Investigate the Relationship Between Traumatic Occurrences and Socio-Economic Status Based on Geographic Information System (GIS): The Case of Qingpu in Shanghai, China

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Abstract. Numerous incidences in the world have been occurring and causing trauma to humans. Trauma that can be physical or psychological causes not only great harms and deaths to patients but also huge burdens of expenses to the families and public health sectors for due to treatments in China. Many studies have been researching on this subject. However, such studies lack to provide comprehensive information on the relationships between trauma incidences and their occurring environment. This study used GIS and trauma patients' data from Qingpu district in Shanghai to investigate the relationships between trauma incidences and their occurring environment. Such environments were studied in two levels of the socio-economic status (SES): Individual and sub-district. At the individual level, trauma incidences were studied with the housing prices, and at the sub-district level, were studied with the per capita disposable income in neighborhoods. We used descriptive and regression methods to count trauma incidences and analyze their relationships with SES. The results showed that trauma incidences are statistically negatively correlated with the the house prices and the per capita disposable income by the Pearson correlation coefficients of 0.71 and 0.72, respectively. The hot spot analyses showed that many trauma cases occurred in the Xiayang and Jinze streets as compared with other streets. When taken together, t These results provide a new baseline information that the researchers and health practitioners that could be used for learning and preparing effective measures for of mitigating and reducing trauma incidences and their resulting adverse impacts.

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X. Meng et al. (Eds.): SpatialDI 2023, LNCS 13887, pp. 140–153, 2023.
https://doi.org/10.1007/978-3-031-32910-4_10

Keywords: Trauma incidences · Trauma patients · Socio-economic status · house prices · per capita disposable income · GIS

1 Introduction

The development of various sectors such as industries, housing, and transportation facilities and infrastructures in many countries has been coupled with serious incidences causing trauma for individuals and society. Such incidences cause not only great harm to patients but also huge burdens of expenses to the families and public health sectors for treatment. According to the World Health Organization (WHO) estimates, one out of 16,000 people dies every day due to trauma, and 90% of trauma incidences occur in the low- and middle-income countries [1–4] identified that in such countries, trauma that could be from physical and physiological injuries has also been causing more deaths to the young people of around 15 years old. Overall, this information shows that trauma patients among different social groups are unevenly distributed and a similar case is also noted economically for the rich and poorer [5–12]. Specifically, such socio-economic patterns have been studied mainly by considering the factors of age, gender, race, and socio-economic status (SES) of trauma patients [13–16]. In public health, SES is referred to as a general indicator used for measuring a person or an area's level of economy.

Several studies on SES and gender, for example have been studied and their main findings show that there are variations of types, death rates, care, post-traumatic disabilities, and return to work of trauma patients with low SES [5, 15–22]. These results imply that similar scenarios are also likely for trauma patients with high SES. The levels or quality of SES have been studied by different parameters. Maciel et al., for example, calculated the urban quality index of the community using four parameters: education, environment, housing, and economy in Victoria, Brazil [23]. Sehat et al. used the interview methods to measure patients' wealth index and house value index for the same purpose [9]. Vyas et al. derived the SES index of the permanent assets using the PCA method without the incomes data, which is often used for cases involving humans [5, 21, 24]. In general, these and other studies have focused more on studying SES with different subjects. Regarding trauma cases, all such studies lack comprehensive information that integrates, e.g., trauma patients, trauma incidences, and their relationships on space at different scales. The inadequacy of such information in China's studies is much more due to various restrictions, including the lack of relevant and sufficient data [25–28].

With the current development, online platforms and more advanced spatial methods based on GIS could be used for mining spatiotemporal data of various diseases [29–31]. Moreover, the descriptive analyses based on the GIS technology could also be done to discover essential information, such as areas with frequent trauma incidences and their causing factors [32]. Thus, this study addresses the identified problem using Qingpu district as the case study area. In particular, it investigates the relationships between trauma incidences (i.e. physical trauma) and the SES variables studied in two levels: Individual and sub-district. At the individual level, trauma incidences are studied with the housing prices of trauma patients. At the sub-district level, trauma incidences are studied with the per capita income in neighborhoods that are also used for population studies.

The realization of all these objectives is expected to provide new baseline information that could benefit various stakeholders such as researchers and governmental and non-governmental organizations when formulating injury prevention programs and policies. The main contributions of this study can be summarized as follows:

1. It extends knowledge on trauma incidences and their influencing factors in an area with scarce research.
2. It introduces a new GIS-based prototype with an additional of one variable of the community level and different socio-economic parameters for studying trauma cases and their related matters.

2 Materials and Methods

2.1 Study Region

Qingpu district is located in the west of Shanghai, China, and it borders with four other districts: Jiading, Minhang, Songjiang, and Jinshan (Fig. 1). This district has three streets and eight towns covering a total area of 676 square kilometers. Further, it has a population of over 1.219 million engaging in different activities such as agriculture, business, and manufacturing of industrial products. There are four vital industrial areas that together with other activities raise the Qingpu's economy: Qingpu Industrial Park (QIP), Zhangjiang Qingpu Park (ZQP), Export Processing Zone (EPZ), and Zhujiajiao Town. When looking at the neighborhood level, the economic developments in the Qingpu district vary from one place to another. The areas close to the downtown of Shanghai, such as the Xujing and Huaxin towns, have higher levels of economic development than others. This situation seems to be attributed by many factors, including the city's transportation network. Similarly, the house prices around the same areas are higher than in the outskirt areas. And the typical examples of this matter can be identified from the two house compounds of Green Wave Garden Villa, in Xujin and Xiayang New City, in Xiayang Street. The house prices in these two compounds are 102,062 CNY and 32,000 CNY per square meter, respectively.

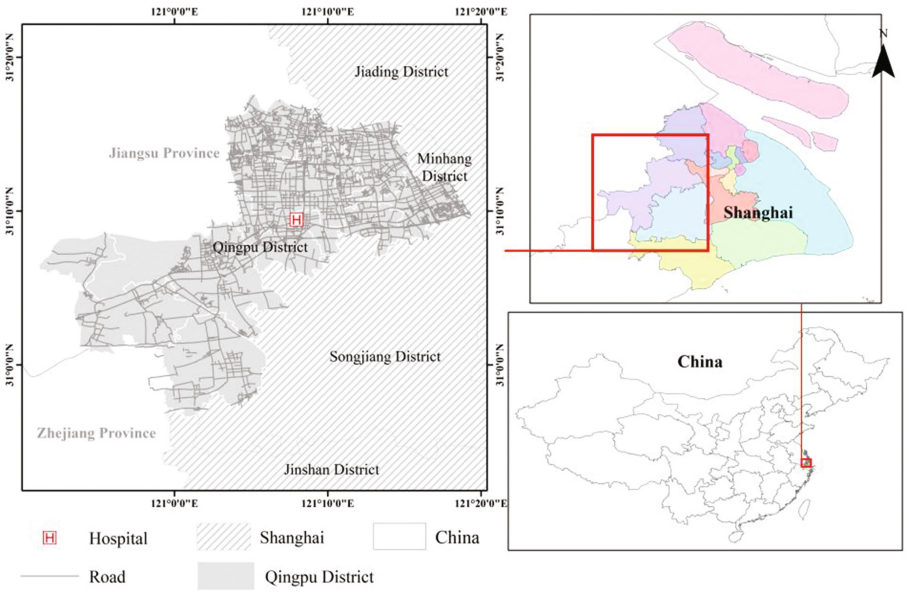

Fig. 1. Case study region

2.2 Data

2.2.1 Trauma Patients Data

Trauma patients data used in this study was obtained from the Zhongshan hospital which is affiliated with the Fudan University of Shanghai. According to the hierarchy of health facilities, the Zhongshan hospital is a tertiary hospital. And spatially, it is found in the central area of Qingpu district. As of 2019, this hospital received 2.11 million trauma patients, and among them, 41,300 were admitted and discharged. For our study, we acquired trauma patients data of adults from 2016 to 2020. The adults, in this case, refer to people with 18 years of age and above as classified by the population data. Next, we used the events' locational information recorded as the address for each patient to download geographical coordinates of trauma incidences. This exercise was done using the Baidu Map API, which besides the access, provides many other services such as geocoding and route planning for the spatially based features. All these data, i.e., the raw trauma patients data from the hospital and their positions by the Baidu Map API were synthesized in one file (i.e., a GIS shapefile) and used for studying different kinds of relationships with the SES variables.

2.2.2 SES Variables

The SES variables used in this research were the house prices and per capita disposable income in Qingpu. These variables are often used [1] and were both considered in our study to understand their total influence and relationships with trauma incidences. The house prices data was obtained from the Anjuke website at http://anjuke.com by running

a Python program. Afterward, we used the Baidu Map API to download the house prices related data such as names, addresses, number of residents, and the boundaries of the residential compounds, as seen in Fig. 2. The per capita disposable income data was downloaded from the website of the Qingpu bureau of statistics at https://www.shqp.gov.cn/stat/tjzltjnj/ and this data was obtained together with the population data in neighborhoods. In other words, this data was acquired at the macro scale when comparing it with the house prices data, and for this reason, we regarded it as a sub-district parameter of SES as defined in the background of this work. For consistency, the SES variables of the house prices and per capita disposable income are studied at the individual and area/sub-district levels. All related data for each variable were first integrated into the GIS file and processed independently with the trauma patients data. Next, they were overlaid together to examine and visualize their patterns and relationships, as explained in the following sections.

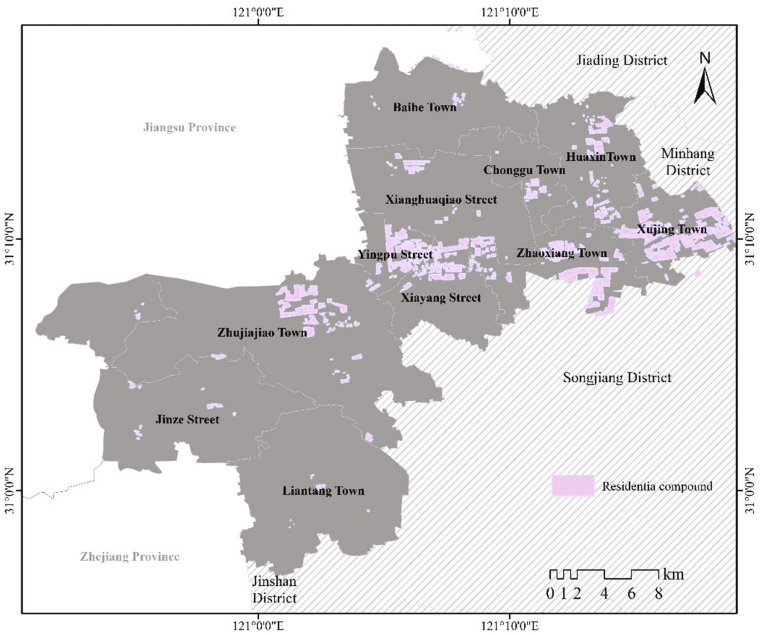

Fig. 2. Spatial distribution of the residential compounds in Qingpu District

2.3 Descriptive Statistics

Our study used three descriptive statistical methods to process the data of trauma incidences and evaluate their relationships with the SES variables. In the first method, the local Getis-Ord Gi* statistic (G*), which is available under the exploratory spatial data analysis (ESDA) tools in the ArcGIS software, was used to compute and visualize spatial distributions of the SES variables. In other words, this static was used to determine the

cold and hot spot areas of the house prices and the per capita income in Qingpu, and according to this method, such areas are measured with two main parameters of the G* and p values. The low values of G* and p indicate that such variables are not significantly clustered, and they are referred to as the cold clusters. In contrast, they reveal the presence of significant clusters. The next statistical method was applied to determine spatial distributions and variations (i.e., magnitudes) of the trauma incidences. This objective was accomplished using the kernel density function available under the spatial analyst tools in the ArcGIS software. Lastly, we used a statistical analysis method of the Spearman Pearson, in the SPSS software to assess the relationships between trauma incidences and the SES variables. Such relationships are expressed using a variable ρ, which is computed by the following formula.

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \tag{1}$$

Specifically, the ρ in this formula refers to the coefficient of correlation between two variables (i.e. x_i and y_i) and it ranges from −1 to 1. The ρ values range from 0 to 1 imply that the two variables are positively correlated. In contrast, they are negatively correlated, i.e., when the ρ values range between 0 to −1. If the value of ρ is equal to 0, then the two variables do not have a specific direction in their relationships.

3 Results and Analysis

In general, the results of data processed for four years (2016–2020) show that 1545 patients were attended by the Zhongshan hospital in Qingpu due to trauma. The annual incidence rate of all trauma cases was 40 per 10,000 person-years. In terms of gender, there was a high rate of trauma incidences for men (40 per 10,000 person-years) compared with women (20 per 10,000 person-years). This result corresponds with the raw data that also shows that, for the same period, men were 67.2%.

3.1 Results of Trauma Incidences at the Individual Level

The results explored by the Getis-Ord Gi* statistic (G*), shows that there are significant clusters of the house princes in Qingpu (Fig. 3). The areas with the highest house prices are found in the Xujing town as empirically spotted in Sect. 2.2.1. The results by the kernel density applied for the data of the house compounds trauma patients showed that more trauma incidences occurred in the Xiyang Street with cold clusters of the house prices (Fig. 4). When assessed with the population data which was also computed using kernel density, it showed that both areas of the Xujing town and Xiyang Street have large numbers of population compared with others. Thus, after factoring out population, we found that trauma incidences vary inversely proportional with the house prices. The Spearman Pearson coefficient which was calculated based on the two-sided test showed that trauma incidences and the house prices are statistically negatively correlated with the ρ value of - 0.71. This relationship is strong because it approaches to −1. Thus, when taken together, it can be inferred that, trauma incidences at the low level on the space

relate more significantly with the socio economic status that is here referred to as the house prices.

Besides the relationships studied between them, we also analyzed trauma incidences to determine the frequency of their occurrence in different compounds (i.e. house compounds), and such compounds were divided into seven groups for the simplicity of our analysis: Q1, Q2, Q3, Q4, Q5, Q6, and Q7. The division of these groups followed the order of the house prices (in Chinese Yuan-CNY) from 15000–25000, 25000–35000, 30000–35000, 35000–40000, 40000–45000, 45000–50000, and 50000 + CNY, respectively. The results as presented in Fig. 5 and Table 1 showed that, trauma incidence rates vary differently between the studied groups. First, they show a rough decline trend from the cheapest compounds Q1 with 13 trauma incidence rate per 10,000 to the most expensive compounds, Q7 with 6 trauma incidence rate per 10,000.

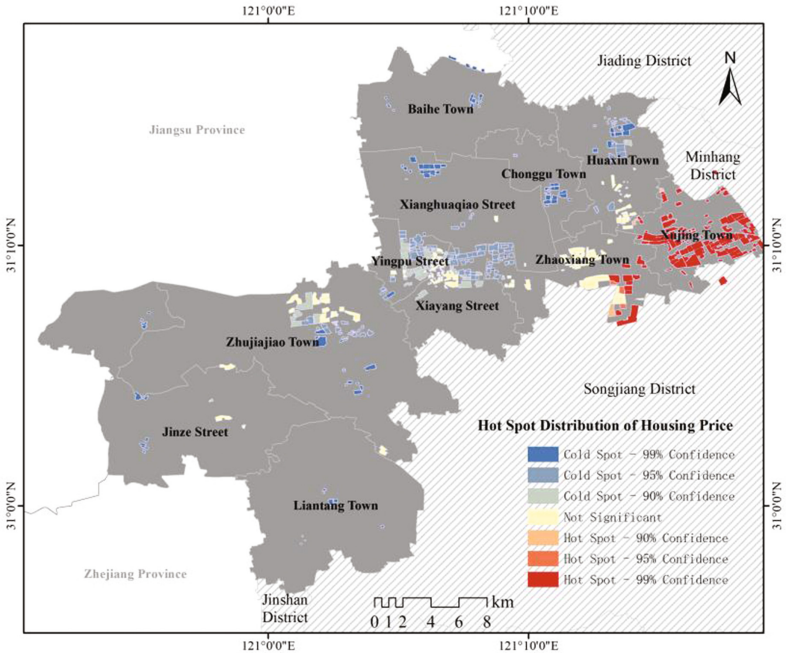

Fig. 3. Clusters of the house prices by the Getis-Ord Gi* statistic (G*) in Qingpu

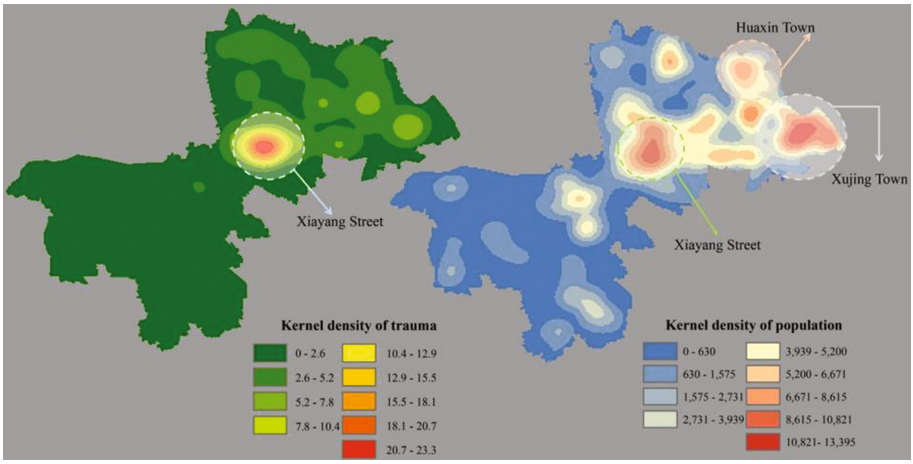

Fig. 4. Kernel density of trauma incidences and population in Qingpu from 2016 to 2020

This trend provides a general conclusion that the lower the house prices the higher the rates of trauma incidences at the micro level of the spatial results. When looking between the Q2 and Q6 compounds, the rates of trauma incidences show an 'arc' shape with low values at the center. In other words, it shows that the rates of trauma incidences for the immediate compounds with the low and high house prices are almost the same.

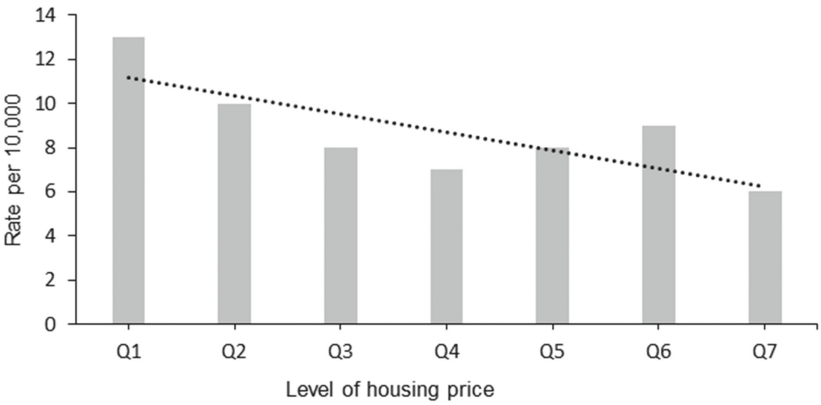

Fig. 5. Trauma incidence rates in Qingpu from 2016 to 2020

Table 1. Classification of trauma incidences and their occurrence rates in Qingpu from 2016 to 2020

Compounds group	Ranges of the house price (CNY)	Average Housing Price (CNY)	Rate per 10,000
Q1	5000–25000	19900	13
Q2	25000–30000	28400	10
Q3	30000–35000	32580	8
Q4	35000–40000	36470	7
Q5	40000–45000	41060	8
Q6	45000–50000	45770	9
Q7	>50000	60910	6

Note: The compounds group refers to the house compounds used to determine trauma incidence rates in Qingpu

3.2 Results of Trauma Incidences at the Sub-district Level

The first results of the Getis-Ord Gi* statistic (G*) at the sub-district level, showed that there are significant clusters of the per capita disposable income in Qingpu as presented in Fig. 6. The highest clusters are found in the Zhaoxiang town followed by the Chonggu town. Both towns are close to the Xujing town that has the highest clusters of the house prices. Thus, despite their closeness, these results imply that the SES variables studied in this research have different implications spatially. The spatial distribution of trauma incidences, showed that there were more trauma cases in Jinze street with cold clusters of the per capita disposable income followed by the Baihe town as seen in Fig. 7. This result shows a similar relationship as noted for the case of trauma incidences and the house prices explored at the individual level. The Spearman Pearson coefficient that was computed similarly as at the individual level, showed that trauma incidences and the per capita disposable income in Qingpu are statistically negatively correlated with the ρ value of - 0.72. This relationship is stronger compared with that of the house prices.

In addition, we also analyzed trauma incidences to determine their occurrence rates associated with the per capita disposable income in neighborhoods. The results as presented in Table 2 showed that more trauma incidences occurred in Jinze town, followed by the Xiayang Street, and the Liantang and Baihe towns with the rates of 16 per 10,000. When narrowed down, we found that all these areas have low population sizes compared with the Xujiang and Huang towns with the least trauma incidence rates. Put simply, this result also demonstrates that the areas with high socio-economic statuses in Qingpu experience little trauma incidences compared with others.

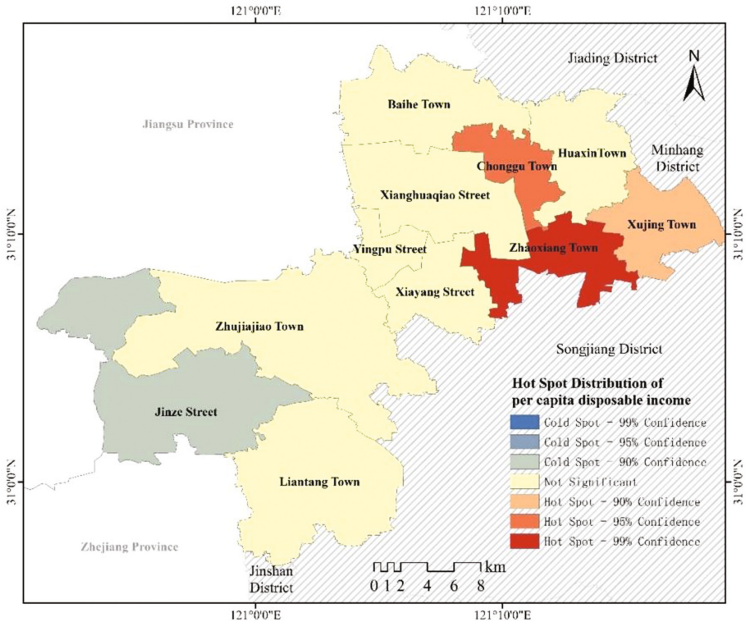

Fig. 6. Clusters of the per capita disposable income by the Getis-Ord Gi* statistic (G*) in Qingpu

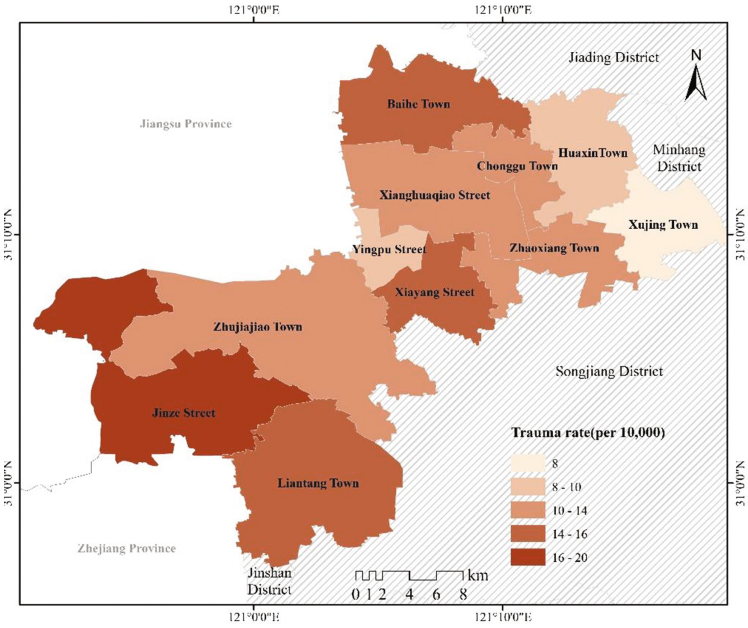

Fig. 7. Spatial distribution of the trauma incidences in Qingpu from 2016 to 2022

Table 2. Trauma incidence rates associated with the per capita disposable income in neighborhoods in Qingpu

Subdistrict	Trauma cases	Population	Per capita disposable income(CNY)	Rate per 10,000
Zhujiajiao Town	124	99568	32410	12
Yingpu Street	121	117442	42456	10
Baihe Town	155	97129	33609	16
Huaxin Town	184	193460	40275	9
Xujing Town	132	165398	48998	8
Chonggu Town	80	56922	37892	14
Xianghuaqiao Street	154	115313	36616	13
Zhaoxiang Town	138	102538	39855	13
Xiayang Street	240	149000	42456	16
Liantang Town	98	62259	31468	16
Jinze Town	115	55871	30611	21

4 Discussion and Limitations of the Study

This study's results have revealed that there are statistically negatively relationships between trauma incidences and the socio-economic statuses studied using the house prices and the per capita disposable income. Such relationships were studied spatially by the spatial-autocorrelation analysis tools used to compute and visualize trauma incidence cases in Qinpu. In addition, they were studied to determine their magnitudes using a statistical analysis method of the Pearson. The specific results showed that trauma incidences are negatively correlated with the house prices and the per capita disposable income by 71% and 72%, respectively. The population data was also studied along with these two variables, and its influence on trauma incidences was found insignificant. In other words, we found that there are some areas with high population and low trauma incidences, including the Huaxin town as seen in Fig. 4. The analysis of the house prices divided into seven groups showed that the trend (rates) of trauma incidences in Qingpu is not completely uniform. This result reminds that despite the clear hypothesizes that could be made on these studies, still there is a need for performing more analyses for optimal results. For simplicity, this could be well understood by considering the following scenario, that, the value of the relationship between trauma incidences and house prices was -0.71. Implying that the higher the house prices the lower the number (rates) of trauma incidences. This notion was however not in agreeable for the house prices of the two compounds of Q6 and Q7, as seen in Fig. 5. Besides that, all the findings of our study are significant since they present new baseline information in this field.

Despite its valuable results, there are some limitations that should be interpreted with the findings of this study. First, we have used only one parameter of the house prices to determine its influence on the occurrence of trauma incidences at the local level. There

are several other socio-economic parameters at this level, including education, income and occupations of the family members in society. Such parameters were not included in this study which focused on identifying the influence of such variables and those at the regional scale. In addition, there could be many other socio-economic parameters at the regional level, besides the per capita disposable income used in this study. Thus, future studies should consider this observation to improve their findings. Moreover, they should also consider using other geo-statistical analysis tools to expand the knowledge of this research.

5 Conclusions

This study investigated the relationships between trauma incidences and the socio-economic statutes in two levels: Individual and sub-district. At the individual level, it explored the relationship between trauma incidences and the housing prices. At the sub-district level, it explored the relationships between trauma incidences were the per capita disposable income in neighborhoods. In both cases, it identified that trauma incidences are statistically negatively correlated with the house prices and the per capital disposable income by the Pearson coefficients of -0.71 and $-.0.72$, respectively. Through its analyses, it has revealed the hot spot areas with high incidence rates of trauma cases in Qingpu district that is used as the case study region. Further, it has shown that the rates of trauma incidences based on the house prices are not uniform. Overall, these results provide new baseline information that individuals, researchers and other stakeholders could use for further studies and appropriate measures for securing people's lives. Future studies should consider to extend this research by including many other socio-economic variables as discussed in the limitations of this studies in Sect. 4.

Acknowledgements. We thank the editors and reviewers for their valuable comments. This work is partially supported by the projects funded by the Chongqing Natural Science Foundation (Grant Number: CSTB2022NSCQMSX2069) and the Ministry of Education of China (Grant Number: 19JZD023).

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