The importance of built environment: Characteristics of the built environment and spatial patterning of type 2 diabetes in pudong district, shanghai.

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Abstract: The built environment encompasses the major physical spaces, including buildings, streets, homes, schools, parks, playgrounds and other infrastructure in which we live, work and play. In an ideal world, the built environment should support and promote physical activity across the lifespan. However, with increased mechanization and urbanization, physical inactivity and higher levels of chronic diseases such as obesity become common among urban residents. Pudong District covers an area of 1,210 square kilometers with 12 streets and 24 towns. With urbanization in China, it formed unique built environment that high levels of residential density and low-density township environment both exist in this District. Physical inactivity increases risk of chronic disease, this study examine relationships between built environment and chronic diseases using spatial models. We use gis-data to explore whether mixed land-use, high levels of street connectivity, and accessible facilities can reduce the incidence of urban residents' chronic diseases. The survey consists two parts: First, the public service facilities poi and road data are used to calculate the built environment feature in Pudong District. Second, the sample address information is re-encoded, and the spatial distribution characteristics of chronic disease patients are obtained through point density analysis of gis. We conduct follow analysis : 1) overlay analysis of high-density residential areas and high chronic disease incidence, to figure out whether supportive built environment may have lower prevalence of chronic disease. 2) Comparative analysis of the built environment characteristics between urban streets and township streets in Pudong District and the spatial distribution characteristics of chronic disease patients. Our analysis suggests there is an association between built environment and chronic disease.

Keywords: health city; built environment; type 2 diabetes; gis; linear regression analysis

1. Introduction

This study is based on the theoretical and empirical contributions of the health literature. The research data is based on the 2016 Diabetes Community Hospital credit card data of Shanghai Pudong District, with 26,687 records. The elderly patients with type 2 diabetes who were older than 60 years old were selected as the final study samples, and a total of 8246 samples were obtained. Since the impact of the built environment on physical health should be a long-term continuous effect, the household registration population of Shanghai Pudong district is selected as the research object to reduce the impact of environmental changes on its health. The samples are mainly distributed in 12 streets and 24 towns except. The address information is spatially encoded using gis to obtain the spatial distribution map of the research samples (Fig. 1). The calculation data of the built environmental factors in the study are the POI data of various facilities in Shanghai in 2016 and the GIS files of Shanghai Road Network. The data population used for calculating density in each street is the sixth census data in 2016.

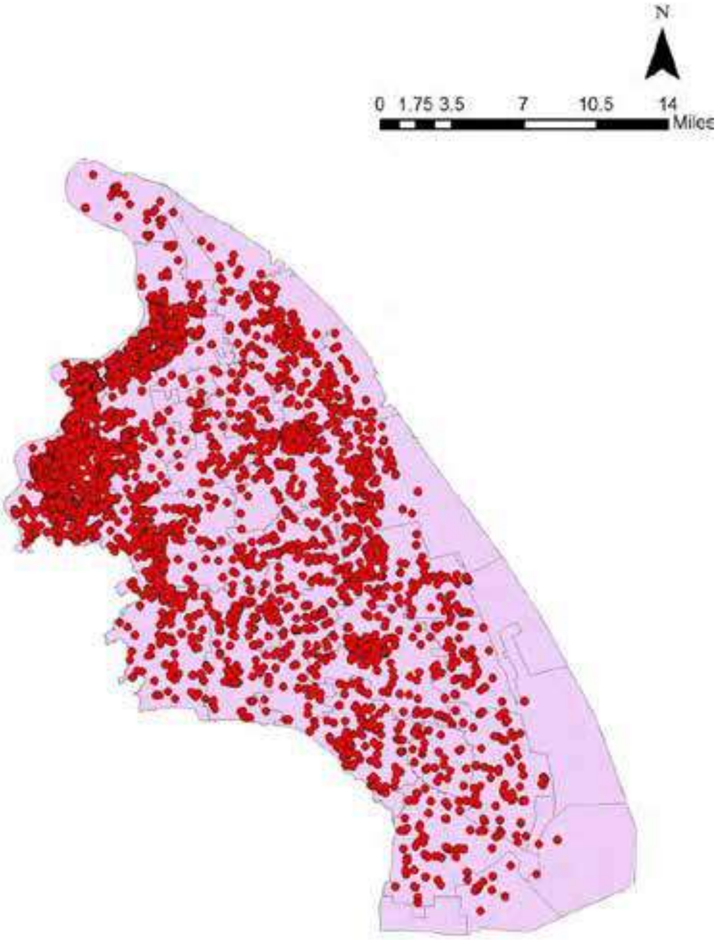

Figure 1 Spatial distribution of type 2 diabetes patients over 60 years old in the study

2.Review

The study of the relationship between built environment and physical activity has always been the focus of academic research. Lack of physical activity has become a major cause of overweight, obesity, diabetes, heart disease and some cancers. Environmental and policy interventions have become an important means of promoting physical activity, and a large number of studies have shown that the supporting elements of the community environment are closely related to physical activity. (Ball et al., 2001) With the World Center for Disease Control and Prevention (CDC), the dynamic community environment (ACES) is able to promote the active participation of all ages people in physical activity. Since 2004, the research has covered the field of health, and a large number of literatures have analyzed the built environment. The correlation between physical health and good community environment can promote the physical health of residents, thereby reducing the proportion of obese people and chronic diseases caused by obesity and improving overall health. In recent years, planners have begun to think about the relationship between built environment and physical health, and hope to promote people's physical activity through reasonable planning. Through the study of the relationship between built environment and physical activity, there is sufficient research foundation to show that the built environment affects physical activity, so we have reason to believe that the built environment will affect people's body index to a certain extent.

2.1 Study on the relationship between built environment and type 2 diabetes

In order to better understand the relationship between the built environment and type 2 diabetes and clarify the intrinsic impact of the built environment on type 2 diabetes, this study's literature review that is based on the web of science database use the software citespace to process quantitative analysis, with the literature from 2000-2018 as a sample. The key words for literature screening were built environment, type 2 diabetes, body mass index (BMI), obesity, and sandentary lifestyle which are closely related with build environment and diabetes. 1,709 articles were finally obtained.

The citespace co-citation network mapping function was used to analyze the citations, and the co-citation network of the relationship between the built environment and type 2 diabetes was generated as a time interval (Fig. 2). Through the analysis of citations, we can see that each node in the figure represents the cited article, and the nodes are composed of different rings of some circles. The larger the radius, the higher the frequency of citations, and the connection between nodes indicates a total of The relationship between the two indicates the strength of the co-introduction. It can be seen from Fig. 2 that the literature co-citation network from 2000 to 2018 has obvious natural clustering, and the clusters are linked through 10 key documents (betweenness centurity ≥ 0.1). In 2018, the clustering is in the lower left, and in 2000, the clustering is in the upper right. Explain that the flow of knowledge is relatively clear and the links between knowledge bases are very close.

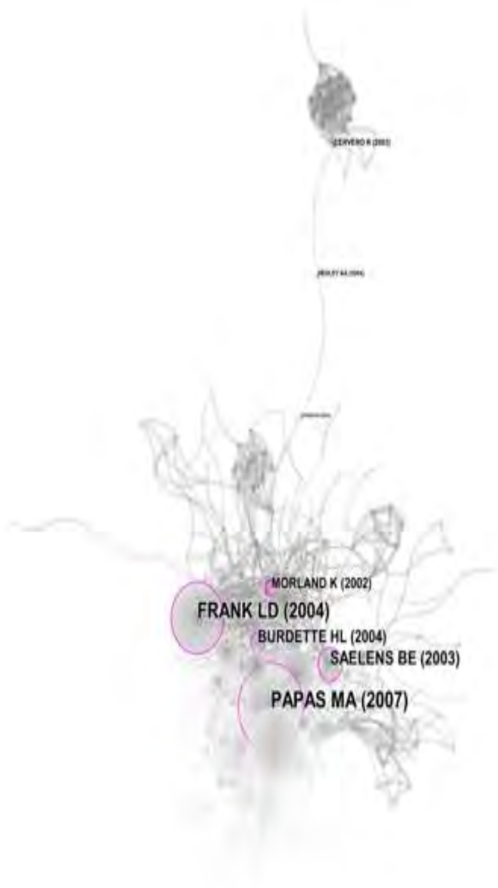

Figure 2 Citation analysis

At the same time, the keywords are clustered to generate Keyword Clustering Common Word Maps, and the 8 clusters represent the main research fields of international literature on international built environment and type

2 diabetes in 2000-2018, namely: children, walking , diet, participation, childhood obesity, community planning, intervention, effectiveness, and social environment (Figure 3).

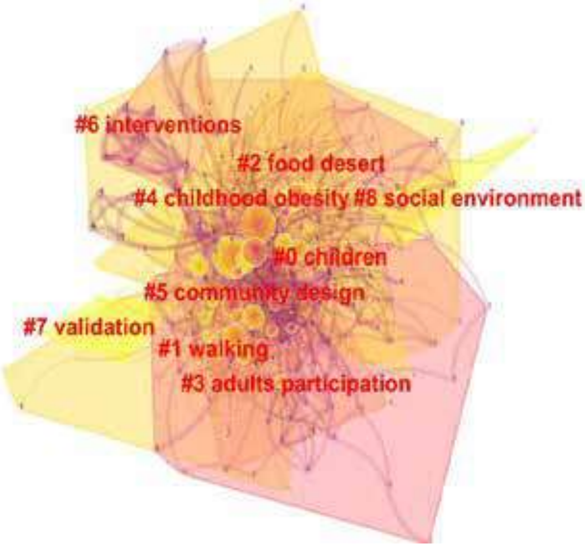

Figure 3 Keyword cluster analysis

Numerous studies have confirmed that the characteristics of the community or living environment may affect health and lead to social and ethnic inequalities in health. Cluster analysis can be seen that the built environmental elements associated with walking and diet are the focus of research. Over the past 15 years, research on the health effects of communities has grown exponentially, with increasing attention to chronic diseases (obesity and related risk factors) and mental health (depression and depressive symptoms). For each type of empirical research, it is divided into two layers: one is to use the census data to directly measure the built environment attributes for correlation analysis, and the other is to review the key concepts, core elements and methodological challenges that are affecting health, and try to clarify the field. Some knowledge gaps and promising new directions. (Auchincloss et al., 2013)

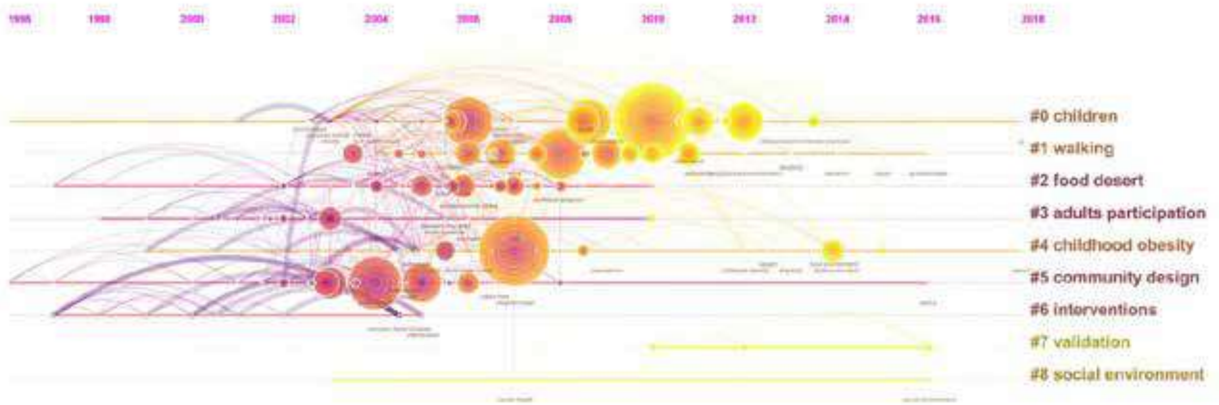

Figure 4 keywords timeline

2.2 Built Environmental Factors That Affect Physical Activity And Physical Health

1) Net residential density (Net residential density)

The net dwelling density is equal to the number of people per acre of land in the household census block. The census data is allowed to be used for population estimation in the calculations and is a more accurate source of data than the 1 kilometer buffer level data. Studies have shown that residential density can promote walking to a certain extent, so it is expected to have a negative impact on obesity. The role of net dwelling density in the study is often used as a control variable [3], or the stratification of the study sample based on the density of the dwelling density [4], and the density of dwelling as part of the evaluation of the walkable index(Smith et al., 2008).

2) Mixed use of land

Some studies have shown that the mixed use of land can promote people to walk, and the main four land uses for calculation are residential, commercial, office and educational facilities. The specific measures for the mixed use of land have the following types of methods in the study:

Entropy Scores: The entropy is obtained by predicting the walkability index through a series of predictors (such as residential density, street connectivity, etc.). The method used to calculate the entropy value was proposed by Lawrence Frank and colleagues. Through two different sets of data, the calculated results are fully correlated with body weight and walking. Entropy has the characteristics of including a wide range of land use categories, but this method also has some drawbacks, which obscures the contribution of individual land use categories. For example, in the calculation, the number of land use categories included will affect the entropy result, less The land use may have the same entropy value as for more land uses, and the land use that is not included in the calculation will also affect the calculation results to some extent(Frank et al., 2006).

$$\text{Lum} = -\sum_{i=1}^{n} pi * lnpi/lnn$$

Destination-Based Measures: The destination measure is mainly to mark the density of various destinations and the average distance to the place of residence by marking the walking destination around the place of residence. The choice of destination can include multiple types, including Parks, fast food restaurants, hospitals, schools, vegetable markets, shops, etc. [7] B. Brown et al. selected three types of facilities closely related to walking in the study of the relationship between land use mix and body mass index (BMI) and obesity: rail transit stations, bus stops, and parks. This method also has certain limitations and cumbersome measures. (Brown et al., 2009)

Proxy-Based Measures: This method uses substitute variable to measure the mix of land use. The first is the number of residents who walk to work in one block, and the second is the age of housing. However, this method is not suitable for large sample size calculations.

3) Street Connectivity (street Connectivity)

Street connectivity is measured by the number of road intersections in the residential buffer zone, more than three intersections per square kilometer are considered to have connectivity.

4) Facility accessibility and distance

This type of research is mainly divided into two levels, one is the built environmental factors related to walking, and the other is the body index and health-related facilities. Although the built environmental elements involved in the two types of research overlap, they also have different emphasis. The facilities related to walking are mainly parks, open spaces, etc., and health-related facilities are mainly food-related, such as supermarkets, restaurants and other facilities(Nagel et al., 2008).

3.Spatial Distribution Characteristics Of Research Samples And Built Environment Elements

3.1 Analysis of spatial distribution characteristics of research samples

ArcGIS software is used for data acquisition and development, as well as subsequent spatial analysis. All residents in the study used address geocoding before calculating the environmental variables built by the GIS. The result of this geocoding process creates a spatial coordinate for each resident's home, allowing further analysis of the relationship of these locations to other GIS layers. Of the 8246 subjects, a total of 8211 were successfully address-matched with an accuracy rate of 99%. The map shown in Figure 1 shows the geocoded locations of the study samples within the study community.

The standard deviation ellipse analysis is performed on the sample data. The generated semi-axis of the ellipse represents the direction of the data distribution, and the short semi-axis represents the range of the data distribution. The larger the difference between the length of the long and the short axes (the larger the flatness). The short semi-axis represents the range of data distribution. The shorter the short semi-axis, the more obvious the centripetal force of the data presentation. Conversely, the longer the short semi-axis, the greater the degree of dispersion of the data. It can be seen from the standard deviation ellipse analysis of the overall sample data that the sample distribution has a certain directionality and centripetality. Generating the area representation range, we can see that the main morbidity range of the sample is concentrated in the northwest region. This area is mainly a high-density urban area. The flat rate indicates his direction clarity and centripetal force. We can see the incidence trend of Pudong district have a clear direction.

The point density analysis of the study samples can be seen: red is high prevalence, yellow is low prevalence, and high-risk areas of type 2 diabetes are high-density urban space along the Huangpu River, and expand with

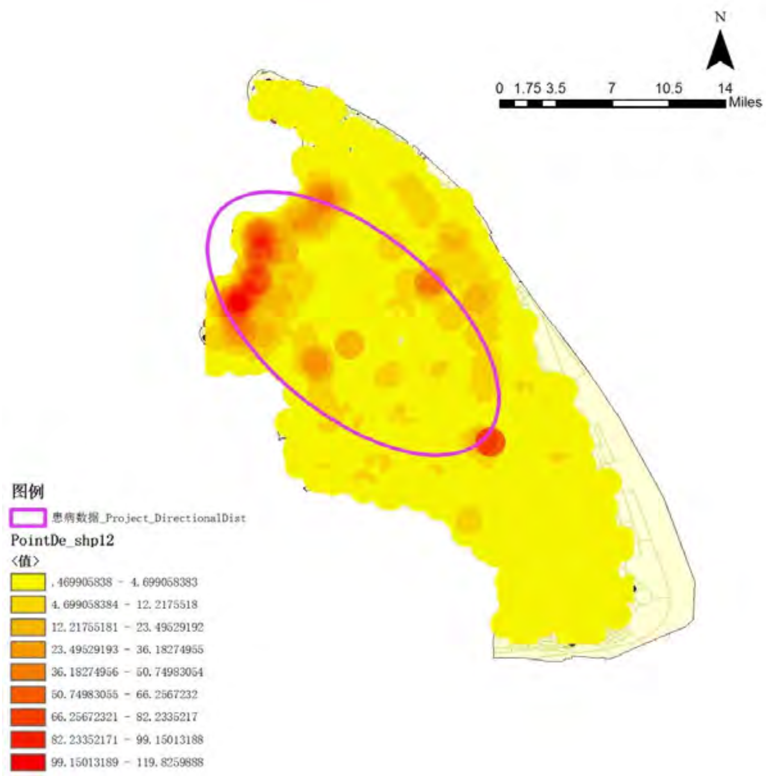

Figure 5 Sample point density and standard

the north-south direction of space.

3.2 Analysis Of Spatial Characteristics Of Built Environment Elements

ArcGIS is used to calculate the characteristics of the building environment in each block. The literature review shows that the built environmental elements that are most closely related to physical activity and health outcome are: (1) food-related facilities (supermarkets, restaurants) Facilities related to physical activity (fitness center, community center); (3) green open space and recreational space (including public parks, open area playgrounds, shopping malls, etc.). Based on the POI data of these facilities, the number of facilities distributed in each study street was calculated, and the density of each street facility was calculated according to the street layer（figure 6）.

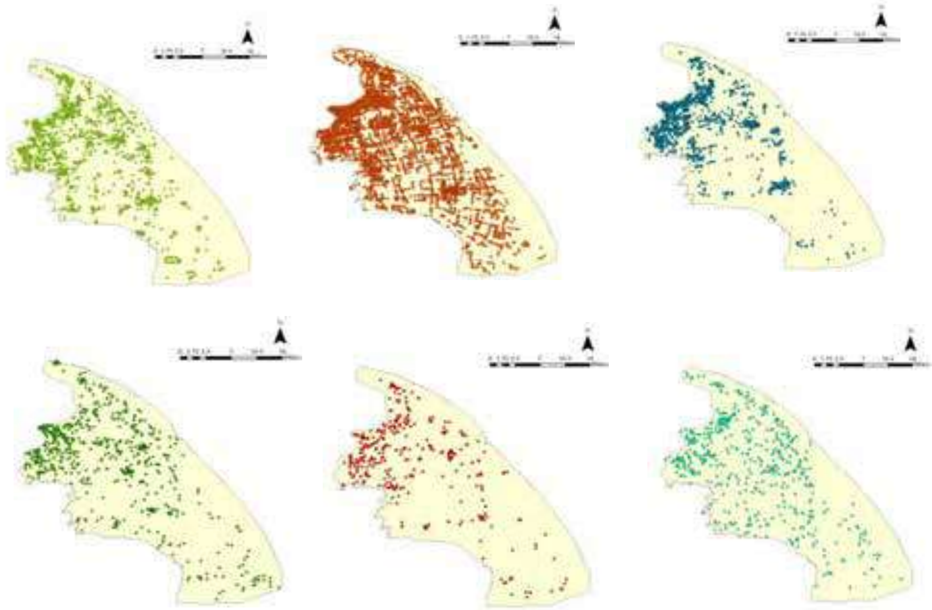

Figure 6 Spatial distribution of various facilities

The current measurement of the built environment focuses on the use of GIS for quantitative analysis, making the results more reliable. At present, some studies have suggested that previous studies have focused on the study of related relationships, and the results of the research are not very applicable. If epidemiological studies based on environmental exposure are used to investigate the effects of environmental density and quantitative levels on physical activity, the results of the study are The application has a better guiding significance. (何晓龙, 2017) In the calculation method of built environment index density, many current studies recommend the use of nuclear density analysis. The significance of the nuclear density equation is that the density distribution is highest at the center of each xi point and decreases outward. When the distance reaches a certain threshold range (edge of the window), the density is 0, and the nuclear density at the center x of the grid is(Cerin et al., 2006) :

$$f(x) = \frac{1}{nh^d}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right)$$

Here K() is the kernel density equation, h is the threshold, n is the number of points in the threshold range, and d is the dimension of the data. For example, when d=2, a commonly used kernel density equation can be defined as:

$$f(x) = \frac{1}{nh^d}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right)$$

Based on the nuclear density analysis method, this study geocodes the research samples to the nearest street, and uses ArcGIS10.3 software to calculate the indicators of each built environment（table 1）.

Table 1 Study the built environment characteristics of the sample street

street	bus stop	market	shopping mall	park	gym	communit y center	restaurant	openspac e	populatio n
laogang	53	12	3	4	1	8	0	8	28060
tang	112	50	11	2	32	13	626	22	36971
xincahng	96	36	6	13	14	16	0	18	49414
yangjing	66	24	10	1	70	9	406	18	107512
zhoujiadu	50	14	10	1	34	14	262	8	124208
heiqng	119	44	10	19	15	30	282	16	49974
kangqiao	164	63	20	4	52	13	816	12	84628
lujiazui	81	23	22	0	60	10	1178	47	73707
tangqiao	38	15	9	0	38	5	381	8	60001
donghai	1	0	0	0	0	2	0	1	3
jinqiao	53	21	12	1	43	9	365	13	24736
handi	0	0	0	0	0	0	0	0	11572
songnan	0	0	0	0	0	0	0	0	96330
dongming	44	23	14	0	26	6	366	9	98084
waigao	85	5	5	0	6	0	63	1	50
zhaoyang	2	0	0	1	0	1	0	0	105
nicheng	66	24	9	7	10	8	0	13	49311
jinqiao	101	17	3	0	14	1	342	5	247
luhugang	14	11	3	0	1		0	3	14945
hangtou	156	48	5	7	16	18	0	10	56417
daqiao	0	0	0	0	0	0	0	0	95897
jinchang	75	32	15	0	54	10	584	7	159554
hudong	42	25	9	1	24	10	287	7	89185
zhangjiang	83	12	12	0	27	2	438	12	6005
zhuqiao	123	39	5	6	17	10	31	10	70014
changqiao	0	0	0	0	0	0	0	0	88406
zhangjiang	160	47	8	4	38	10	729	24	70602
gaohang	83	42	14	2	51	8	612	9	63487
zhoupu	204	48	21	7	46	14	539	11	90334
sanlin	143	76	18	6	92	20	1075	43	173228
shansha	339	121	43	38	176	62	1744	107	191761
wanxiang	38	7	1	0	0	4	0	0	20752
huamu	139	35	26	0	98	16	909	52	147435

nanmatou	38	19	5	1	32	4	316	9	87856
caolu	121	68	8	15	39	20	756	25	68205
beicai	128	65	21	1	74	28	863	27	159081
liuzao	49	16	1	7	4	13	8	8	30175
huinan	279	88	23	6	92	19	0	16	152765
gaodong	62	27	5	6	11	16	283	15	34978
weifang	39	23	6	0	56	10	679	16	72824
puxinglu	57	35	7	1	42	16	447	4	135287
datuan	64	29	2	7	4	17	0	11	60682
shanggang	44	20	12	3	26	9	339	29	90079
shengang	16	11	5	1	7	3	0	18	12526
shuyuan	86	16	3	5	5	12	0	7	42452
gaoqiao	95	51	10	1	32	17	657	54	92500
xuanqiao	67	28	3	6	4	8	0	62	40000

4.Analyse

The spatial research analysis is divided into two parts. One is to calculate the prevalence of each street by using the spatial distribution of the patient population, and obtain the spatial distribution map of the prevalence rate (Fig. 7).we can see the spatial differences in the incidence of type 2 diabetes in Pudong district, high-incidence streets and low-incidence streets. The second is to use the calculation results of the built environment elements calculated by gis, and compare and analyze the disease situation of each street in space, and use gis to normalize the environmental density and prevalence of each built environment, and obtain Figure 8. By comparison, it can be found that areas with low prevalence tend to have more homogeneous service facilities, and various facilities have higher density in spatial distribution; high prevalence is concentrated in urban high-density areas and central areas. Urban and rural areas combined with urban and rural characteristics. Although the high-density urban-type area has a perfect built environment configuration, due to the restrictions on land use and population, the per capita facilities use less land. For urban-rural areas, on the one hand, there are differences in the layout of facilities in urban areas, and on the other hand, The space environment is biased towards the street and the wide road network, which limits the physical activity of the residents to a certain extent. Therefore, the prevalence rate in these areas is relatively high.

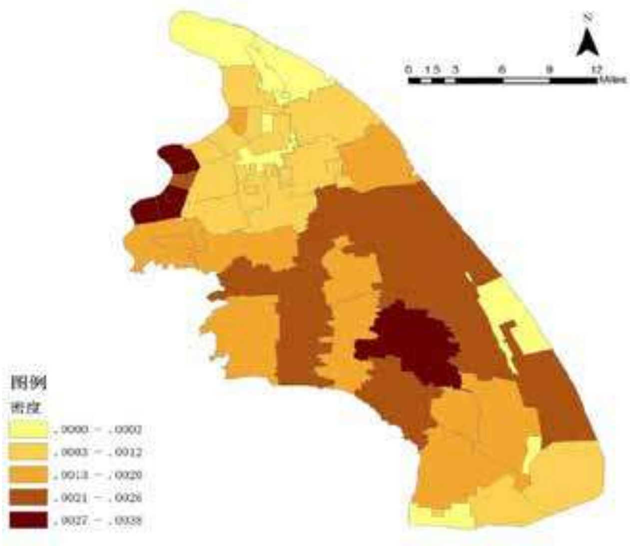

Figure 7 Disease density of each street

Figure 8 Comparison of disease density and density of various facilities in each street

In order to further analyze the relationship between the built environment factors and the prevalence rate, according to the area of each street, calculate the density of various facilities, and carry out regression analysis with the disease density of each street to quantitatively analyze the relationship between them（table 2）. Through the analysis of the regression results, we can see that the two variables of open space and surrounding leisure tourism facilities passed the significance test in the model, and the other variables failed the test in the model. By analyzing the statistical results of variables in different models, the stability of the relationship between the prevalence and the intensity of each street of the dependent variable can be judged. Model 2 reflects the variable relationship more comprehensively. The results show that the indicators that play a positive role in the physical health of residents include the open space area, that is, the number of physical activity facilities such as park green space and squares around the community. This shows that when the living space around the residents has a fitness park, it has a significant effect on physical activity, thereby promoting the physical health of the residents.

Table 2 Results of regression analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.001	.000		4.755	.000	.000	.001
	开放空间_d	.001	.000	.585	5.724	.000	.000	.001
2	(Constant)	.000	.000		2.547	.013	.000	.001
	开放空间_d	.000	.000	.508	5.842	.000	.000	.001
	周边旅游_d	.005	.001	.456	5.242	.000	.003	.007

a. Dependent Variable: 密度

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	公交站点_d	.324[b]	2.234	.029	.273	.468
	超市_d	.315[b]	2.323	.023	.283	.533
	商场_d	.210[b]	1.179	.243	.148	.327
	周边旅游_d	.456[b]	5.242	.000	.554	.972
	健身_d	.185[b]	1.122	.266	.141	.382
	社活_d	.321[b]	2.430	.018	.295	.555
	餐厅_d	.049[b]	.227	.821	.029	.224
2	公交站点_d	.245[c]	1.984	.052	.246	.460
	超市_d	.193[c]	1.628	.109	.204	.509
	商场_d	.262[c]	1.776	.081	.222	.326
	健身_d	.243[c]	1.779	.080	.222	.380
	社活_d	.167[c]	1.402	.166	.177	.513
	餐厅_d	.290[c]	1.573	.121	.197	.211

5.Results

As a space carrier for the daily life of the citizens, the urban built environment has shaped the lifestyle of the residents and affected the health of the residents. Since the 20th century, chronic diseases caused by lack of physical activity have attracted widespread attention from scholars at home and abroad. A large number of empirical studies abroad have clarified the factors that influence the urban built environment on the physical activity of residents by tracking observations and cross-section confidentiality. In order to further test the universality of the existing conclusions, this paper conducted a regression analysis based on the streets of Pudong District, Shanghai.

The study found that good community space structure and community outdoor activity space can have a positive and significant impact on residents' physical health. Outdoor activities such as parks in the living circle near the community can significantly stimulate residents' willingness to carry out physical activities and promote the physical health of residents. Therefore, in the future, for community planning in healthy cities, it is necessary to rationally set up community facilities and improve the environmental quality of facilities. In the future, this research can be further expanded to analyze the relationship between the built environment and physical health from the community and individual levels.

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