1=Low, 2=Relatively Low, 3=Middle, 4=Relatively High, 5=High |
| Air Quality                       | X9   | 1=Low, 2=Relatively Low, 3=Middle, 4=Relatively High, 5=High |
| Physical Health                   | Y1   | Quantitative Data                                        |
| Mental Health                     | Y2   | Quantitative Data                                        |
3. Results and Analysis

3.1. General Information of the Respondents

120 people are included in this study at the aged from 12 to 80 years. 61 women (50.83%) are included in this study, which can be seen in Table 2.

| Table 2a. General Information of the Respondents (X district) |
|---------------------------------------------------------------|
| **Variable** | **Sort** | **Number** | **ratio (%)** |
| Gender | Male | 28 | 46.67 |
| | Female | 32 | 53.33 |
| Age (year) | <18 | 8 | 13.33 |
| | 18–23 | 10 | 16.67 |
| | 24–30 | 4 | 6.67 |
| | 31–50 | 18 | 30.00 |
| | >50 | 20 | 33.33 |
| Height (cm) | <150 | 1 | 1.66 |
| | 150–160 | 12 | 20.00 |
| | 161–170 | 31 | 51.67 |
| | 171–180 | 15 | 25.00 |
| | >180 | 1 | 1.67 |
| Weight (kg) | <45 | 1 | 1.66 |
| | 45–55 | 16 | 26.67 |
| | 56–65 | 24 | 40.00 |
| | 66–75 | 16 | 26.67 |
| | >75 | 3 | 5.00 |
| Vocation | Indoor | 18 | 30.00 |
| | Others | 20 | 33.33 |
| | Retire | 7 | 11.67 |
| | Student | 11 | 18.33 |
| | Outdoor | 9 | 15.00 |

| Table 2b. General Information of the Respondents (Y district) |
|---------------------------------------------------------------|
| **Variable** | **Sort** | **Number** | **ratio (%)** |
| Gender | Male | 31 | 51.67 |
| | Female | 29 | 48.33 |
| Age (year) | <18 | 12 | 20.00 |
| | 18–23 | 19 | 31.67 |
| | 24–30 | 5 | 8.33 |
| | 31–50 | 13 | 21.67 |
| | >50 | 11 | 18.33 |
| Height (cm) | <150 | 6 | 10.00 |
| | 150–160 | 14 | 23.33 |
| | 161–170 | 23 | 38.33 |
| | 171–180 | 15 | 25.00 |
| | >180 | 2 | 3.34 |
| Weight (kg) | <45 | 10 | 16.67 |
| | 45–55 | 18 | 30.00 |
| | 56–65 | 11 | 18.33 |
| | 66–75 | 12 | 20.00 |
| | >75 | 9 | 15.00 |
| Vocation | Indoor | 27 | 45.00 |
3.2. Scores of Environmental Assessment

In this study, regional environmental satisfaction, plant richness sensitivity, plant ornamental sensitivity and air quality sensitivity were selected as the environmental evaluation indicators of residential areas. The average score of regional environmental satisfaction of the two districts is 3.442, of which the average score of X district is 3.54 and the average score of Y district is 3.37, the highest score is 5, the lowest score is 2. The total average score of plant richness is 2.883, of which the average score of X district is 3.22 and the average score of Y district is 2.64, the highest score is 5, the lowest score is 1. The total average score of plants appreciation is 2.867, of which the average score of X district is 3.1 and the average score of Y district is 2.7, the highest score is 5, the lowest score is 1. The average score of air quality perception is 2.683, of which the average score of X district is 3.28 and the average score of Y district is 2.25, the highest score is 5, and the lowest score is 1, which is shown in Table 3.

Table 3. Descriptive Statistics of Environmental Assessment Variables

| Variable               | Study Object | Sample Number | Mean Value | Standard Deviation | Minimum | Maximum |
|------------------------|--------------|---------------|------------|--------------------|---------|---------|
| Environmental Satisfaction | X district  | 50            | 3.54       | .646               | 2       | 5       |
|                        | Y district  | 70            | 3.371      | .705               | 2       | 5       |
| Plant Richness         | X district  | 50            | 3.22       | .815               | 2       | 5       |
|                        | Y district  | 70            | 2.643      | .852               | 1       | 5       |
| Plants Appreciation    | X district  | 50            | 3.1        | .863               | 1       | 5       |
|                        | Y district  | 70            | 2.7        | .906               | 1       | 5       |
| Air Quality            | X district  | 50            | 3.28       | .64                | 2       | 5       |
|                        | Y district  | 70            | 2.257      | .793               | 1       | 4       |

Through T-test, it can be found that there is no significant difference in regional environmental satisfaction between the two districts (t=1.3364, p>0.05). There are obvious differences in plant richness (t=3.7243, P < 0.001), plant ornamental sensitivity (t=2.4307, P < 0.05) and air quality sensitivity (t=7.5332, P < 0.001), which shows that the environmental quality of X district is higher than that of Y district.

3.3. Scores of Physiological and Mental Health

The average score of community residents' physical health is 0.594, the highest score is 0.825, the lowest score is 0.35; the score of community residents' mental health is 0.549, the highest score is 0.833, the lowest score is 0.167. The percentages are shown in Figure 1 as below.
3.4. Comparison of health status
The result of one-way analysis of variance shows that there are statistical significant in the differences comparing the scores of non-plant richness (F = 2.74, P < 0.05) and plants appreciation (F = 4.18, P < 0.01) with the physiological health status. There are statistical significant in the differences among the scores of richness sensitivity (F = 2.58, P < 0.05), plants appreciation (F = 3.8, P < 0.05), air quality sensitivity (F = 3.02, P < 0.05) of different plants and mental health status. (See in Table 4)

3.5. Multiple Regression Analysis of Environment and Health
On the basis of environmental assessment and analysis, plant richness and appreciation are substituted into the regression equation of physiological health, and the regression equation is obtained as follows:

\[ \hat{Y}_1 = 0.923 + 0.036X_1 + 0.007X_2 - 0.385X_3 + 0.003X_4 - 0.007X_5 - 0.011X_7 + 0.052X_8 \]

From the regression equation (P<0.001), it can be seen that the richness of plants is negatively correlated with residents' physical health, and the higher the richness scores, the lower the impact on residents' physical health is. The appreciation of plants is positively correlated with residents' physiological health. The higher appreciation of plants scores, the higher the impact on residents' mental health is.

Furthermore, according to the analysis of environmental assessment, plant richness, plant appreciation and air quality sensitivity were substituted into the regression equation of mental health that is obtained as follows:

\[ \hat{Y}_2 = 0.771 + 0.022X_1 + 0.028X_2 - 0.425X_3 + 0.003X_4 + 0.063X_5 - 0.028X_7 + 0.072X_8 - 0.008X_9 \]

From the regression equation, it can be seen that plant richness is negatively correlated with residents' physical health, and the higher the richness, the lower the impact on residents' mental health. The appreciation of plants is positively correlated with residents' physical health. The higher the appreciation of plants scores, the higher the impact on residents' mental health is. Air quality is negatively correlated

| Variable          | Assignment Score | Number | Physical Health (x±s) | F     | P   | Mental Health (x±s) | F     | P   |
|-------------------|------------------|--------|-----------------------|-------|-----|---------------------|-------|-----|
| Plant Richness    | 5                | 5      | 0.680 ±0.074 8        |       |     | 0.750 ±0.166 6     |       |     |
|                   | 4                | 26     | 0.623 ±0.091 6       |       |     | 0.557 ±0.217 8     |       |     |
|                   | 3                | 56     | 0.603 ±0.104 7       | 2.74  | <0.05| 0.557 ±0.214 3     |       |     |
|                   | 2                | 30     | 0.542 ±0.119 3       |       |     | 0.494 ±0.193 2     |       |     |
|                   | 1                | 3      | 0.558 ±0.112 4       |       |     | 0.527 ±0.287 6     |       |     |
| Plants Appreciation| 4               | 6      | 0.700 ±0.090 0       |       |     | 0.760 ±0.155 3     |       |     |
|                   | 3               | 22     | 0.650 ±0.100 0       |       |     | 0.560 ±0.220 2     |       |     |
|                   | 2               | 58     | 0.590 ±0.100 0       | 4.18  | <0.01| 0.570 ±0.212 9     |       |     |
|                   | 1               | 29     | 0.550 ±0.110 0       |       |     | 0.480 ±0.129 7     |       |     |
|                   | 5               | 5      | 0.520 ±0.110 0       |       |     | 0.370 ±0.124 7     |       |     |
| Air Quality       | 5                | 2      | 0.491 ±0.041 7       | 1.5   | <0.02| 0.166 ±0.000 0     |       |     |
|                   | 4                | 18     | 0.609 ±0.108 3       |       |     | 0.640 ±0.155 7     |       |     |
|                   | 3                | 50     | 0.612 ±0.101 3       |       |     | 0.514 ±0.215 4     |       |     |
|                   | 2                | 40     | 0.582 ±0.118 7       |       |     | 0.571 ±0.228 7     |       |     |
|                   | 1                | 10     | 0.542 ±0.113 1       |       |     | 0.533 ±0.135 4     |       |     |

(See in Table 4)
with residents' mental health. The worse the air quality is, the higher the impact on residents' mental health is.

4. Results and Analysis
This study analyzes the relationship between residential environment and residents' health by investigating the environment of two residential districts in Hefei and their physical and mental health in Hefei. By the investigation of the physical and mental health status based on the SF-36 scale, it was found that the scores of physical health and mental health of residents in two residential district are (0.594 ± 0.1115) and (0.565 ± 0.2153). In the analysis of environmental assessment, the total average scores of perception in the aspects of regional environmental satisfaction, plant richness, plant appreciation and air quality are 3.442, 2.883, 2.867 and 2.683. Through T-test, it is showed that there was no obvious difference in terms of regional environmental satisfaction between the two districts. Nevertheless, it is discovered that the environmental quality is higher in terms of plant richness, plant appreciation and air quality sensibility in X district than those in Y district.

It is showed in this study that plant richness and ornamentally in residential areas are related to residents' physiological health. The richness of plants and residents' physiological health is negatively correlated with each other, that more negative effect on residents' physiological health is produced with the increase of plant varieties. This is accompanied by the increase of plant varieties and the lack of greening management measures within the community, resulting in the disorder of environmental space, thereby reducing the frequency of people using the space to carry out activities, which has a negative impact on the physical health of residents. On the other hand, there is a positive correlation between appreciation of plants and residents' physical health, that is, the higher the appreciation of plants scores, the more positive impact on residents' physical health produces. Similar to plant richness, appreciation of plants directly determines the frequency of residents' use of green space. High-frequency use increases residents' exercise time in outdoor space, which has a positive effect on their physical health [4-5].

In the aspect of mental health, plant richness, appreciation of plants and air quality in residential areas are all related to them [6]. From the regression equation coefficients, it can be seen that the rich plant varieties and good appreciation of plants have a higher positive effect on mental health compared with residents' physical health [7-8]. Plant richness brings a variety of colors with the result that a variety of atmosphere of natural space is created to adapt to the changes of human emotions for the mitigation and relief of psychological emotions. Meanwhile, the perception of air quality has a negative impact on mental health that with the deterioration of air pollution, the lower score of mental health gets and the worse the physical and mental health is. There are some investigations showing that neurotoxins contained in air pollutants can cause many diseases, which lead to adverse psychological effects [8]. At the same time, with the decrease of air quality, the time of residents staying outdoors will be reduced to limit the chances of social activities and outdoor fitness, which have a negative effect on their mental health.

To sum up, in the process of considering about residential environment, more attention should be paid to the designing of appreciation plants, and strengthen the improvement of air quality by plants. On the contrary, it should be avoided that plant varieties are produced excessively when the design of appreciation plants is strengthening in order to prevent negative effects on residents' physical and mental health.

References
[1] Huang Ruogang, Cao Hongxia, Jiao Shufan. Summary of 2014 Beijing Health and Population Health Status Report [J]. Capital Journal of Public Health, 2017,11(01):4-6.
[2] Georgina E Southona, Anna Jorgensena, Nigel Dunnetta, Helen Hoyle, et al. Perceived Species-richness in Urban Green Spaces: Cues, Accuracy and Wellbeing Impacts[J].Landscape and Urban Planning,172,2018:1-10.
[3] Zhang Ludan. Application of Regenerative Environmental Theory in Landscape Design of
Xu Zhimin, Wu Jianping. The Relationship between Green Space Environment and Residents’ Physical and Mental Health in Residential Areas—Mediating Role of Life Satisfaction [J]. Psychological Technology and Application, 2015(06):7-13.

Xu Zhimin. Study on the Relationship between Residential Environment and Residents’ Physical and Mental Health [D]. Beijing: Beijing Forestry University, 2015.

Fang Cheng, Wang Cheng, Guo Erguo, et al. Relationship between Urban environment and Urban Residents’ Health [J]. Journal of Northeast Forestry University, 2010, 38(4): 114-116.

Lv Xiaokang, Wang Cong. Damage of Cognitive Function and Mental Health Caused by Air Pollution [J]. Advances in Psychological Science, 2017, 25(1): 111-120.

Marianne Abramsson, Eva Andersson. Changing Preferences with Ageing – Housing Choices and Housing Plans of Older People [J]. Housing, Theory and Society, 2016, 33(2): 217-241.