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The Connection between Green Space and Cardiovascular Health in Winter City of Harbin, China

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Abstract:

Severely cold climates have a significant impact on cardiovascular health. Studies have shown that green space, as an important health resource, can play a positive role in promoting cardiovascular health through the air environment and exercise. There are few studies on the correlation between urban green spaces and cardiovascular health in winter. In this study, Harbin was used as an empirical case and representative community samples were selected to explore the correlation between community green spaces and cardiovascular health. The results showed that the characteristics of green spaces in residential areas were related to cardiovascular disease and its risk factors. In communities with a green space ratio of less than 28%, residents are at higher risk of lack of exercise, overweight or obesity, high blood pressure and stroke. In communities with a green view index of less than 15%, residents have a higher risk of insufficient physical activity, overweight/obesity, high blood pressure, dyslipidemia, and stroke. There are also significant differences in the cardiovascular health scores of residents in communities with different green space characteristics. Emphasizing the importance of effectively increasing the ratio of community green spaces and the green landscape index to reduce the risk of cardiovascular disease may be of benefit to intervention efforts.

Keywords*:* Winter city; Community; Green space; Cardiovascular health; Risk factors

I. INTRODUCTION

Climate and health are closely related. A large number of studies have found that the morbidity and mortality of cardiovascular disease are higher in high latitudes, cold areas and winter season [1]. In severely cold areas, for every 1 degree drop in temperature, the death rate from cardiovascular disease increases by 1% [2]. In China, winter cities usually refer to cities where the average daily temperature is below 0℃ for more than 3 months of the year, with low

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temperatures, snow and ice, and long winters. According to data from the International Winter Cities Association, there are at least 30 countries in the northern Hemisphere, and more than 600 million people have experienced winter. According to China's sixth census, about 93.55 million people lived in winter cities in 2010, accounting for 13.98% of China's total population. How to overcome the influence of climate factors and promote public health in winter cities with more serious cardiovascular health problems is the key to the prevention and treatment of cardiovascular disease in winter cities in China and the world.

In compare to the other regions, the dietary characteristics and living habits of urban residents in winter in China are unique. They usually have a diet high in salt, rarely participate in outdoor activities and physical exercise, and have excessive fat metabolism, which leads to overweight or obesity. The temperature drops sharply, and the blood vessels of the human body contract easily, causing convulsions, hypoxia, and increasing the burden on the heart. Many key risk factors are related to the winter urban environment and the lifestyle of residents. At the same time, medical research points out the importance and necessity of proper outdoor exercise in winter for the prevention and rehabilitation of cardiovascular disease [3]. Therefore, severely winter climates have a dual impact on cardiovascular health.

A key component of the socio-ecological model published by the World Health Organization is that urban space is an important factor affecting public health and affects people's behavior. This shows that by optimizing urban space, it is possible to increase the burden on cardiovascular disease risk factors. Studies have shown that the main factors leading to cardiovascular disease are behavioral, metabolic and environmental factors. The sum of these three individual risk factors is 20.4% of the total risk. However, by properly controlling these factors, it is possible to minimize the incidence of cardiovascular disease.

Green space is considered to be one of the key elements of the city. Green space refers to land that is partially or completely covered by grass, trees, shrubs or other vegetation, including parks, community gardens, campuses, playgrounds, public seating areas, public squares and open spaces. It can provide residents with open space and help improve the environmental quality of the community. Studies have shown that living close to the natural environment is related to long-term health benefits, including reduced mortality and cardiovascular disease [4]. Studies have also shown that the mortality rate of cardiovascular disease in areas with a higher degree of green living environment is reduced [5]. A study found that the area of green space was negatively correlated with the incidence of stroke [6]. Related studies have also found that living near green spaces is associated with lower levels of diabetes, stroke, and cardiovascular disease, as well as higher survival rates after stroke [7].

In China's winter cities, community green spaces, as the most important spatial element carrying daily communication and exercise activities in a high-density living environment, have extremely important value for health. This study takes the cardiovascular health of urban

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residents in winter in China under the background of severe cold climate as the research object and explores the correlation between green space and residents' cardiovascular health.

II. MATERIALS AND METHODS

Harbin is located at the intersection of 45° North latitude and 128° West longitude. It is a typical winter city in Northeast China, with an average annual temperature of 3.6 °C. Harbin is also the political, economic and cultural center of Northeast China. The main urban areas of Harbin include Daoli, Daowai, Nangang, Songbei, Xiangfang, etc., as shown in Fig 1. Medical research in Harbin has shown that when the temperature in late winter is below -19°C, the number of deaths in Harbin increases significantly as the temperature decreases [2]. 2.7% of the mortality rate is due to cold temperatures, especially for patients with coronary heart disease who are most affected by cold stimulation [2]. At the same time, Harbin is experiencing a period of rapid development with an aging population. By the end of 2015, there were 1.85 million elderly people aged 60 and above in the city, accounting for 19.2% of the total population. Because a large number of elderly people are at risk, the city is facing a very serious risk of cardiovascular disease.

Figure 1. Harbin's main urban areas map

Communities in Harbin are currently polarized. Communities built in recent years usually have better environmental quality and infrastructure. However, more than 50% of communities were built before the 1980s and 1990s, with poor environmental quality and infrastructure. They are distributed in the main areas of the city, and most residential buildings are multi-storey and high-density. In order to withstand the severe cold climate, the layout of the building is mainly enclosed, and some adopt a circular or mixed layout. In gated communities, the scale of green spaces is usually small and activities are relatively monotonous. Due to the

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impact of the cold climate on the safety and comfort of activities, the attractiveness of outdoor activities is weak and the space utilization rate is limited.

2.1 Materials

The monitoring project for chronic diseases and risk factors of residents in Heilongjiang Province is a large-scale survey conducted by Heilongjiang Province to grasp the prevalence and changing trends of major chronic diseases such as hypertension and diabetes. According to the equilibrium of spatial distribution and the existing working basis and conditions, monitoring points were selected in Harbin and other cities and counties in Heilongjiang Province. The recruited respondents were received by doctors at the monitoring point hospital, and the trained staff introduced the informed consent form to the respondents participating in the screening and signed it on a voluntary basis. Monitoring methods mainly include questionnaires, physical examinations, laboratory examinations, dietary surveys, etc. The health survey data used in this study came from one of the components of a series of surveys from 2013 to 2015. The monitoring point database contains 5,342 participants between the ages of 20 and 98. The research content includes: socio-demographic information, lifestyle information, health status information, stroke risk classification screening results, and home address information. After excluding the participants with missing data, the final data contained 4155 samples.

The data collection of this study was carried out at two levels. The personal level includes demographic information, physical activity, height and weight, blood pressure, blood sugar and blood lipids. The second level includes the proportion of community green spaces and the green landscape index.

Age, gender, education level, cardiovascular family history, smoking and physical activity level are self-reported. The education level is divided into five groups: (1) primary school and below, (2) junior high school, (3) high school, (4) university, (5) master's degree and above. Cardiovascular family history is divided into two groups: (1) family history of cardiovascular disease, (2) no family history of cardiovascular disease. Smoking is divided into two groups: (1) smoking now or quitting smoking for less than 12 months, and (2) never smoking or successfully quitting smoking for 12 months. Physical activity levels are divided into two groups: (1) little or no physical exercise; (2) regular exercise. Factors that cause cardiovascular disease include insufficient exercise, overweight/obesity, high blood pressure, diabetes, and dyslipidemia. The index that measures overweight is designated as the BMI index, which is calculated by dividing body weight (kilograms) by the square of height (meters). The overweight/obesity threshold set by the World Health Organization is 25 kg/m2 for adults. Blood pressure is measured by an electronic sphygmomanometer that has been inspected by the quality inspection department and uniformly corrected before on-site screening. The unit of measurement is millimeters of mercury (mmHg) (1mmhg = 1.33kpa). The blood pressure

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measurement part is unified into the upper arm of the left hand. The first blood pressure measurement required participants to rest quietly for at least 5 minutes. The interval between the two blood pressure measurements is at least 1 minute. According to the recommended standards of the "Chinese Guidelines for the Prevention and Treatment of Hypertension (2010)", systolic blood pressure of 140mmhg and diastolic blood pressure of 90mmhg are normal blood pressure, and systolic blood pressure of 140mmhg or diastolic blood pressure of 90mmhg are hypertension. In the fasting blood glucose test, fasting venous blood is collected during the physical examination after 12 hours of fasting. According to the "Guidelines for the Prevention and Treatment of Type 2 Diabetes" Blood glucose diagnostic criteria: blood glucose <6.1mmol/L is normal blood glucose, 6.1~7.0 mmol/L is impaired fasting blood glucose, and 7.0 mmol/L is diabetes. Blood lipid testing also uses fasting venous blood after 12 hours of fasting to detect. In accordance with the diagnostic criteria for dyslipidemia recommended by the "Chinese Guidelines for the Prevention and Treatment of Blood Lipids in Adults", total cholesterol (TC) is greater than or equal to 6.22mmol/L, triglycerides (TG) is greater than or equal to 2.26 mmol/L, low-density lipoprotein cholesterol (LDL-C) is greater than or equal to 4.14 mmol/L, and high-density lipoprotein cholesterol (HDL-C) is greater than or equal to 1.04 mmol/L as the threshold for abnormalities. The risk of stroke is assessed by the doctor based on the stroke scorecard. Insufficient exercise, overweight/obesity, hypertension, diabetes, and dyslipidemia are used to represent independent cardiovascular risk factors; stroke risk and cardiovascular health scores are used to represent the comprehensive status of cardiovascular health.

2.2 Green space variables

The extracted green space characteristics include two indicators: the green space ratio and the green landscape index. The green space ratio is the ratio of the green space area between neighbors divided by the total land area between neighbors. The green area is derived from the original data of the green area scale obtained through field surveys and ranging records in the research area. Based on the land use status data of Harbin City in 2010 and the Google Map of Harbin City in 2015 as a reference, the total surrounding land area is obtained.

The green landscape index is a comprehensive value calculated from the average value of the walking system, open space and plants in the community. A walking system refers to a road system suitable for human and bicycle traffic in a neighborhood. It has the functions of walking traffic and pedestrian leisure, and can serve both non-motor vehicles and motor vehicles. According to the principles of representativeness, universality and operability, observation and sampling points for walking systems, open spaces and plants in each neighborhood are selected. The observation sampling point of the walking system is selected in the middle of the path and takes pictures along the path. The plant observation sampling point is selected on a path or square where residents can easily see the green landscape, at a certain distance from the plants, and the plants are photographed. Select the observation and sampling

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points of the square where the residents are concentrated, and take pictures from the square to the surrounding direction. According to the spatial pattern of the green space, several survey and observation images of the same size and different directions were collected from the perspective of people at each sampling point. Collect 2 to 4 observation images at an observation point, and then correct them according to the field of view to ensure that the image can be included in people's line of sight. Finally, calculate the proportion of green plants in the image as the green landscape index of the sampling point to calculate the comprehensive green landscape index. According to previous research, 15% was selected as the tangent point of the green landscape index.

2.3 Statistical analysis

Using the green space ratio (the first set of models) and the green landscape index (the second set of models) as independent variables, the logical regression model for cardiovascular risk factors and stroke risk was calculated separately. Dependent variables that do not contain cardiovascular risk factors= 0, contain cardiovascular risk factors= 1, do not contain stroke risk factors= 0, and contain stroke risk factors= 1 are included in the model to represent cardiovascular health variables. Factors that cause cardiovascular disease include lack of exercise, overweight/obesity, high blood pressure, diabetes, and dyslipidemia. In order to determine the independent effects of these three characteristics on 5 cardiovascular risk factors and 1 stroke risk factor, two sets of models were constructed (each set includes 6 models). In all models, age, gender, and education level have been adjusted. Factors such as smoking and cardiovascular family history were also added to the cardiovascular risk factor analysis model for adjustment.

The analysis results are expressed by a 95% confidence interval advantage ratio, which estimates the probability of inactivity, overweight/obesity, high blood pressure, diabetes, dyslipidemia, or stroke risk, and represents the change in cardiovascular risk factors and stroke risk when the green space ratio is from greater than 28% to less than 28%, and the green landscape index is from greater than 15% to less than 15%.

III. RESEARCH RESULTS

3.1 Characteristics of participants

There were 5,342 people in the starting sample. Since 1,187 participants were unable to obtain complete residential address information, the final samples available for analysis were 4,155. The characteristics of the sample are shown in Table I. There were slightly more male participants (52.3%); the average age was 54.6 years old. The largest education level is primary school and below, about 63.9%. In this study, a total of 8.2% of respondents reported a lack of physical activity. The average cardiovascular health score is 5.60 points.

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TABLE I. Demographic and health general situation of participants

Project	Numerical value
Average age	54.6
Male ratio	2174
Number of people with primary and below education	2654
Number of people with secondary education	888
Number of people with high school education	547
Number of people with university education	65
Number of people with master's degree and above	1
Number of people with a family history of cardiovascular disease	205
Number of people smoking	225
Number of overweight people	727
Number of people who meet the standard of physical activity	3816
Number of people with hypertension	200
Number of diabetics	53
Number of people with dyslipidemia	138
Stroke risk n (% yes) 430 (10.4)	430
Average cardiovascular health score	5.6

3.2 Cardiovascular disease and cardiovascular risk factors

Judging from land use information, field surveys and demographic characteristics, the characteristics of each community are similar to the surrounding built environment, and the socio-economic characteristics of the residents are relatively consistent. Through a binary logical regression analysis of the relationship between the green space ratio and cardiovascular risk factors (the first set of models), we found that after adjusting the individual level characteristics, there is a significant relationship between the green space ratio and physical inactivity, overweight/obesity and hypertension. These estimates are shown in Table II and Fig 2 can be interpreted as indicating that compared with communities with a green space ratio of more than 28%, respondents in communities with a green space ratio of less than 28% are at higher risk of physical inactivity, overweight/obesity, and hypertension.

Similarly, the second set of models showed that communities with a green space ratio of less than 15% had a higher risk of insufficient physical activity, overweight/obesity, high blood pressure, and dyslipidemia. This result is also obtained after adjusting according to individual characteristics. Participants who live in communities with a green landscape index of more than 15% have a lower risk of lack of exercise, overweight/obesity, high blood pressure, and dyslipidemia.

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TABLE II. Logistic Regression Analysis of the probability of occurrence of cardiovascular disease risk factors by greenfield characteristics

Variable	Lack of exercise	Overweight /obesity	High blood pressure	Diabetes	Dyslipidemia
Green Space ratio	0.62	1.22	0.27	0.79	0.68
	(0.006)	(0.036)	(0.000)	(0.515)	(0.108)
Green Landscape Index	0.53	1.28	0.31	0.87	0.61
	(0.000)	0.004	(0.000)	0.64	0.021

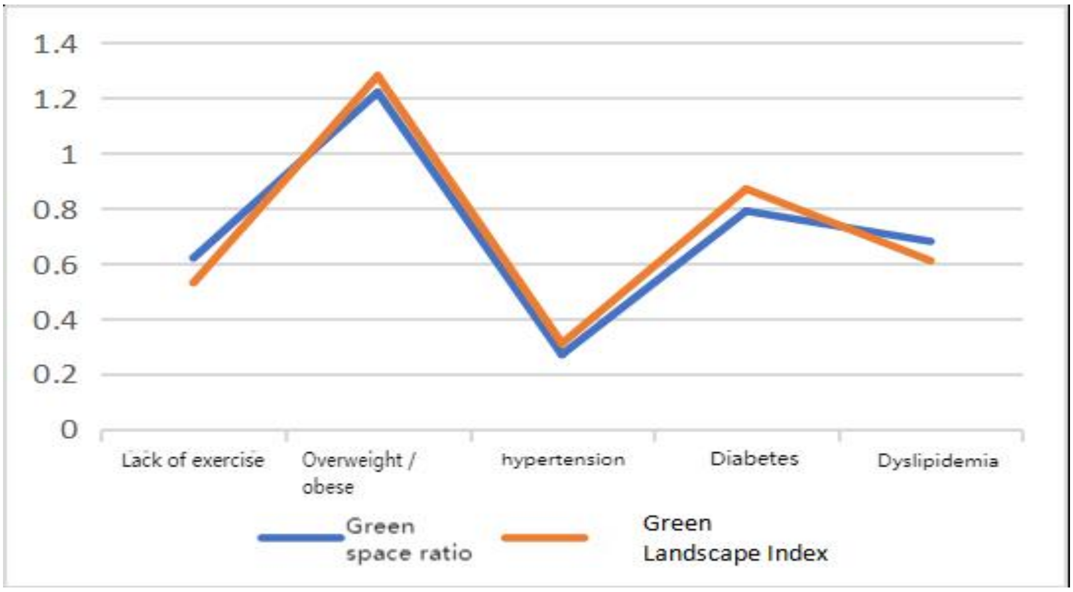

Figure 2. Logistic Regression Analysis of the probability of occurrence of cardiovascular disease risk factors by greenfield characteristics

3.3 Cardiovascular disease and stroke risk

The results of the logical regression model are shown in Table III. It shows that the green space ratio is less than 28%, and the green landscape index is less than 15%, which is accompanied by a higher risk of stroke.

TABLE III. Logistic Regression Analysis of greenfield characteristics on the risk of stroke

Variable	Green space ratio	Green Landscape Index

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Risk of stroke	0.49	(0.000)	0.48	(0.000)

3.4 Green space and Cardiovascular health score

The results of the comparative study on the cardiovascular health scores of respondents living in different green space ratios and green landscape indexes are shown in Table IV. There are significant differences in cardiovascular health scores corresponding to different health characteristics. Residents in communities with a green space ratio higher than 28% and a green landscape index higher than 15% have higher cardiovascular health scores.

TABLE IV. The comparison of the average cardiovascular health scores of respondents with different health characteristics

Green space characteristics		Average cardiovascular disease ratio	p value
Green space ratio	>28% (Sample size = 1029)	5.68	0
	<=28% (Sample size = 3126)	5.57	0
Green Landscape Index	>15% (Sample size = 1487)	5.67	0
	<=15% (Sample size = 2668)	5.55	0

IV. CONCLUSION

The results of this study show that the ratio of green space and the index of green landscape in the community are related to cardiovascular and stroke risk. The green space ratio is equal to or less than 28% and is related to lack of exercise, overweight or obesity, high blood pressure and stroke risk; the green landscape index is equal to or less than 15% and is related to lack of exercise, overweight or obesity, high blood pressure, dyslipidemia and stroke risk. The results also showed that the cardiovascular health scores of respondents in areas where the proportion of green space in residential areas is higher than 28% and the green landscape index is higher than 15% were significantly higher than those in areas where the proportion of green space in residential areas is equal to or less than 28%, and the green landscape index is equal to or less than 15% of respondents.

The problem green spaces in winter cities are facing is that the sports promotion effect and ecological benefits of green spaces in winter cities will be greatly weakened. In terms of physical activity, affected by the severe cold climate, the overall activity participation rate of residents in winter cities will decrease. On the one hand, the long winter has led to a lack of outdoor activities for residents, which is not conducive to human health. On the other hand,

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long-term activities in a low-temperature environment can have adverse effects on human cardiovascular health. Therefore, existing winter sports research generally emphasizes the suitability of outdoor activities in winter. At the same time, through the study of the sports characteristics of the elderly in winter cities, it is found that most of the elderly still adhere to fitness and health in winter, and 80% of the elderly who participate in fixed fitness groups choose to adhere to daily outdoor fitness activities in winter. This shows that some residents still have a strong need for exercise in winter. By providing paths and activity spaces, green spaces can play an important role in supporting sports activities. In terms of ecological benefits, due to the withering of a large number of deciduous plants in winter, it may be difficult to fully achieve dustproof and air purification. However, studies have also shown that the configuration of evergreen plants in winter and the use of appropriate planting methods (such as block planting and row planting) can also effectively reduce air pollution. Therefore, although green space has challenges in terms of activity participation rate and ecological benefits, it can still play an active role in a healthy lifestyle promotion.

Since this is a study of a single city, some comparative variables between different cities are not included, air quality for example. Due to the similar communities, relatively consistent location characteristics, and the use of coal-fired central heating, we assume that the health effects of these factors on air quality are controllable. The health value and health impact of the characteristics of community green spaces are the focus of research. From the perspective of spatial influence, since the surrounding environment of the community in which the respondents lived is relatively similar and the construction period is relatively close, the research results can be regarded as a comparison of the internal environmental factors of the community to a large extent.

The weak point of this research is that the use of green space is not taken into account. In communities with relatively good green space resources, residents' use of green space may be more closely related to health outcomes. In addition, not all residents' sports activities take place on green spaces. In addition, there may be elderly people who move from rural areas to cities with their children. Local residents are experienced in living in severe cold climates, and the climate is more adaptable, making it easier to carry out outdoor activities in winter. However, newly moved people have a weak ability to adapt to the climate and are unfamiliar with the new community environment, which reduces their level of participation in outdoor activities. Therefore, there may be heterogeneity in the research results. In addition, in the process of analysis, eating habits were not analyzed, and diet plays an important role in the risk factors of cardiovascular disease. People who prefer a high-salt diet tend to be at a higher risk of high blood pressure and cardiovascular disease.

Another important factor is the change in residents' behavior and activities. Compared with non-winter cities, the overall duration and frequency of activities of residents in winter cities are more affected by winter. This change in activity plays an important intermediary role in the relationship between green space and cardiovascular health, making the relationship between green space and cardiovascular health in winter cities different from that of non-winter cities. In other words, in winter cities, due to changes in space and activities, the relationship between green space and cardiovascular health is special and meaningful. Our research has established a direct relationship between green space and cardiovascular health. The main feature we pay attention to is the overall characteristics of the green space. The spatial indicators with seasonal differences are not comprehensive and prominent enough, and the effects of urban green spaces on individual sports activities and cardiovascular health in winter need further research.

In future analysis, more comprehensive identification of green space characteristics and measurement of winter health benefits need to be further explored. The characteristics of green spaces discussed in this article are mainly reflected in the overall characteristics, and the relationship between specific green space characteristics (such as plant layout, configuration methods, etc.) and cardiovascular health has yet to be further studied. In addition, other important features of green spaces, such as the accessibility of sports fields in green spaces and the types of activities that sports fields can support, also need more exploration. With the decrease of walking speed, endurance time and travel distance, residents have a higher demand for the accessibility of green spaces in winter. Accessibility is an important prerequisite for residents to visit green spaces in winter, and it is also an important factor that many scholars pay attention to. As far as sports venues are concerned, climatic factors should be taken into account. Combining the layout of sports venues suitable for the activity period and people's activity preferences, the matching of supply and demand is studied.

REFERENCES

[1]Bhatnagar, A. Environmental Determinants of Cardiovascular Disease. Circ. Res. 2017, 121, 162-180.
[2]Liu, Z.X. Focusing on the Impact of Climate Change on Human Health from the Perspective of Cold Medical Treatment-Interview with Professor Tian Ye, Dean of Cardiovascular Hospital of First Affiliated Hospital of Harbin Medical University. Chin. Med Bull. 2013, 10, 1-3.
[3]Sun, J.P. How Can Cardiovascular Patients Survive the Winter? TCM Health Life-Nurturing: Beijing, China; pp. 39-41.
[4]Rook, G.A. Regulation of the immune system by biodiversity from the natural environment: An ecosystem service essential to health. Proc. Natl. Acad. Sci. USA 2013, 110, 18360-18367.
[5]Xiao, Y.; Wang, S.; Li, N.; Xie, G.D.; Lu, C.X.; Zhang, W.; Zhang, C.S. The Reduction of Atmospheric PM(2.5) by Beijing Urban Green Space. Resour. Sci. 2015, 37, 1149-1155.
[6]Gascon, M.; Triguero-Mas, M.; Martinez, D.; Dadvand, P.; Rojas-Rueda, D.; Plasencia, A.; Nieuwenhuijsen, M.J. Residential green spaces and mortality: A systematic review. Environ. Int. 2016, 86, 60-67.
[7]Ulrich, R.S. View through a window may influence recovery from surgery. Science 1984, 224, 420-421.