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Assessing Amenities Requirements: A Methodology for Quantifying Demand, Space Requirements, and Distance for a Given Community

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Abstract: The challenge of understanding the connection between the needs and usage of amenities and services in a given population has been amplified by segregated land use and urban sprawl. The ability to travel long distances and the lack of integrated planning approaches have further obscured the relationship between proximity and demand, particularly in the context of a 15-minute walkable city. However, there is growing recognition among urban stakeholders that walkable communities are critical for achieving social integration, economic vitality, and environmental sustainability in cities. To achieve this level of walkability, neighborhoods and communities must be designed and structured in ways that enable daily activities to be conveniently accessed within walking distance. In this context, by using Safegraph and Replica data [correlated], this paper presents a methodology for optimal distribution of amenities, taking into account not only the quantity and size, but also the appropriate distances from housing. The methodology is based on the analysis of mobility patterns and the use of logistic regression to determine the distances that people are willing to walk to each amenity, referred to as "walking boundary". By combining the frequency of use with the walking boundary, this methodology responds to the amenity needs of a population.

Keywords: urban planning; Amenities Requirements; 15-minute walkable city; Safegraph and Replica data

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1. Introduction

In the last century, the rate of urbanization has dramatically increased, with the global urban population growing from 751 million in 1950 to 4.2 billion in 2018, accounting for 55% of the world's population, and projected to reach 68% by 2050 [1]. This rapid urban expansion presents numerous challenges, including the need to improve urban quality of life by providing better access to housing, transportation, education, healthcare, job opportunities, and enhancing the safety and aesthetic appeal of cities [1][2]. Central to addressing these challenges is understanding the urban infrastructure, services, and population distribution to improve livability [3]. The physical design and layout of urban areas significantly influence the livability of a city, where a well-designed environment can improve accessibility, safety, and quality of life for its residents [4][5]. Studies have shown that a diverse mix of land uses in urban areas enhances walkability and creates more vibrant neighborhoods [6].

The City Science (CS) group, led by Kent Larson, focuses on the interplay between human behavior and the physical space of cities. They advocate for Live-Work Symmetry, Net-Zero Commuting, and Distributed Services and Amenities to create more efficient and livable urban spaces [9]. To support this, they developed City Scope, a tool for assessing urban performance and facilitating collaborative decision-making [10][11][12]. Although some research has identified positive associations between neighborhood characteristics and walkability [7], there is still a need for more comprehensive studies on how the ideal mix of amenities varies with neighborhood population size. For instance, Cesar Hidalgo et al.'s research in 47 US cities explores amenity clustering and the effectiveness of amenity supply in neighborhoods [13], while another study used Safegraph and Replica data to evaluate the amenity needs within a 15-minute walkable distance for live-work symmetry [15][16]. Further research is needed to better understand the relationship between neighborhood amenities, population size, and their distance from housing, which can inform policy interventions to enhance urban livability.

2. Methodology

Building upon the foundational methodology of Cesar Hidalgo et al.'s [13], this analysis innovatively combines the comprehensive trip data from Replica with the rich point-of-interest (POI) details from Safegraph, employing NAICS codes to establish a common attribute for dataset correlation. This integration allows for a nuanced mapping of POIs to specific trips in Replica's database, using a weighted randomization approach based on visit frequency data from Safegraph. This method significantly enhances the understanding of population behavior patterns, enabling the calculation of specific amenity needs per 1,000 people, as well as their spatial requirements in terms of square meters.

A key innovation of this study is the detailed examination of the frequency of visits to various amenities, taking into account not just individual visits but also household and vehicle numbers for certain amenity types. This leads to a more accurate ranking of amenities in terms of their proximity to housing, based on their usage patterns. The study goes further by implementing logistic regression analysis to identify the "walking boundary," a crucial metric that defines the maximum distance individuals are willing to walk to access an amenity. This metric is important in understanding the interaction between people's mobility patterns and amenity locations.

However, the research acknowledges that relying solely on walking boundaries may not completely address the needs of a population. To resolve this, the study integrates both the frequency of amenity usage and the walking boundary data to determine the most optimal distances for amenity placement. This dual-factor approach ensures that the final placement of amenities not only aligns with the population's mobility patterns but also with their actual usage needs.

Taking cues from Xia et al.'s work [17], the study assigns a weighting system, ranging from 0 to 1, to each amenity based on its frequency of use. Amenities with higher usage frequency receive greater weight, indicating their higher significance in daily mobility. These weights are then ingeniously correlated with distances, adhering to the principle that amenities should be within a 15-minute walkable radius. This approach cleverly uses the one-kilometer distance as a benchmark, considering the average walking speed, and inversely relates weight to distance, ensuring that more frequently used amenities are closer.

Conducted in the Boston Urban Area, Massachusetts, this analysis provides insights specific to an urban context, distinct from the broader perspective in Cesar Hidalgo et al.'s [13]. The choice of this area is strategic, recognizing the unique characteristics and social customs of urban settings compared to rural areas. The study also advances the classification of amenities, moving beyond top-level categories to include 80 specific sub-amenities, allowing for a deeper and more granular understanding of various amenity types and their roles in urban environments. This refined classification system is crucial in capturing the nuanced differences between amenities, providing a comprehensive understanding that is vital for urban planning and development.

3. Results

The findings underscore the importance of ensuring that residents have access to essential amenities within a 15-minute radius, a concept integral to improving the overall quality of life and fostering more sustainable, walkable neighborhoods.

3.1 Amenities Requirements per 1000 People

Appendix A [14] details the number and size of amenities required in the Boston Urban Area, derived from the visiting patterns of its residents. This section presents a table (Table 1) summarizing the data, categorizing amenities by age group, income group, sub-amenity type, the number of visits per month, and the necessary number and size of amenities per 1000 people. This detailed breakdown provides a clear picture of the specific needs of different demographic groups and helps in planning amenities that cater to the diverse population of the area.

Table 1 Header of the outcome table included in Appendix A

Age Group	Income Group	Sub amenity	Visits/pm	NPOIS/1000p	Nsqm/1000p

3.2 Location of Amenities

In Table 2, the results for the eight most frequented sub-amenities are collated (with the full table available in Appendix B). This ranking, based on usage frequency, helps prioritize which amenities should be closest to residential areas in urban design. The table includes the "walking boundary" derived from logistic regression analysis, indicating the maximum distance residents are willing to walk to access each amenity. This insight into mobility behavior is crucial for designing walkable cities, as it reveals the varying distances people are prepared to travel for different amenities.

Table 2. Frequency, walking boundary, and optimal distance for the 8 most frequented amenities.

Sub amenity	Frequency (visits/pm)	Walking boundary (miles)	Distance (miles)
Full-Service Restaurants	2.388	0.229	0.229
Snack and Nonalcoholic Beverage Bars	1.215	0.26	0.263
Limited-Service Restaurants	1.065	0.267	0.272
Grocery or Supermarket	0.853	0.45	0.454
Home Goods Store	0.609	0.488	0.491
Hotel and Lodging	0.565	0.275	0.287
Zoos and Nature Parks	0.517	0.289	0.303
Gym	0.501	0.242	0.26

The study employs an exponential function to combine the frequency of amenity use with the walking boundaries, determining the optimal distances for amenity placement. These distances, listed in the last column of Table 1, are foundational for creating 15-minute walkable neighborhoods. By ensuring that essential amenities are easily accessible, this approach promotes a healthier, more active lifestyle, reduces dependence on vehicles, and contributes to the development of vibrant, community-centric urban spaces.

4. Conclusion

The study builds upon previous research [13] by offering a more detailed analysis of amenity types and focusing on a specific urban area, thereby enhancing accuracy. A key accomplishment is the development of a methodology to determine optimal amenity distances, ensuring accessibility within a 15-minute radius. The methodology's critical aspects include prioritizing amenities based on usage frequency for proximity to residential areas and employing logistic regression to understand the maximum walking distances preferred by people. These combined analyses provide a nuanced approach to identifying suitable amenity locations.

This research advances our understanding of community amenity needs using big data analysis, offering a versatile tool applicable across various geographical locations. The methodology's adaptability to different cities and countries, given the availability of necessary data, is a notable strength. However, the study recognizes its limitations in generalizing distance analysis for the entire population, pointing out the need for future research to focus on specific demographic groups for a more personalized understanding of amenity distance requirements.

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