Contrary to Common Observations in the West, Urban Park Access Is Only Weakly Related to Neighborhood Socioeconomic Conditions in Beijing, China

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Received: 1 March 2018; Accepted: 3 April 2018; Published: 9 April 2018

Abstract: Parks provide critical ecosystem services to urban residents. Park access critically determines how parks are used by residents. Many existing studies, which mostly have been conducted in developed countries, reported that park access disproportionately benefits the socioeconomically advantaged groups. To test if this observation also holds true in developing countries, we examined the park access and its relationship with socioeconomic conditions in Beijing, China. We used a buffering method and a road network-based analysis to calculate the park access of 130 neighborhoods, and applied the Pearson correlation to examine how neighborhood park access is related to socioeconomic conditions. Our results showed that (1) the park access decreased from 76% in the downtown areas to 24% in the suburbs; (2) the correlation coefficients (r) between socioeconomic conditions and park access were all smaller than 0.3 (p < 0.05)—that is, explaining less than 8% of the variability. Our study indicated that neighborhood socioeconomic conditions were only weakly associated with park access in Beijing and did not support the common phenomenon in western countries. Such a contradiction might be explained by the fact that park planning in Beijing is funded and administered by the city government and influenced by the central government’s policy, whereas in most developed countries market sectors play a critical role in park planning. Our research suggested that urban planning funded by governments, when aimed at improving the wellbeing of all urban residents, may effectively reduce potential environmental inequalities.

Keywords: urban parks; urban greenspace; park access; neighborhood socioeconomic conditions; environmental justice

1. Introduction

Urban parks are important public amenities in cities. Researchers found that living closer to urban parks encouraged residents to conduct more physical activities, which enhances health [1,2]. Empirical studies also reported that residents living closer to parks have lower body mass index and better mental health [3–7]. With a vital role in influencing residents’ use of parks as well as physical and psychological well-being, park access has attracted considerable attention from researchers as well as urban planners [8–11].
Related to park access, a particular environmental injustice concern has been identified in many studies: socioeconomically disadvantaged residents, such as ethnic minorities and the poor, often had less access to parks due to the history of land development, ethnic-racial oppression, and state oppression [12]. Some other studies, however, reported that park access favored disadvantaged neighborhoods [13,14]. There are also studies that found no relationship between park access and neighborhood socioeconomic conditions [15–17]. These inconsistent findings not only make the topic a scientific puzzle that remains to be solved but also indicate opportunities for urban planners to avoid the potential environmental injustice in terms of park access.

To delve into this puzzle, we conducted a systematic literature review to collect the papers with the terms (park or parks) AND (equity or disparit* or justice) AND (access* or proximit*) in titles, abstracts, or keywords in the Web of Science Core Collection database. We limited the search to English articles published in journals between 2005–2016. The search generated 146 papers. Through screening the abstract and full text of the papers, we included 24 case studies which examined the relationship between urban park access and residents’ socioeconomic conditions. Then we reviewed the methods and results of the 24 papers (Table S1). We found that two issues are likely to explain the inconsistency among the findings: (1) locations of the study areas, and (2) the methods of estimating park access.

First, the studies in different regions drew different conclusions. For example, a study in Yokohama, Japan found that census grid cells with a higher percentage of professional and managerial workers had more parks within the boundaries of the cells [18]. Meanwhile, a study in Maryland, USA found that income and percentage of minorities had an interaction in terms of the relationship with park access, and stated that the mostly-white block groups with lower income and mostly-minority block groups with higher income had fewer parks than mixed-race neighborhoods within the boundaries of the block groups [19].

Such divergence may indicate that historical, cultural, and political structures may play a role in forming the relationship between park access and residents’ socioeconomic conditions, which calls for more case studies in different regions. However, among the 24 studies we reviewed, the majority (16 studies) were carried out in the United States (e.g., [20,21]) and the other five were conducted in Israel, Japan, Australia, and the UK. Only three of them were carried out in developing countries, namely, China, South Africa, and Iran (Table S1) [14,22,23]. Therefore, studying the park access patterns and their relationship with neighborhood socioeconomic conditions in cities of developing countries, where most urbanization is taking place [24–26], will enhance our understanding on this issue and contribute to urban sustainability [2].

Second, researchers estimated park access by different methods. Commonly used methods include the container method, buffering method, and road network-based analysis. The three methods are similar in that they all generate a spatial area for each neighborhood and then consider the parks within that area as accessible by residents living in the focal neighborhood. The difference lies in how to generate the accessible area. The container method uses the boundary of the administrative or census unit in which a neighborhood is located as its accessible area [19,27]. The buffering method uses a circle of a given radius around a neighborhood as its accessible area [16,17,28,29]. Road network-based analysis calculates the area that can be reached from a neighborhood within a given walking distance as its accessible area [23,30].

The method used to estimate park access may affect the conclusions on its relationship with neighborhood socioeconomic conditions. Researchers found that changing the spatial scales of analysis had an impact on the resulting correlations between environmental amenities and residents’ socioeconomic conditions [31]. Estimating park access by different indicators (e.g., accessible park area per capita and presence of accessible parks) was also found to affect the conclusions on how park access is related to neighborhood socioeconomic conditions [13]. However, efforts to compare the widely used estimating methods of park access (e.g., container method, buffering method, and road network-based analysis) and their influence on the relationship between park access and residents’ socioeconomic conditions remain limited due to data availability.
Our study aims to examine the spatial distribution of the urban park access and how it is related to neighborhood socioeconomic conditions in Beijing, China, one of the most populous and fast-growing cities in the developing world. We used both the buffering method and road network-based analysis to compare how these two methods influence the results of park access. Specifically, we asked two questions: (1) how does neighborhood park access vary spatially across Beijing? and (2) how is park access related to neighborhood socioeconomic conditions in the context of Beijing?

It is worth noting that we did not include the container method for comparison in this analysis. Unlike the buffering method and road network-based analysis, which based park accessibility on distance, the container method assumes residents can only reach the parks within the administrative or census unit where the residents live. Although the administrative boundary itself does not hinder residents’ use of parks in fact, the container method is still widely used due to its simplicity and ease of implementation [32].

2. Materials and Methods

2.1. Study Area

We focused on the six central urban districts of Beijing as our study area (Figure 1). They are the most densely populated areas in Beijing, including the urban core area and part of the suburban area. The six districts accommodate 12.8 million people (59.3% of the total population in Beijing) with an area of 1367.77 km² (8.6% of Beijing) [33]. The study area contains 130 neighborhoods (“jiedao” in Chinese). We defined a neighborhood as the smallest geographic unit with available census data in China. Within our study area, the neighborhood socioeconomic conditions vary considerably. For example, the proportion of elderly people (age > 60) ranges from 9.4% to 42.13%, and the proportion of high school graduates ranges from 18.34% to 86.67% [34]. There are 139 parks in our study area (Figure 1). On average, each resident has a park area of 6.89 m². The densely populated urban landscape, the urban to suburban gradient, and the variation of neighborhood socioeconomic conditions make Beijing an ideal area to explore our research questions.

![Figure 1. Parks and neighborhoods in the six districts of Beijing. (a) The location of Beijing in China; (b) The location of study area, including six districts in Beijing; (c) The boundary of 130 neighborhoods (bold lines), 139 parks (green areas) and residential areas (gray areas).](image-url)
2.2. Data

We obtained the geographic data of road network and neighborhood boundaries from the Beijing municipal department. We derived an inventory of public urban parks in Beijing from the Beijing Gardening and Greening Bureau. We manually mapped the park boundaries, park entrances, and residential area boundaries according to Amap.com, a widely used online mapping platform [35]. We validated the park boundaries and entrances through a ground-truth survey between 14 October–20 November 2015.

We described neighborhood socioeconomic conditions using six variables, including economic status, percent of elderly people (>60), children and youth (<19), high school graduates, bachelor degree holders, and local residents. Data for income is only available at the district level, therefore, we described the economic status of a neighborhood by combining average house rent of the neighborhood and per capita income of the district where the neighborhood is located [34,36]. We assumed that the per capita income of a neighborhood is proportional to its average house rent in Beijing (Equation (1)). Total income of a district equals the total income of the neighborhoods which located in the districts (Equation (2)). By integrating Equations (1) and (2), the economic status (i.e., estimated per capita income) for each neighborhood can be obtained from Equation (3) (An example of estimating per capita income of a neighborhood is shown in the Supplementary Materials):

\[
\frac{y_i}{y_j} = \frac{r_i}{r_j} \quad (1)
\]

\[
\sum_{i=1}^{k} n_i y_i = NY \quad (2)
\]

\[
y_i = \frac{NYr_i}{\sum_{i=1}^{k} n_i r_i} \quad (3)
\]

where \(y_i\) and \(y_j\) are the per capita income of neighborhood \(i\) and \(j\) respectively; \(r_i\) and \(r_j\) are the average house rent of neighborhood \(i\) and \(j\) respectively; \(Y\) is the per capita income of the district in which neighborhood \(i\) is located; \(n_i\) is the population of neighborhood \(i\); \(N\) is the population of the district in which neighborhood \(i\) is located; and \(k\) is the number of neighborhoods in the district.

We used both the percentage of high school graduates and bachelor degree holders to characterize the education level. We presented the age groups by percentage of elderly people (>60) and children and youth (<19). We highlighted the elderly and the youth because they have a high demand for park use and relatively limited mobility to visit distant parks. Local residents refer to the people who have been living in Beijing for more than six months and are registered in the household registration system (the Hukou system) of Beijing. Local residents have access to a variety of resources, including good education, medical insurance, and low-income subsidy [37]. Local residents are more familiar with available social resources, and can often receive social support from their families and friends around. Therefore, we considered percentage of local residents as a proxy variable for social resources availability. Data for education level, age, and local residency were derived from the 2010 Census [38].

2.3. Analysis

In this study, we defined the park access of a neighborhood as the area ratio of residential areas within the neighborhood that can reach a park within a walking distance of 1 km, which is the distance people are likely to walk [39,40]. Firstly, we generated two park access maps using the buffering method and road network-based analysis, respectively. We applied buffering analysis in ArcMap 10.3™ to generate a park access map of the areas that are within 1 km Euclidean (straight line) distance to the entries of the 139 parks. We excluded the roads without pedestrian lanes from the road network map, and applied road network-based analysis in ArcMap 10.3™ to generate a park access map of the areas that are within 1 km walking distance to the entrances of the parks.
Then we overlaid the residential area map with the two park access maps generated by the buffering method and road network-based analysis respectively to identify the residential areas that can reach a park within 1 km. Such residential areas were defined as “residential areas with park access”. Finally, we calculated the proportion of residential areas with park access in a neighborhood, which is referred to as “neighborhood park access” in the following text.

We analyzed the relationship between neighborhood park access and socioeconomic conditions (i.e., economic status, elderly people, children and youth, percent of high school graduates, bachelor degree holders, and local residents) using Pearson correlation in SPSS Statistics 23. The ring roads represent the urban–suburban gradient of Beijing. In order to examine the effects of urbanization as well as establishment time, we divided the neighborhoods into five groups according to their locations relative to the ring roads (within the 2nd ring, between the 2nd–3rd ring, 3rd–4th ring, 4th–5th ring, outside the 5th ring), and compared their park access and the relationship between their park access and socioeconomic conditions.

3. Results

3.1. Comparing the Buffering Method and Road Network-Based Analysis

The buffering method generated a larger park access map than road network-based analysis (Figure 2a). Therefore, the buffering method generated higher neighborhood park access than road network-based analysis (Figure 2b). The correlation coefficients (r) between neighborhood socioeconomic conditions and park access generated by the buffering method were larger than their counterparts generated by road network-based analysis (Figure 2c). With that being said, the buffering method and road network-based analysis generally agreed with each other on the results of park access’ spatial pattern (Figure 3) and its relationship with neighborhood socioeconomic conditions (Figure 4).

Figure 2. Comparison between the buffering method and road network-based analysis. (a) The park access map by the buffering method (yellow area) and road network-based analysis (orange area); (b) The neighborhood park access by the buffering method (light orange box) and road network-based analysis (dark orange box) along the urban–suburban gradient; (c) Pearson correlation coefficients between neighborhood park access estimated by the buffering method (light orange bars) and road network-based analysis (dark orange bars), and socioeconomic conditions variables including economic status (US dollar, USD), percentage of elderly people (%), percentage of children and youth (%), percentage of high school graduates (%), percentage of bachelor degree holders (%) and percentage of local residents (%).
3.2. Spatial Patterns of Park Access in Beijing

Our results showed that park access across the 130 neighborhoods varied considerably, ranging from 0 (no residential area in the neighborhood has access to any park within a 1 km walk) to 100% (all the residential areas in the neighborhood can reach at least one park within a walk of 1 km). Neighborhood park access decreased from the urban center to the periphery (Figure 3). According to the results from the road network-based analysis, the average neighborhood park access decreased from 76% to 24% from within the 2nd ring road to outside the 5th ring road, which represents the urban–suburban gradient of Beijing. Specifically, among the 25 neighborhoods that are located within the 2nd ring road, 17 had park access higher than 70%. In contrast, none of the 30 neighborhoods located outside the 5th ring road had park access higher than 70% (Figure 3).

**Figure 3.** The spatial pattern of neighborhood park access calculated by the buffering method and road network-based analysis. (a) Spatial distribution of neighborhood park access by the buffering method; (b) Spatial distribution of neighborhood park access by road network-based analysis; (c) Neighborhood park access along the urban–suburban gradient. The bar chart shows the comparison of neighborhood park access regarding their location between the ring roads. The bars show the number of neighborhoods in different park access categories indicated by the orange-green colors. Bars titled ‘B’ are neighborhood park access by buffering method. Bars titled ‘N’ are neighborhood park access by road network-based analysis. The lines stand for the mean values of neighborhood park access by buffering method (dark blue line) and road network-based analysis (light blue line). Mean-B is the mean value of neighborhood park access calculated by buffering method and Mean-N is the mean value calculated by road network-based analysis. The five maps below the bars show the location of neighborhoods relative to the ring roads (gray area).
### 3.3. Relationships between Neighborhood Park Access and Socioeconomic Conditions

The results based on the 130 neighborhoods showed that most of the correlation coefficients (r) between neighborhood park access and socioeconomic conditions were statistically significant (p < 0.05), except for the percentage of bachelor degree holders. All the correlation coefficients (r) were smaller than 0.3 (Figure 4). The effect sizes (as correlation coefficients) are generally considered small [41] and should be taken into consideration. Additionally, all r^2 values were less than 0.08, indicating that the socioeconomic variables can only explain less than 8% of the variance of neighborhood park access.

Regarding the five groups based on the neighborhoods’ location relative to the ring roads, most of the correlation coefficients between neighborhood park access and socioeconomic conditions variables were statistically insignificant (p > 0.05), except for elderly people and economic status within the 2nd ring (Table 1). The correlation coefficients between percentage of elderly people and park access by the buffering method and road network-based analysis were 0.415 and 0.426 (p < 0.05), respectively. The correlation coefficient between neighborhood park access by road network-based analysis and economic status within the 2nd ring was −0.434 (p < 0.05).

#### Table 1. Correlation coefficients of neighborhood park access derived by the buffering method and road network-based analysis with socioeconomic conditions.

|                      | within 2nd Ring (N = 25) | 2nd–3rd Ring (N = 21) | 3rd–4th Ring (N = 21) | 4th Ring–5th Ring (N = 33) | outside 5th Ring (N = 30) |
|----------------------|--------------------------|-----------------------|------------------------|-----------------------------|---------------------------|
| **Neighborhood park access by buffering method** |                         |                       |                        |                             |                           |
| Economic status      | −0.384                   | −0.093                | 0.024                  | 0.151                       | 0.172                     |
| Elderly people %     | 0.415 *                  | 0.280                 | 0.176                  | −0.284                      | 0.143                     |
| Children and youth % | −0.361                   | 0.028                 | −0.101                 | 0.088                       | −0.113                     |
| High school graduates % | −0.051             | −0.124                | 0.029                  | −0.121                      | 0.309                     |
| Bachelor degree holders % | −0.127             | −0.166                | 0.018                  | −0.048                      | 0.315                     |
| local residents %    | 0.228                    | 0.109                 | 0.113                  | −0.223                      | 0.211                     |
| **Neighborhood park access by road network-based analysis** |                         |                       |                        |                             |                           |
| Economic status      | −0.434 *                 | −0.011                | 0.191                  | 0.056                       | 0.209                     |
| Elderly people %     | 0.426 *                  | 0.165                 | 0.118                  | −0.118                      | −0.124                    |
| Children and youth % | −0.347                   | 0.138                 | −0.149                 | −0.086                      | 0.044                     |
| High school graduates % | −0.093              | 0.035                 | 0.084                  | −0.101                      | 0.259                     |
| Bachelor degree holders % | −0.184             | −0.022                | 0.044                  | −0.103                      | 0.341                     |
| Local residents %    | 0.225                    | 0.086                 | 0.029                  | −0.165                      | −0.033                    |

Note: * Correlation is significant at the 0.05 level (2-tailed).

**Figure 4. Scatter plots showing the relationship between socioeconomic conditions and neighborhood park access by buffering method (top row) and road network-based analysis (bottom row).**

The correlation coefficients (r), p value, and fitted lines are shown. (a) scatter plot of economic status (USD) with neighborhood park access; (b) scatter plot of percent of elderly people (%) with neighborhood park access; (c) scatter plot of percent of children and youth (%) with neighborhood park access; (d) scatter plot of percent of high school graduates with neighborhood park access; (e) scatter plot of percent of bachelor degree holders (%) with neighborhood park access; (f) percent of local residents (%) with neighborhood park access.
4. Discussion

4.1. How Does the Neighborhood Park Access Vary Spatially across the City of Beijing?

Our results show that in Beijing the neighborhood park access decreases from the urban center to the suburbs. This is in sharp contrast with the commonly reported observations from developed countries that suburban residents have more park access than city dwellers [21,28]. This result is not surprising as there are a number of parks in the urban core area of Beijing. Most parks within the 2nd even the 3rd ring road of Beijing have historical legacies. They are either ancient imperial gardens or linear parks built upon ancient city walls. These places in the central area were kept as public parks while the city sprawled and new buildings emerged around them. In contrast, the recently developed areas in the suburbs failed to take advantage of the modern urban planning, and apparently did not have as much park access as the old neighborhoods around the Forbidden City in central Beijing.

4.2. How Is Park Access Related to Neighborhood Socioeconomic Conditions?

We conclude that the park access was only weakly associated with income level, education level, age groups, or local residency in Beijing for the study period. Although all the p values are smaller than 0.05, the correlation between neighborhood park access and socioeconomic conditions was weak ($r^2 < 0.08$). $p$ value is a function of sample size [42], and the small $p$ values here were primarily a consequence of the relatively large sample size (n = 130). Thus, $p$ values must be interpreted in light of effect size which denotes the magnitude of the association strength in correlation (correlation coefficients) [41,43]. If the results show a small $p$ value with a small effect size, it means that the result is statistically significant but not ecologically or practically [43]. Our conclusion is further supported by the ring road-based analysis in which reduced sample sizes led to statistically insignificant results.

Therefore, access to parks within a 1 km walking distance from home did not favor the people with more income, higher education, or living in Beijing for a longer time. Neighborhoods with more children and youth or elderly people did not enjoy extra park access either. This finding seems to contradict the observations in most western countries that park access favors socioeconomically advantaged groups [12,20,44]. Admittedly, we examined only six socioeconomic variables in this study, so it is possible that other socioeconomic factors might influence the park access in Beijing. Nevertheless, we considered the critical socioeconomic factors, which were commonly reported to determine the park access in studies on western countries [18,21,44], and found that these factors are not associated with the park access in Beijing, China.

Recent studies in Chinese cities also reported similar results. A study in Hangzhou, China found no significant differences among different socioeconomic groups in terms of park access and changes in that access. This study concluded that the park allocation policies in Hangzhou improved the park access without causing socioeconomic inequities [45]. Another study in Shanghai, China reported that park access favored the disadvantaged groups, and concluded that the equitable planning approach from China’s socialist era was a reason [46].

4.3. How May Urban Planning Practice Affect the Association between Park Access and Neighborhood Socioeconomic Conditions?

The urban planning practice of Beijing may explain our results. The urban parks in Beijing are dominantly funded and managed by the city government through the Urban Green Space System Planning (2004–2020) [47], which aims to improve the environment and residents’ well-being, as an implementation of the General Urban Planning of Beijing (2004–2020) proposed by the city government [48]. According to the Urban Green Space System Planning of Beijing (2004–2020), more than one hundred public urban parks with a total area of 1700 hectares were funded and built by the city government between 2005–2010 [47]. In addition, public land ownership make it relatively easier to obtain land and build new parks in Beijing compared with cities in some western countries [13]. The Wanghe Park built in 2014 provides an example. The Beijing government relocated 1000 stores
and 15,000 residents to obtain an area of 22.5 hectares and built this wetland park with a total area of 39.6 hectares [49].

Previous studies showed that the urban park related practices of private developers and park funding in market economies tended to benefit socioeconomically advantaged groups [18,21]. Market-oriented reforms and neoliberal trend in cities of developed countries were reported to lead to inequities in public service delivery [50]. City governments in developed countries tended to privatize their services or turn to voluntary organizations to provide and maintain urban parks, which may result in social disparities of urban park access [51]. The park-bond funding in Los Angeles, US were also found to exacerbate existing inequities in park distribution [21]. Therefore, our study revealed the need to further examine the consequences of environmental justice induced by urban planning practices and policies through comparative studies.

4.4. Comparing the Buffering Method and the Road Network-Based Analysis

Methods to estimate park access may influence findings on the relationship between park access and neighborhood socioeconomic conditions. We compared the buffering method and the road network-based analysis in this study. Although the results from both methods indicated that park access was not affected by neighborhood socioeconomic conditions, the correlation coefficients generated by buffering method were consistently larger than those generated by road network-based analysis. The buffering method counted the length of the straight line between a neighborhood and a park as the distance between them, which is usually shorter than the length of the walking path traveled by residents. Therefore, the buffering method may overestimate park access and the correlation between park access and neighborhood socioeconomic conditions.

4.5. Future Research

Our results show that the neighborhood park access decreased from the urban center outward, which might be due partly to the differences in establishment time as neighborhoods farther away from the urban center tend to be more recently developed areas. This suggests the need to control establishment time for future studies of comparing and understanding park accessibility patterns among different parts of the Beijing metropolitan region. Also, while focusing on the spatial pattern of park access and its relationship with neighborhood socioeconomic conditions, our study did not consider some other factors that may affect park accessibility, such as park size, landscape design, and facilities [52]. These factors should be considered in future studies to produce knowledge directly useful for park/urban planning. In addition, more studies that explicitly consider urban planning policies with more spatial details are needed to further verify our findings here, and link park accessibility with human wellbeing measures.

5. Conclusions

We examined the spatial pattern of neighborhood park access in six districts of Beijing and how park access was related to neighborhood socioeconomic conditions. Our results show that the neighborhood park access in Beijing is highly heterogeneous in space and decreases along the urban–suburban gradient. This spatial pattern is inconsistent with the reported patterns in cities in western countries that park access increases along the urban–suburban gradient.

Our results on the correlations between neighborhood park access and socioeconomic conditions did not support the common observations in the west; that is, neighborhood socioeconomic factors were not correlated with park access in Beijing, China. It is sensible for two reasons. First, there might be other socioeconomic factors, rather than those analyzed in our study, that affect the park access in Beijing. Second, the park planning practices in Beijing, funded and administered by the city government, instead of private sectors or park-bond funding, may explain the lack of association between park access and neighborhood socioeconomic conditions.
In addition, we calculated neighborhood park access by two methods: the buffering method and road network-based analysis. We found that the two methods generated consistent results. However, the buffering method resulted in higher park access, and larger correlation coefficients between park access and neighborhood socioeconomic conditions than did the road network-based analysis. This result indicates that the methods used to calculate park access may affect the statistical results of the relationship between park access and its potential determinants.

**Supplementary Materials:** The following are available online at http://www.mdpi.com/2071-1050/10/4/1115/s1. Table S1: Studies published during 2005–2016 on the relationship between neighborhood park access and socioeconomic conditions. An example of estimating neighborhood per capita income.

**Acknowledgments:** This work was supported by the National Natural Science Foundation of China (41301645) and the Chinese Ministry of Science and Technology through the National Basic Research Program of China (2014CB954303, 2014CB954300).

**Author Contributions:** Ganlin Huang, Xingyue Tu, and Jianguo Wu conceived and designed the experiments; Xingyue Tu analyzed the data; Ganlin Huang and Jianguo Wu contributed materials and analysis tools; Xingyue Tu, Ganlin Huang, and Jianguo Wu wrote the paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

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