

## Article

# Exploring the Relationship Between 15 Minute Access and Life Satisfaction

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## Abstract

The 15 min city concept seeks to promote health, well-being, and quality of life by ensuring that essential services are located within a 15 min walking or cycling distance from housing and are accessible through sustainable modes of transportation. This study aims to evaluate the compliance of this concept in a developing country context and provide supporting evidence by examining if residing within the 15 min reach to basic services affects perceived health, perceived accessibility, and life satisfaction. To assess pedestrian accessibility in Lahore, Pakistan, we adapted the NEXT proximity index—originally developed as part of the Landscape Metropolis Project in Italy—which scores 15 min access using open data sources. A network analysis was conducted to determine the shortest travel times to various points of interest, including education, transportation, healthcare, shops, restaurants, leisure spaces, places of worship, and financial services. Each hexagonal unit in the study area was assigned an access score proportional to its proximity to these facilities. These access scores were then analyzed using multiple regression models, based on survey data collected from 519 university students regarding their perceived health, perceived accessibility, and life satisfaction. According to the network analysis conducted using WorldPop estimates of Lahore’s population, only up to 30% of the population resides in areas that qualify as a 15 min city for each facility type. Moreover, access to bus stops significantly enhances both perceived accessibility and life satisfaction, while proximity to healthcare services shows the strongest positive association with life satisfaction.



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**Keywords:** 15-min city; NEXT proximity index; r5r package; perceived health; perceived accessibility; satisfaction with life

## 1. Introduction

Although the 15 min city concept was coined in 2016 [1], neighborhood-based planning can be dated back to the 20th century, when Perry discussed the functional and organizational structure of neighborhoods [2]. However, the 15 min city concept was triggered largely due to adherence to social distancing and the need to avoid unnecessary travel during the COVID-19 pandemic [3–5]. The COVID-19 pandemic exposed the impossibility of neighborhood-based lifestyles in many urban environments and made us rethink our planning approach. Today, the 15 min city concept is one of the top trending models in the field of planning research [4] and discussions are moving further towards providing equitable access to all population groups [6].

The 15 min city concept underscored the need for the location/allocation of services in close proximity to support as a way to enhance citizens’ quality of life [1,7]. The 15 min

city concept promotes health, well-being, and quality of life by encouraging active modes of transport and basic services within a 15 min reach. Potential positive impacts are diverse and address the following [8]: (1) social cohesion by promoting a sense of place; (2) health by increasing the use of active modes; (3) the environment by reducing the use of private modes; and (4) the economy by reducing costs of public health or road maintenance.

However, many researchers have objected that accessibility cannot be reduced to land use allocation and transport, and that individual access can be affected by other factors—e.g., socio-economic—and personal preferences [9–11]. For example, when the affordability of any type of service (e.g., grocery store) comes into play, people might opt for cheaper options even if they are farther away. Similarly, the quality of any type of service provided at a place also varies spatially, which may also play a role in perceived accessibility levels [12–14]. For example, one might opt for a certain health facility or a school because of the quality of treatment/education delivered. Bittencourt and Giannotti highlight that availability of public services in terms of capacity also plays an important role in people's preference to go there [6]. Therefore, our study aims at exploring the 15 min city concept by empirically analyzing the effects of (objective) proximity to basic services on perceived health, perceived accessibility, and satisfaction with life.

Perceptions of health, accessibility, and life satisfaction were gathered from 519 university students to assess their relationship with 15 min access to essential services in Lahore, Pakistan. Life satisfaction is a multifaceted and context-dependent construct, which makes general reasoning about its relationship with proximity difficult to generalize across different settings. While most empirical studies on the 15 min city model have been conducted in Europe and other developed countries [4,15], this study contributes valuable insights from a developing country context. Furthermore, to the best of our knowledge, it is the first study to examine the connection between health, life satisfaction, and the 15 min city model in this region.

### *1.1. Accessibility, Perceived Health, and Satisfaction with Life*

The study of accessibility in relation to health, well-being, and satisfaction with life is not new. The concept of accessibility has been explored through objective and perceived measures under research areas such as the built environment, neighborhood design, and access to subway or different facilities [16–25]. For example, in a study on the relationship between the built environment and life satisfaction, McCarthy et al. found that shorter distances to parks or sport fields is associated with higher life satisfaction, while higher population density is associated with lower life satisfaction [16]. Cao studied neighborhood design in relation to life satisfaction, employing both objective and perceived indicators of accessibility [17]. For example, he found that population density and cul-de-sac density are negative factors on life satisfaction, whereas land use mix and share of open spaces were statistically insignificant. Moreover, perceived accessibility to different types of facilities contributed to life satisfaction. Yin et al. studied the association between subway and life satisfaction and found that perceived walkability and perceived accessibility to different types of facilities both affect life satisfaction positively [18].

Beyond these empirical findings, theoretical approaches to accessibility have evolved from early gravity-based and cumulative-opportunity models [26] to more nuanced space-time frameworks [27] and activity-based perspectives emphasizing daily mobility patterns and individual constraints. These frameworks conceptualize accessibility, not merely as spatial proximity, but as the potential for participation in desired activities, mediated by social, economic, and temporal factors. More recent models, such as those by Geurs and van Wee [28], integrate these dimensions to highlight the interactions between land use, transport, and individual capabilities. Incorporating such perspectives strengthens the

conceptual understanding of accessibility as a multidimensional construct closely tied to equity and well-being.

The concept of the 15 min city promotes active travel modes, which previous literature found to be associated with better physical and mental health, subjective well-being, and life satisfaction [21,22,25,29–33]. However, to the best of our knowledge, the previous literature has not focused on the impact of accessibility on life satisfaction, specifically in the context of developing countries. Therefore, we aim to objectively measure access to different types of facilities and relate it with perceived measures of accessibility and life satisfaction, to potentially refine the development of the 15 min city concept.

In addition, there is growing evidence from cities in Latin America, Africa, and Southeast Asia; these cities have begun experimenting with accessibility-based planning principles similar to the 15 min city. Studies in Bogotá and Barranquilla, for instance, have demonstrated how urban morphology and transport equity shape neighborhood-level accessibility and subjective well-being [34,35]. In African contexts such as Kigali and Cape Town, research has highlighted the challenges of implementing proximity-based models in informal or spatially fragmented contexts [36]. Similarly, in Southeast Asia, cities like Jakarta and Manila face difficulties in aligning accessibility planning with socio-spatial realities of high-density, mixed-income urban environments [37]. These studies collectively suggest that while the 15 min city model has global appeal, its application in the Global South requires sensitivity to local governance structures, informality, and inequalities in access. Situating our study within this emerging body of literature allows for a more nuanced understanding of how accessibility and well-being intersect in developing-city contexts.

### *1.2. Methods to Measure 15 Min Access*

Recently, there has been a plethora of research assessing the compliance of cities with the 15 min (or X-minute) city concept [4,38–52]. Despite the fact that methods to measure accessibility vary in each case, Papadopoulos et al. identified three major components to define each approach, as follows [4]: (1) definition of trip origins; (2) selection of urban amenities; and (3) network analysis specifications. Selecting trip origins implies the need to decide on the scale and granularity of spatial analysis. Population data for case studies are usually available at the scale of administration units or census tracts. Therefore, most of the studies use more aggregated spatial units to represent trip origins. Others have used customized grid cells, varying in size from 100 × 100 m to 500 × 500 m, whereas some studies have maximized granularity by using housing units instead of population data [5]. The second step is the selection of urban amenities, which also varies across studies, depending on whether they are considered important for citizens' quality of life in their contexts. Such amenities may include grocery stores, health facilities, facilities relating to education, restaurants, places of worship, banks, parks, and job locations. The third step is related to network analysis specification, where we decide on the transport mode, speed, and threshold for time or distance. Most authors perform network analysis in GIS environments, while others have utilized packages and libraries (such as `r5py`, `r5r`, `networkx`) for programming languages R and Python in integrated development environments.

Building on these methodological advances, recent comparative studies have also sought to standardize indicators of “proximity equity,” by measuring how accessibility varies across income levels and neighborhood types [1,53]. These approaches have been particularly useful in revealing spatial inequalities and in testing how accessibility goals can be adapted to diverse urban contexts.

### 1.3. The NEXT Proximity Index

The NEXT proximity index analyzes where the 15 min city requisites are fulfilled. This index was first developed within the Landscape Metropolis Project for a case study set in Ferrera, Italy [51]. Considering the different adaptations of the three main methodological steps in the assessment of the 15 min model, there have been previously used indices such as Walk Score methodology [54], the 10 min city index by BSI [55], the online global analysis of CITYACCESSMAP [56], and the 15 min city index developed by EneIX and the University of Florence [57]. However, the NEXT proximity index stands out because of its interpretability, replicability, and scalability. The index is replicable because it uses open data sources and can incorporate other data sources. One can divide the analysis region into desired hexagons whose centroids serve as origins in the network analysis. The NEXT index uses eight types of urban amenities (parks, sustenance, grocery, banks and ATMs, shops, healthcare, education, and entertainment), in line with Moreno's social functions, that are needed to sustain urban life as destinations [1]. Network analysis specifications of the NEXT index compute the travel time needed to reach each urban amenity category by the formula "travel time = network-based length of shortest path between origin and destination/speed". Results of the NEXT index entail following three indicators:

1. NEXT Minutes: Travel time in minutes required to reach each type of category from each hexagon (travel time is calculated by using a walking speed of 5 km/h).
2. NEXT-Global: Based on the Walk Score methodology, access scores are computed for each hexagon. If all the services can be reached within 15 min, then a 100 score is given. If all the services can be reached within 15 to 30 min, then the score is distributed proportionally from 99 to 1, respectively. If you need more than 30 min to reach the services, then a score of zero is given.
3. NEXT Discomfort identifies areas that need immediate attention to improve proximity to facilities. A high level of discomfort means that a hexagon is highly populated, but proximity values are low. NEXT Discomfort is calculated by the formula  $\{\text{discomfort} = (100 - \text{global}) \times \text{population}\}$ .

## 2. Materials and Methods

The methodological framework of this study (shown in Figure 1) is divided into three main parts, as follows: (i) the case study; (ii) the measurement of 15 min access and NEXT scores; and (iii) the survey instrument and analyses.

### 2.1. Case Study

Lahore is the second-most populated metropolitan area in Pakistan, and is the capital of the country's largest province, Punjab. As per 2020, Lahore was housing 10.8 million people [58]. The city has grown dramatically from a population of 1.12 million people in 1950 to nearly 12 million in 2022 [59,60]. In terms of land area, the city doubled its expansion in just 12 years (1999–2011) and currently occupies 1772 sq. km [61].

Urban mobility in Lahore has worsened over the past 15 years due to rapid population growth and increased car ownership [62]. For every 1000 inhabitants, registered car ownership has risen from 95 in 2001 to 238 in 2008, with daily mobility estimated at 12 million trips [63]. Consequently, active modes of transport have become scarce and the dependence on private modes of transport has increased. The government of Punjab took the initiative to improve the aggravating mobility situation in Lahore and created the Punjab Mass-transit Authority (PMA) in 2015 [64]. The PMA aims to integrate all public transportation services in the city; so far, three services have been integrated, including the Orange Line Metro Train System (Metro Train), the Metro Bus System (BRT), and the Feeder Bus System. The Orange Metro Train features a 27.1 km elevated route, 27 trains,

26 stations, and a daily demand of 245,000 trips. The Metro Bus System features a 27 km (ground-level and elevated) route, 27 stations (9 of which elevated), and a ridership of 179,104 trips per day. The Feeder Bus System works to extend the reach of the Metro Bus System with the help of 200 standard buses. Figure 2 shows the public transport network along with the population distribution.

Lahore city operates within three administrative tiers: district, tehsil, and union councils. The smallest tier, union councils, can be considered as neighborhoods, which can be categorized into three types: the older parts of the city, the new city, and peripheral or newly planned areas. The older neighborhoods are rich in cultural heritage, characterized by narrow streets and mixed land uses that have developed organically. In contrast, new city neighborhoods exhibit a mix of organic growth and some degree of planned development. Peripheral and newly planned areas, however, are predominantly planned according to the Lahore Master Plan 2050 [65] and Housing Scheme Rules [66]. In these areas, land uses are designated based on specific percentages and proper zoning. However, due to the city’s horizontal, zoned growth, there is a high dependency on vehicles to access basic facilities. Lahore’s growth has primarily been horizontal, with new housing schemes largely focused on double-story, single-family homes. Although housing scheme regulations mandate that 10% of residential areas must be allocated for apartment buildings, the majority of development continues to emphasize single-family housing.

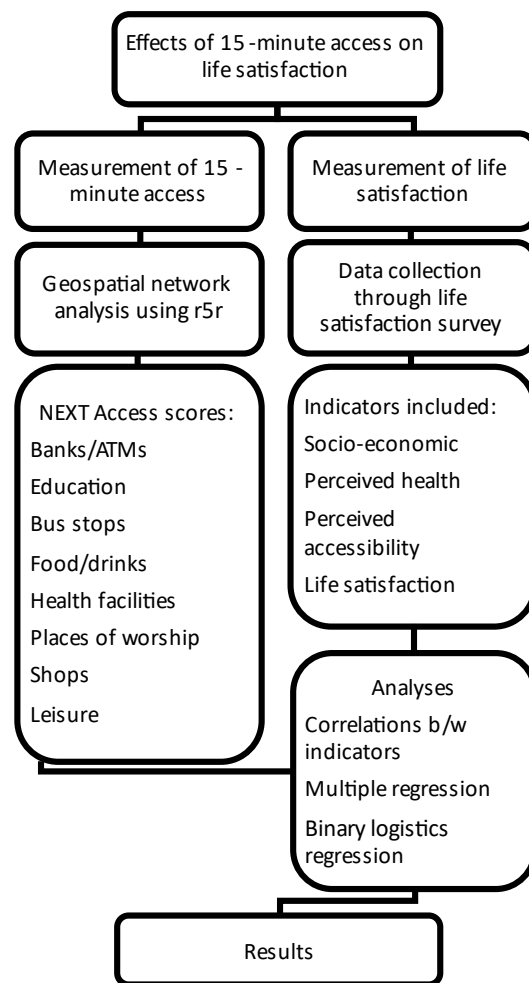
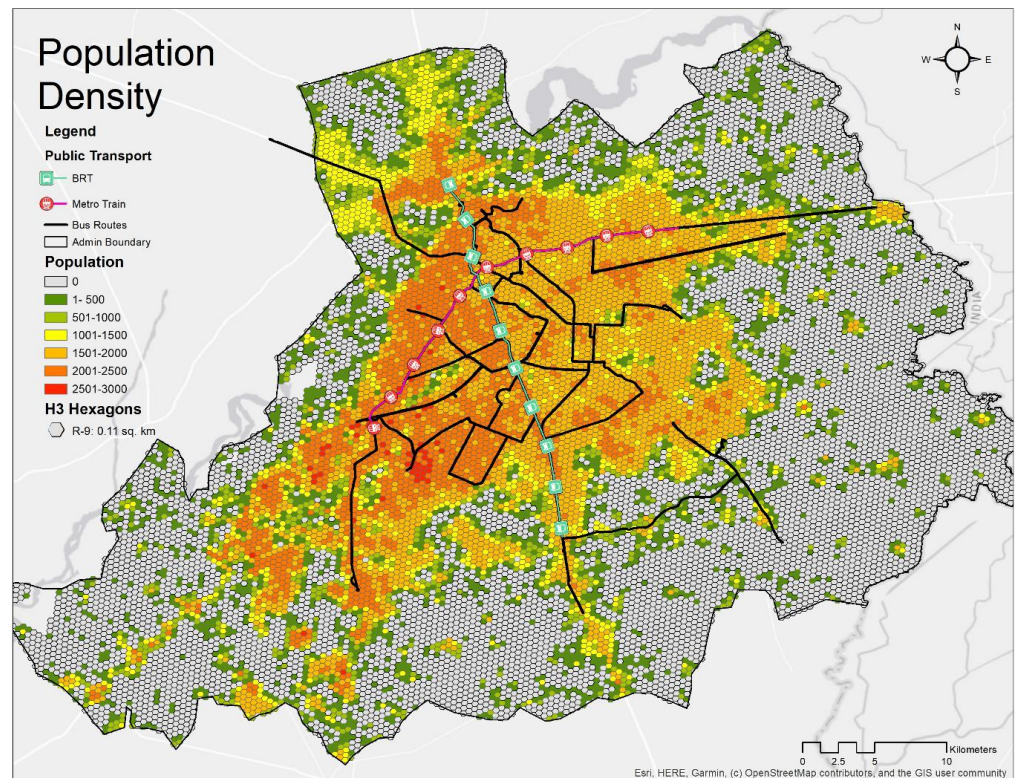


Figure 1. Organization of the study.



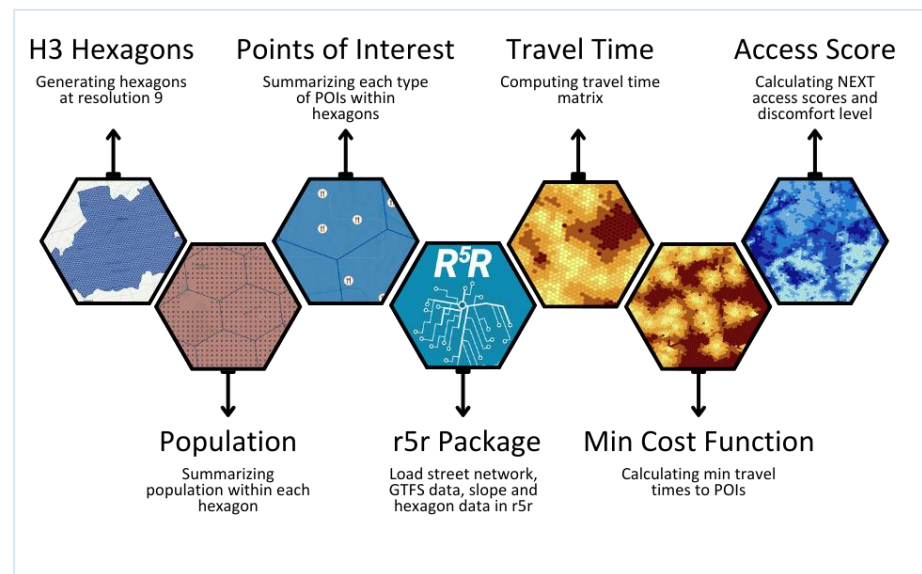
**Figure 2.** Population density of Lahore District.

### 2.2. Measurement of 15 Min Access and NEXT Scores

The measurement of 15 min access follows the outline presented in Figure 3. First, H3 hexagons for the case study area were retrieved at resolution 9 using H3 library in R. H3 is a discrete global grid system (DGGS) developed by Uber that indexes geographic locations using a hexagonal grid structure [67]. At resolution 9, the hexagons have an area of 0.11 sq. km. Population data was then summarized in each hexagon. Population data on a small scale is a huge challenge in the scenario of a developing city. Therefore, we used the open dataset, available to download in Geotiff format at a resolution of 3 arc (approximately at 100 m) from WorldPop [58]. Points of interest from OSM for each type of basic facility were also summarized for each hexagon. Points of interest for urban amenities were accessed from the OpenStreetMap database. Table 1 shows the urban amenity categories included in the study.

To perform network analysis, the street network dataset was also retrieved from OpenStreetMap [68]. Elevation or slope data was accessed in the form of GeoTiff from the opentopography website [69]. It helps in achieving better accuracy in the calculation of the travel time matrix. GTFS data are particularly useful for calculating multimodal accessibility, but *stops.txt* file was used to locate public transit stops.

Hexagon centroids were treated as origin-destination in the *r5r* package and a travel time matrix was calculated using “Walk” as the travel mode [70]. The min cost function to closest facility was used for each type of facility to compute travel times. These travel times were later transformed into access scores, adapting to the NEXT proximity index. Travel times shorter than 15 min were given a maximum score of 100, and travel times lasting 16 to 30 min were given a proportionate score from 99 to 1, respectively, whereas more than 30 min of travel time resulted in an access score of 0. Furthermore, for each hexagon, the survey results were aggregated according to the geolocations of the houses of the respondents.



**Figure 3.** Measurement of 15 min access and NEXT scores.

**Table 1.** Urban amenities, categories, OSM features, and data sources.

Urban Amenities	Category	OSM Features/Data Source
Education	Facilities/Education	childcare, kindergarten, school, university, college, language_school, driving_school, music_school, dancing_school, prep_school.
	Public Schools	School Census 2018 [71]
Transport	Bus Stops	GTFS data
Health	Facilities/Health	hospital, clinic, doctors, dentist, pharmacy, baby_hatch, veterinary, orthodontics, physiotherapist, alternative, laboratory.
Shops	Shop	Supermarket, convenience, general, kiosk, bakery, butcher, seafood, dairy, cheese, frozen_food, deli, pastry, confectionery, chocolate, tea, coffee, herbalist, marketplace, greengrocer, farm, organic, water, alcohol, beverages, wine, cannabis, nutrition_supplements, health_food, spices, clothes, boutique, fashion_accessories, fashion, shoes, shoe repair, bag, outdoor, dry_cleaning, laundry, tailor, fabric, computer, electronics, mobile_phone, hifi, video, video_games, music, radiotechnics, doors, furniture, appliance, electrical, kitchen, houseware, lighting, curtain, window_blind, art, frame, bed, etc.
Restaurants	Facilities/Food + Drinks	restaurant, fast_food, food_court, café, bubble_tea, ice_cream, pub, biergarten, bar.
Leisure	Facilities/Leisure	slide, swing, cinema, bandstand, zoo, escape_game, resort, swimming_pool, fitness_station, sauna, dog_park, miniature, toy_library, playground, picnic_site, picnic_table, bbq, fishing, firepit, bird_hide, amusement_arcade, adult_gaming_centre, nightclub.
Places of Worship	Facilities/Places of Worship	christian, muslim, jewish, buddhist, hindu, shinto, sikh, monastery.
Money	Money	Bank, bureau_de_change, money_transfer, atm, payment_centre, payment_terminal, pawnbroker, money_lender.

### 2.3. Survey Instrument and Analysis

This study uses data from the Life Satisfaction Survey, conducted between January and March 2024 at two public and one private university in Lahore, Pakistan. These universities are located in older, central, and peripheral parts of the city. A team of 12 university students were trained in a three-day workshop to administer a questionnaire-based survey (see Table A1) in both Urdu and English (based on the respondent's preference). Working in small groups, the surveyors were stationed at key university activity areas, such as cafés, libraries, and studio rooms.

University students, as respondents, may be perceived as a biased group; however, this bias is relevant to the study's focus (see similar study [72]). As they belong to a more privileged socio-economic group, these individuals have the ability to choose their daily travel modes. As such, using university students as respondents aligns with the aim of the study, to better analyze life satisfaction and its relationship with accessibility [73]. Since the primary aim of this study is to obtain an analytical depiction of the associations among several variables rather than a descriptive assessment of the (student) population, it is essential to ensure a large and sufficiently varied sample instead of a representative one (see, e.g., [73]). However, this sample will not be representative of the overall urban population with its varying age groups and socio-economic characteristics.

The survey included questions on socio-demographic information, perceived health, perceived accessibility, and life satisfaction. It was administered using the open-source QField app v3.7.8, which facilitated the collection of geographic coordinates for each respondent's home location. This geographic data was instrumental in matching respondents' information with the city's hexagonal grid. For each respondent's home location, the hexa-grid was identified geographically, and its access score was later used to correlate with the variables of the survey. A total of 519 respondents completed the survey. After addressing the missing values, the final sample size ranged from 497 to 519. The sample was geographically diverse, with a representative distribution of respondents across the city. Table 2 presents the means, standard deviations, skewness, and kurtosis for the sample's demographic characteristics.

Initially, the sample was divided into public and private university groups, but no significant differences between the two were found. The average age of the sample was 20, with ages ranging from 16 to 35. Female respondents dominated the sample (61%), which may be attributed to the higher likelihood of women participating in research related to domestic matters [74]. The average monthly household income was approximately PKR 200,000, while the minimum wage in Pakistan is around PKR 37,000 per month. Preliminary models also considered travel mode, education level, and employment status; however, these variables were subsequently discarded as they exhibited zero correlation with the dependent variables.

The widely used Satisfaction with Life Scale (SWLS), developed by Diener et al. [75], was employed to measure life satisfaction using the following three statements: "So far, I have achieved important things in my life," "In most ways, my life is close to ideal," and "If I could live my life again, I would not change anything." Responses were measured on a 5-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (5). The scale demonstrated reliability, with inter-item correlations significant at the 0.01 level and a Cronbach's Alpha of 0.9 (see Table 3).

**Table 2.** Sample description.

	N	Min	Max	Mean/ Percent	SD	Skewness	Kurtosis
Age	510	16	45	20.64	2.519	2.182	7.134
Gender (%)	518	1	2	--	--	--	--
Male	197	--	--	37.7	--	--	--
Female	321	--	--	61.4	--	--	--
Household Income (PKR)	509	10,000	10,000,000	191,365.42	474,905.515	17.627	359.985
Satisfaction with Life Scale (SWLS)	519	1.	5	3.37	1.057	−0.486	−1.094
In most ways, my life is close to my ideal.	519	1	5	3.40	1.135	−0.439	−1.041
So far, I have achieved important things in my life.	519	1	5	3.49	1.137	−0.556	−0.859
If I could live my life over, I would change almost nothing.	514	1	5	3.24	1.199	−0.329	−1.185
Perceived Accessibility Scale (PAC)	517	1.00	5.00	3.2456	1.01116	−0.105	−1.333
I have easy access to daily activities.	517	1	5	3.42	1.141	−0.377	−1.184
I will not change anything regarding my mode of transport.	517	1	5	3.20	1.093	0.014	−1.427
Access to my preferred activities is satisfying.	517	1	5	3.12	1.166	−0.007	−1.391
Perceived Health	511	1	5	4.27	0.640	−0.400	−0.254
How well do you rate your health?	511	0	100	56.53	25.61	−0.426	−0.833
Access Scores (Mean)	511	0	100	71.56	37.65	−1.016	−0.564
Bus Stops	511	0	100	53.61	41.51	−0.144	−1.658
Primary School	511	0	100	42.61	43.06	0.271	−1.692
Middle School	511	0	100	62.54	41.66	−0.508	−1.472
High School	511	0	100	29.04	39.78	0.898	−0.930
Leisure	511	0	100	68.91	40.75	−0.836	−1.044
Shops	511	0	100	46.69	43.53	0.128	−1.758
Banks ATM	511	0	100	63.42	42.70	−0.577	−1.453
Worship	511	0	100	65.64	41.17	−0.677	−1.269
Health	511	0	100	61.07	43.81	−0.469	−1.608
Restaurants	511	0	100	56.78	44.19	−0.284	−1.727
Education	511	0	100				

**Table 3.** Inter-item correlations and Cronbach's Alpha values.

	1	2	3	Cronbach's Alpha
Satisfaction with Life Scale (SWLS)				0.902
1. In most ways my life is close to my ideal.	1.000	0.854	0.715	
2. So far, I have achieved important things in my life.	0.854	1.000	0.699	
3. If I could live my life over, I would change almost nothing.	0.715	0.699	1.000	
Perceived Accessibility Scale (PAC)				0.871
1. I have easy access to daily activities.	1.000	0.621	0.777	
2. I will not change anything regarding my mode of transport.	0.621	1.000	0.679	
3. Access to my preferred activities is satisfying.	0.777	0.679	1.000	
Perceived Health				0.532
1. How well do you rate your health?	1	0.364		
2. Satisfaction with Life Scale	0.363	1		

Perceived accessibility was measured using the Perceived Accessibility Scale (PAC), developed by Lättman et al. [76]. Respondents were asked to rate the following three statements on a 5-point Likert scale: "I have easy access to daily activities," "I would not change anything regarding my mode of transport," and "Access to my preferred activities is satisfying." The scale's reliability was appropriate, with inter-item correlations significant at the 0.01 level and a Cronbach's Alpha of 0.871 (see Table 3).

Perceived health was assessed through a single question in the survey, asking respondents to rate their health on a 5-point Likert scale, ranging from "extremely poor" (1) to "extremely well" (5). As a single-item scale, its convergent validity was checked by correlating it with the Satisfaction with Life Scale. Pearson correlation showed a strong positive relationship between perceived health and life satisfaction, with significance at the 0.01 level.

The means of the access scores, calculated through network analysis, are provided in Table 2. Prior to conducting the regression analyses in SPSS v25, correlations were drawn

between the means of life satisfaction, perceived accessibility, and perceived health. Only variables and access scores that were significantly correlated were included in the final regression models (similar to Kent et al. [23]).

### 3. Results

#### 3.1. Network Analysis

Travel time matrix is calculated using the minimum cost function included in the r5r package. Figure 4 shows the walking times to each type of facility. Facilities like shops, food/drinks, banks/ATMs, and health are found to be concentrated in the central area of the city, while primary, middle, and high schools are more or less evenly distributed. In terms of access to bus stops, the city provides a high level of access in the central area, while the outskirts of the city suffer from low levels of access. Lahore lacks opportunities for leisure activities. Places of worship are sparsely distributed. On average, it is seen that Lahore hardly provides 15 min access to all types of facilities in some central areas. Figure 4 shows that the city center and some parts in the middle have 15 min access to all facilities.

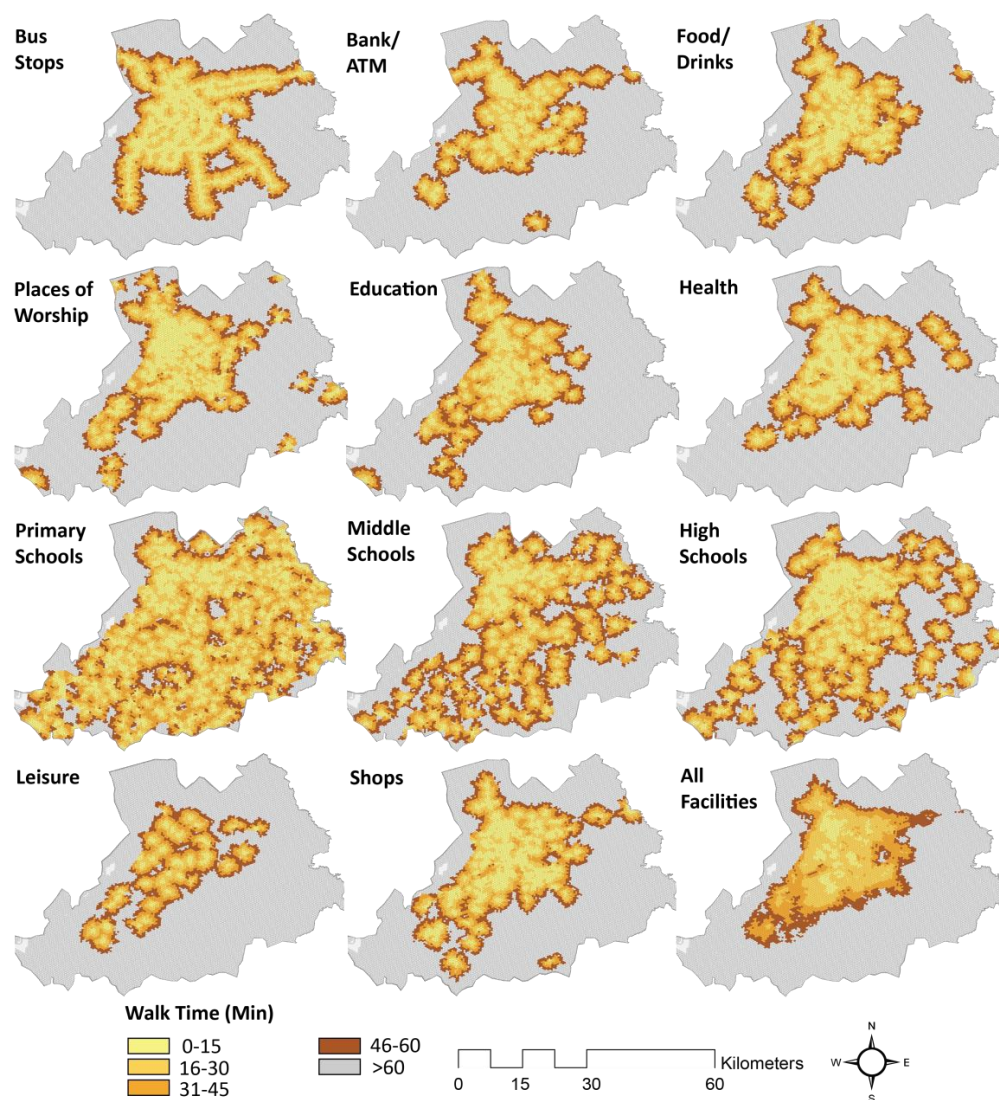


Figure 4. Walk time to facilities (NEXT Minutes).

In accordance with the NEXT proximity index, access scores were given; a score of 0 was given to all the hexagons within which a person would need more than 30 min to reach a facility, and a score of 100 was given if the walk time falls within the 15 min

threshold. If the walk time was between 15 and 30 min, a proportionate score was given from 99 to 1, respectively. Later, the population of each hexagon was summarized for walk times under the 15 min threshold, between 15 and 30 min, and for more than 30 min. Figure 5 shows that for all types of facilities, only about 30% of the population can achieve access within 15 min. For leisure activities, only about 5 percent of the whole population can achieve access within 15 min. However, the results show that the situation is not too precarious, since around 90% of the whole population can reach all types of facilities within 15 to 30 min.

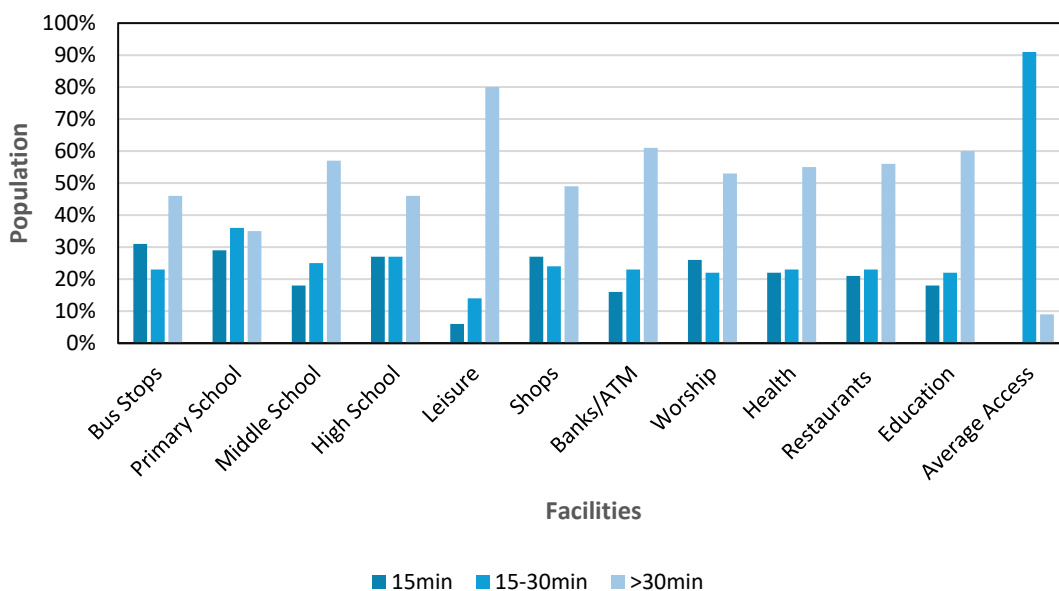


Figure 5. Population served under 15 min, 15–30 min, and >30 min access.

The visualization of the access score (Figure 6) illustrates that the gray area represents regions where people cannot access a particular facility within 30 min, while darker colors indicate better access to the facilities. However, the NEXT access scores do not consider that there could be a smaller population or no population at a given hexagon. Therefore, the NEXT discomfort index is a way to identify areas in the city that are in dire need of a facility by providing a discomfort level for the population. But the discomfort level  $\{discomfort = (100 - access\ score) \times population\}$  tells us that the higher the value of discomfort, the higher the priority for developing infrastructure. One critique of discomfort index could be that when the access score is 100, the symbology for the hexagon becomes similar to that of a hexagon with zero population. Therefore, in the center of the city, where a few hexagons have a discomfort score of zero (see Figure 7), it really means that the population living there has 15 min access to all facilities. Figure 7 shows the discomfort scores in relation to all facilities.

The discomfort index shows that in the suburban areas where newly developed housing schemes are located, people do not have 15 min access to basic facilities. Most of the new housing scheme developments are car dependent or dependent on private modes of transport because services are planned in zones and sectors. This is unlike the situation in older neighborhoods, where services are located based on demand and supply, and we observe rather mixed land use as opposed to planned housing schemes. Therefore, there is a need to revisit the existing planning approach.

### 3.2. Regression Analyses

In the area of life satisfaction research, there has been ongoing debate among researchers regarding whether a single-item numerically scaled measure can be treated as a

continuous variable to allow for the use of OLS regression, or whether it must be treated as an ordinal variable, requiring the use of ordered probit or logit regression [77]. However, Ferrer-i-Carbonell and Frijters conclude that regardless of whether a single-item life satisfaction measure is treated as being continuous or ordinal, the OLS and ordered logit or probit models yield little difference in results [78]. Therefore, for the ease of interpretation, this study takes the mean of the three items used to measure life satisfaction and treats it as a continuous variable to employ a multiple regression model, e.g., [23,77]. To check for robustness, life satisfaction was also rescaled into a binary variable, and binary logistic regression was employed. This rescaling was motivated by the sample size, which does not permit the use of ordered logit regression.

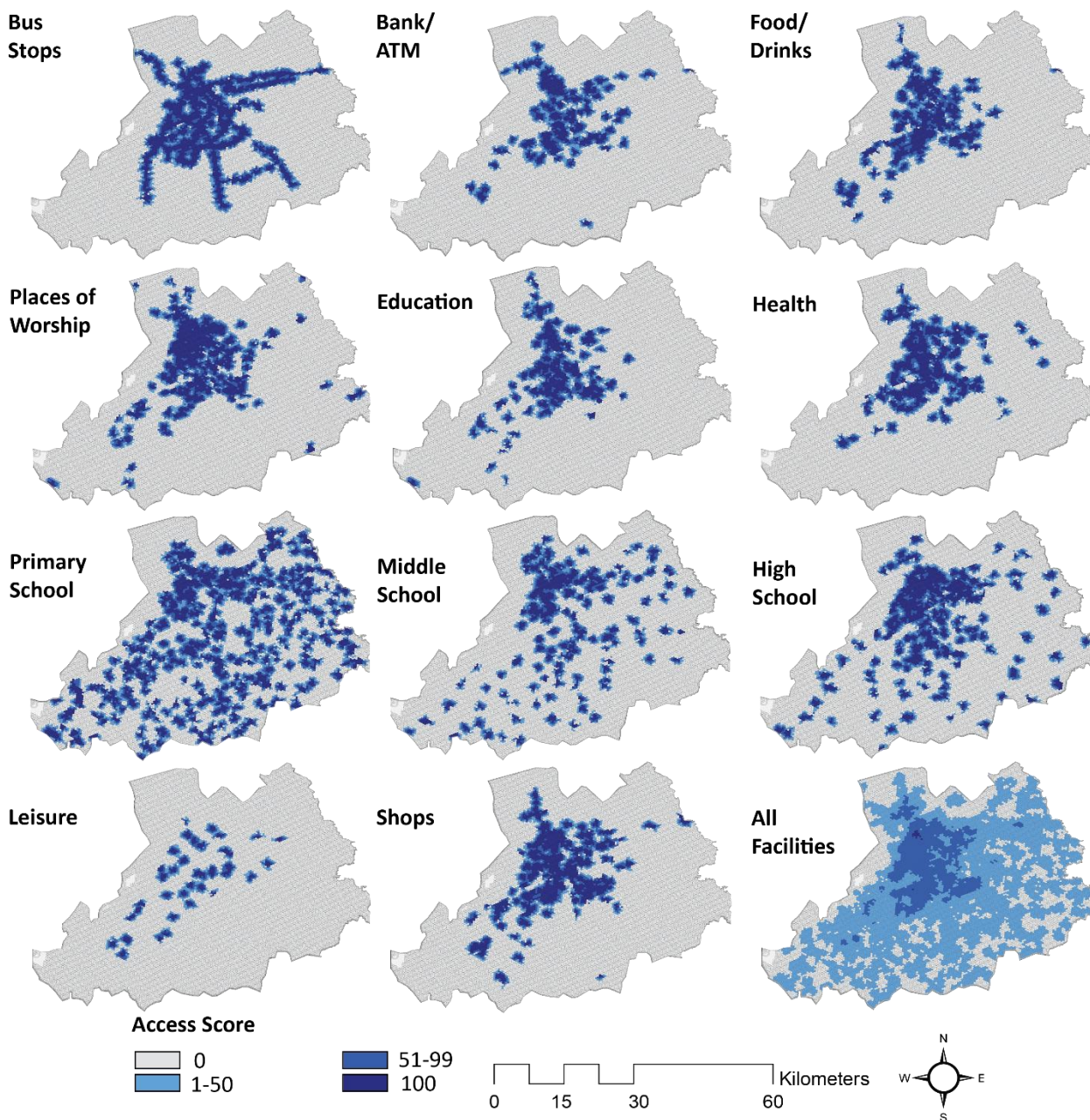
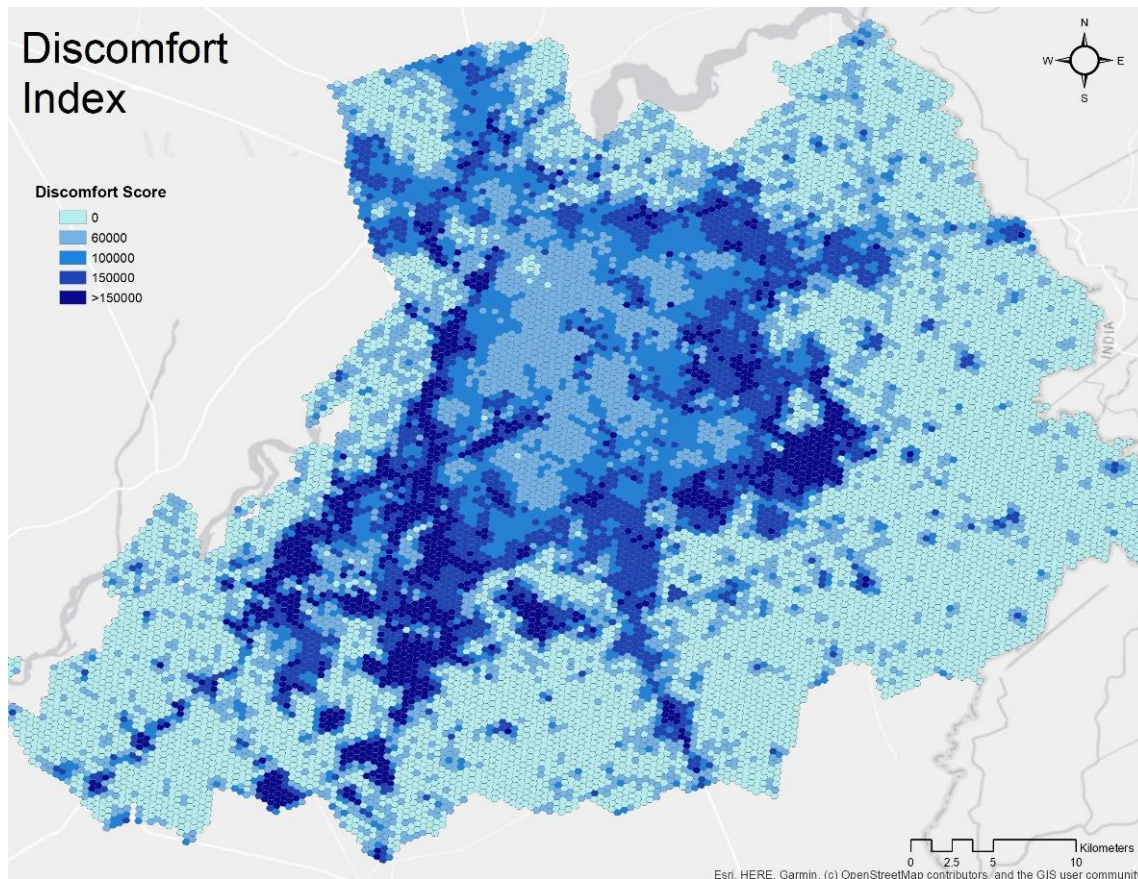


Figure 6. Estimation of NEXT access scores for facilities.



**Figure 7.** Discomfort index.

The results of the main linear regression model for life satisfaction are presented in Table 4 as **Model 1**. In terms of goodness of fit, the R-squared value indicates that the model explains 18% of the variance in the data, and the model is statistically significant ( $F = 10.9$ ,  $p = 0.000$ ). The R-squared value of the model is comparable to similar, though not identical, models; Morris produced an R-squared of 0.081 [77], Kent et al. reported a value of 0.05 [23], Brown et al. achieved a value of 0.12 [79], and Frey and Stutzer found a score of 0.91 [80], among others. **Model 2** uses perceived health as the dependent variable, with an R-squared value of 0.09. The model was statistically significant ( $F = 5.17$ ,  $p = 0.000$ ). **Model 3** presents the results for perceived accessibility as the dependent variable, with an R-squared value of 0.104, and the model was statistically significant ( $F = 6.11$ ,  $p = 0.000$ ). Finally, **Model 4** reports the results of binary logistic regression with life satisfaction as the dependent variable. The overall significance level of the model is 0.005, and pseudo-R-squared estimates explain between 16% and 22% of the variation in the data.

Cross-relationships between the main variables—perceived health, perceived accessibility, and life satisfaction—are also assessed through regression models. Individuals who perceive their health to be good are more likely to report higher life satisfaction, with a highly significant relationship observed in both Models 1 and 4. In Model 4, being in good health is associated with a 2.6 times higher likelihood of reporting greater life satisfaction. Perceived accessibility is also a significant predictor of both life satisfaction and perceived health. Individuals who perceive better access to facilities tend to have higher perceived health and life satisfaction. Similarly, in Model 4, individuals with higher perceived accessibility are 1.6 times more likely to report higher life satisfaction.

**Table 4.** Regression models for life satisfaction, perceived health, and perceived accessibility.

Method Model	Multiple Regression			Binary Logistics	
	1	2	3	4	
Dependent variable	Life Satisfaction	Perceived Health	Perceived Accessibility	Life Satisfaction	
	B (p-value)	B (p-value)	B (p-value)	B (Wald)	Exp(B) (p-value)
Constant	0.878 (0.177)	3.160 (0.000)	2.339 (0.000)	−4.152 (9.774)	0.016 (0.002)
Perceived health	0.324 (0.000)		0.249 (0.000)	0.959 (28.216)	2.609 (0.000)
Perceived accessibility	0.158 (0.000)	0.253 (0.000)		0.475 (17.462)	1.608 (0.000)
Socio-demographic Variables					
Age	−0.096 (0.030)	−0.110 (0.018)	−0.056 (0.000)	−0.079 (3.203)	0.924 (0.063)
Gender	0.091 (0.038)	0.030 (0.522)	−0.160 (0.000)	0.321 (1.887)	1.379 (0.070)
Household Income	0.078 (0.061)	0.052 (0.024)	0.020 (0.647)	0.005 (4.509)	1.005 (0.034)
Access Scores					
Bus Stops	0.023 (0.063)	0.027 (0.589)	0.070 (0.016)	0.002 (0.361)	1.002 (0.054)
Primary School	0.004 (0.932)	0.006 (0.900)	−0.040 (0.435)	0.002 (0.477)	1.002 (0.490)
Middle School	0.093 (0.073)	−0.085 (0.121)	0.029 (0.593)	0.005 (2.365)	1.005 (0.124)
High School	−0.129 (0.016)	−0.081 (0.150)	0.073 (0.191)	−0.008 (4.606)	0.992 (0.032)
Health	0.106 (0.036)	0.043 (0.042)	0.005 (0.923)	0.009 (4.750)	1.009 (0.029)
Model Summary					
R <sup>2</sup>	0.189	0.090	0.104		
Adj. R <sup>2</sup>	0.172	0.072	0.087		
F	10.996	5.177	6.119		
−2 Log likelihood					535.111
Cox and Snell R Square					0.162
Nagelkerke R Square					0.224
Chi-square					21.744 (0.005)

Age is consistently significant in predicting life satisfaction, perceived health, and perceived accessibility. Younger individuals tend to report higher life satisfaction than older individuals. However, age shows weak significance in the binary logistic model. Being an older adult decreases the odds of life satisfaction by a factor of  $\text{Exp}(B) = 0.9$ . Younger individuals are more likely to perceive themselves as healthier, with an odds ratio of 0.11. Aging is associated with a decrease in perceived accessibility to facilities by a factor of 0.056. In comparison to men, being a woman is linked to higher life satisfaction in Model 1, while a weaker significance is observed in Model 4, where being a woman increases the likelihood of reporting higher life satisfaction by a factor of 1.38. Gender does not have a significant effect on perceived health. However, women perceive their accessibility to facilities as lower than men, with a significant effect of 0.16 in Model 3. Higher household income is associated with an increase in life satisfaction by a factor of 1.005, with a significant relationship shown in Model 4. Household income also shows a positive but weaker significance in Model 1. A higher household income is also linked to higher perceived health, although this relationship with perceived accessibility is insignificant.

Access to bus stops is significantly related to both life satisfaction and perceived accessibility. Living closer to bus stops increases life satisfaction by a factor of 1.002, according to the binary logistic model. Similarly, individuals who live closer to bus stops are likely to report a 0.07 times higher perceived accessibility to facilities. Access to primary and middle schools is found to be insignificant in predicting life satisfaction, perceived health, and perceived accessibility. Access to high schools, however, is significantly associated with life satisfaction in a negative direction. Greater access to high schools is associated with 0.99 times lower life satisfaction (see Model 4). Access to health facilities significantly affects both life satisfaction and perceived health in a positive manner. Living closer to health

facilities increases life satisfaction by a factor of 1.009 in Model 4. Additionally, perceived health shows an effect size of 0.043 with closer access to health facilities. However, these results should be interpreted with caution due to potential sample bias and the influence of multiple unobserved factors. For instance, both life satisfaction and perceived health may also be shaped by other contextual aspects, such as the overall quality or esthetic characteristics of the neighborhood, which may themselves be linked to the availability of well-planned services.

#### 4. Discussions

This study has assessed the effects of objective proximity to basic services on perceived health, perceived accessibility, and life satisfaction. A combination of two analytical approaches is employed as follows: (i) geospatial network analysis, which calculates travel times to the nearest facilities, and (ii) statistical analysis of survey responses.

Geospatial analysis reveals that Lahore exhibits a distribution pattern similar to that of European cities in terms of service allocation. Specifically, essential services such as shops, food and beverage outlets, banks/ATMs, and healthcare facilities are concentrated in the city center [46,48,51,81,82]. Central areas benefit from mixed land use and better access to services due to the competitive nature of land allocation, as businesses seek locations closer to the city center to maximize profitability [83].

Additionally, Lahore's urban form follows a multi-nuclei model, where certain areas exhibit accessibility levels comparable to those of the city center. These areas, identified in Figure 4, demonstrate that all essential services are within a 15 min walking distance. For each type of service, approximately 30% of the population can access them within this time frame, while the remaining 70% is split between 15 and 30 min and over 30 min of travel time (Figure 5). Mapping of the access scores and the discomfort index highlights the areas in which access to facilities is most lacking. The discomfort index (Figure 7) identifies suburban areas as the most affected, suggesting that newly developed housing schemes are predominantly car-oriented and struggle to provide essential services that are within walking distance. This aligns with the observation that suburban developments cater predominantly to the high-income class, who are more likely to rely on private vehicles for daily travel [77,84,85]. These newly developed schemes likely place additional pressure on the road infrastructure, as Lahore experiences severe traffic congestion during peak hours along the routes leading to these residential developments. Compounding the issue, the city planning authority has responded by constructing signal-free underpasses instead of traditional four-legged junctions, prioritizing uninterrupted traffic flow [86].

Subsequently, access scores, along with socio-demographic control variables, were incorporated into a regression analysis to assess their impact on perceived health, perceived accessibility, and life satisfaction. The findings indicate that both perceived health and perceived accessibility positively influence life satisfaction, which is consistent with the results of [19,25,87,88]. As observed in the literature, younger individuals tend to report better perceived health, greater accessibility, and higher life satisfaction. Brown et al., in a cross-sectional study of OECD metropolitan areas [79], found that age exhibits a U-shaped relationship with life satisfaction, aligning with the results of [89]. According to their findings, life satisfaction tends to reach its lowest point around the age of 45. However, caution is warranted when interpreting the results for age, as the maximum age in this study is 45 years, whereas Mattson et al. reported the highest life satisfaction among individuals aged 75–85 in the United States [25].

Women generally report higher life satisfaction levels, which may be attributed to Pakistan's socio-cultural context. For instance, women are not necessarily expected to work; rather, it is a choice, as financial responsibility traditionally falls on male family

members. Before marriage, women typically reside with their parents, and after marriage, they often live with their husbands, reducing financial pressures. However, perceived accessibility is lower among women, primarily because they rely on male household members for transportation, often in the form of pick-up and drop-off services. When traveling independently, they face significant challenges with public transport, which is often unreliable and inadequate in terms of service delivery. For instance, women carrying goods or pushing a stroller may find it extremely difficult to board a bus at a station. Similarly, urban street design lacks pedestrian-friendly elements, making walking difficult, especially for those who are mobility-impaired, carrying luggage, or pushing a stroller. In addition, safety concerns are prevalent for women using both public and private modes of transport, further limiting their mobility. Meanwhile, household income is positively associated with life satisfaction, aligning with the results of previous studies [17,77,87].

Consistent with previous research, proximity to bus stops is found to positively influence perceived accessibility and life satisfaction. For instance, Yin et al. demonstrated that in Xi'an, China, living near a subway station enhances perceived accessibility, which in turn improves life satisfaction [18]. Similarly, Cervero et al. found that in Alameda County, California, closer proximity to bus and rail stops increases job accessibility [84], and being employed is associated with higher life satisfaction [25]. In the context of Lahore, access to public transportation holds particular significance, as many daily activities occur around bus and metro stations. These areas often house cellphone top-up stalls, street vendors, banks/ATMs, grocery shops, and mobile selling carts, fostering social interaction and economic activity. Additionally, these active public spaces enhance perceived security, further contributing to life satisfaction. This aligns with Cao [17], who found that neighborhood satisfaction is a strong predictor of life satisfaction, while nuisance, crime rates, and feelings of insecurity negatively impact life satisfaction. Interestingly, access to high schools is negatively associated with life satisfaction, whereas access to primary and middle schools shows an insignificant positive relationship with life satisfaction. This discrepancy may be due to spatial distribution patterns. Primary and middle schools are widely dispersed and often located within close walking distances, whereas there are fewer high schools, which means longer commutes are required for most people. This results in traffic congestion during pick-up and drop-off times, exacerbated by the unregulated parking practices of private school vans and cars. Additionally, the use of loudspeakers by school doormen to call students for pick-ups and the general noise generated by high school students may contribute to lower neighborhood satisfaction [17]. On the other hand, better access to healthcare facilities is positively correlated with both life satisfaction and perceived health, as reported by Mattson et al., who found that ease of access to quality healthcare improves overall livability [25]. However, similar to previous studies [16,90], this study found that proximity-based variables such as access to banks/ATMs, food outlets, religious places, leisure facilities, and retail shops do not significantly impact life satisfaction.

## 5. Conclusions

In the case of Lahore, Pakistan, a large metropolitan city in a developing Asian country, this study finds no strong evidence to support the argument that living in a 15 min city significantly enhances life satisfaction, at least for those citizens who have the ability to make choices regarding their daily mobility. This may be attributed to individual preferences and the availability of alternative options. For instance, service capacity, product quality, and costs vary across locations, influencing decision-making. Healthcare facilities differ in terms of bed capacity, and parents may choose to enroll their children in a prestigious school rather than the nearest available option [13].

However, this study focuses solely on the direct relationship between 15 min facility access and life satisfaction, while neglecting any potential indirect effects. For instance, proximity to services encourages active modes of transportation, and previous studies have demonstrated that active travel positively influences both health and life satisfaction [21,22,25,29–33]. Nevertheless, the findings of this study should not be misinterpreted as a critique of the 15 min city concept, which aims to enhance not only subjective well-being but also objective measures of urban sustainability. Equitable spatial distribution and allocation of essential services is a crucial step toward reducing inequalities and improving accessibility. Transportation policies are also mainly concerned about lowering travel costs to ensure efficient and equitable access to services within an urban system [91].

### 5.1. Policy Implications

The findings from the geospatial network analysis highlight that peripheral and newer developments provide lower levels of walkable access to basic facilities. As a result, residents must rely on private transport even for essential tasks like grocery shopping, at a time when Lahore is already grappling with severe air pollution, a lack of open and green spaces, rising temperatures, and extreme traffic congestion. This underscores the urgent need for efficient service allocation in new developments through integrated planning policies with multidimensional objectives. The discomfort index highlights areas where planning authorities must urgently address the lack of basic facilities. The “15-min city” slogan could be instrumental in encouraging developers, contractors, and policymakers to promote active and sustainable transportation modes. However, restricting private vehicles must be accompanied by significant improvements in the public transport network [92]. Network analysis has identified areas with similar accessibility levels—where 15 min access is feasible. These areas should be better connected through integrated public transport options such as Metro lines and BRT, especially given that proximity to public transport stations has been linked to higher life satisfaction. Future developments must prioritize social inclusion, ensuring that all groups—including women and individuals with disabilities—have a safe, comfortable, and accessible walking and public transport experience. Existing infrastructure should be upgraded to accommodate the needs of marginalized communities. Neighborhood nuisance levels can be reduced through policy instruments aligned with 15 min city principles [93], such as discouraging private car use through congestion charges, carbon pricing, low-emission zones (LEZs), car-free streets, and parking regulations [92]. Additionally, the strategic allocation of healthcare facilities should be a priority, as studies indicate that proximity to these services contributes to higher life satisfaction.

These policy directions are not unique to Lahore but reflect the broader urban challenges faced by many rapidly developing South Asian cities, including Dhaka, Karachi, and Delhi. Similarly to Lahore, these metropolitan regions have experienced rapid and often uncoordinated urban expansion, where housing growth has outpaced the provision of basic services and public infrastructure. For example, Dhaka’s Transport Master Plan continues to emphasize large-scale road construction and motorized transit projects, frequently at the expense of walkability and last-mile connectivity. Karachi faces comparable difficulties, where fragmented governance structures and insufficient investment in pedestrian infrastructure have deepened spatial inequalities in accessibility. In Delhi, despite progressive initiatives such as the Master Plan 2041 promoting compact development, the practical implementation of mixed-use zoning and non-motorized transport infrastructure remains limited.

Positioning Lahore within this regional trajectory highlights that the barriers to realizing the 15 min city model are structural and systemic, embedded in policy priorities that

have historically favored car-oriented growth, centralized service delivery, and unequal spatial development. Comparative evidence from these cities indicates that advancing toward a more accessible and inclusive urban form in South Asia requires institutional reform and greater coordination among land use, housing, and transport authorities. Moreover, the adaptation of the 15 min city concept in this context should focus on incremental, context-sensitive strategies rather than the direct replication of Western models. This includes promoting mixed-use zoning in peripheral neighborhoods, developing localized service hubs, and incentivizing non-motorized and public transport options through affordable and low-carbon policy measures.

In this way, Lahore and other South Asian cities can move toward a more balanced urban mobility framework in which accessibility, environmental sustainability, and social inclusion are treated as interconnected objectives rather than competing priorities. Integrating the principles of the 15 min city into national urban and transport policies has the potential to enhance everyday livability while strengthening urban resilience to environmental and socio-economic challenges.

### 5.2. Limitations

This research advances the discussion on accessibility in the context of developing cities. It highlights the potential limitations of relying on open data sources such as OpenStreetMap (OSM) for accessibility calculations. For instance, when comparing access to educational facilities using OSM data versus official government data, the findings revealed that official data indicated that 50% more of the population was served, compared to the OSM estimates. Moreover, the statistical approach did not explicitly account for spatial dependence or heterogeneity, which are inherent in urban data. Ignoring spatial autocorrelation may lead to biased parameter estimates and overstated significance levels. Future research should employ spatially explicit analytical methods—such as Spatial Lag Models (SARs), Spatial Error Models (SEMs), or Geographically Weighted Regression (GWR)—to capture local variations and spatial effects in the relationship between accessibility and life satisfaction. Incorporating neighborhood-level variables such as topography, population density, road network connectivity, and public transport frequency would further enhance the robustness of spatial analyses and provide a deeper understanding of the contextual influences on perceived accessibility and quality of life.

The study's survey respondents were university students, meaning the results may not be representative of the broader population. While these findings should be interpreted with caution, analyzing a social group with actual decision-making power can be a strategic tactic. Sociologists have shown that when lower-income groups gain the ability to choose, they often emulate the preferences of higher-income groups [94,95].

Future studies with more representative samples could yield more reliable estimates. Additionally, in life satisfaction research, the contextual theory of happiness holds true, i.e., a generally happy person is more likely to report higher life satisfaction. Since transportation and land use conditions vary across different locations, the findings of this study cannot be universally generalized.

Moreover, future research should incorporate a more detailed examination of individual thematic layers of the urban environment, such as transportation networks, land use, socio-economic characteristics, and environmental factors. Such an approach would help avoid overly broad generalizations and provide a deeper understanding of local specificities.

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## Appendix A

**Table A1.** Questionnaire.

General Information	
Questionnaire code:	
Date:	Interviewer
Nationality:	University
City:	House Location
Personal/Household Information:	
1. Age?	_____
2. Gender:	Male <input type="checkbox"/> Female <input type="checkbox"/>
3. Marital Status:	Single <input type="checkbox"/> Married <input type="checkbox"/> Divorced <input type="checkbox"/>
4. Education:	None <input type="checkbox"/> Undergraduate/Matric <input type="checkbox"/> Bachelor <input type="checkbox"/> Masters or Higher <input type="checkbox"/>
5. Occupation:	Employed <input type="checkbox"/> Unemployed <input type="checkbox"/> Self-Employed <input type="checkbox"/> Student <input type="checkbox"/> Retired <input type="checkbox"/>
6. Average monthly household income (Gross):	..... PKR
Self-Reported Health	
7. In general, would you say your health is?	
Excellent	Very Good
Fair	Poor
	Terrible
Satisfaction with Life	
How much do you agree with following statements: Strongly disagree (1), somewhat disagree (2), neutral (3), somewhat agree (4), strongly agree (5)	
8. In most ways my life is close to my ideal.	
9. So far, I have gotten the important things I want in life.	
10. If I could live my life over, I would change almost nothing.	
Perceived Accessibility Scale	
How much do you agree with following statements: Strongly disagree (1), somewhat disagree (2), neutral (3), somewhat agree (4), strongly agree (5)	
11. I have easy access to daily activities.	
12. I will not change anything regarding my mode of transport.	
13. Access to my preferred activities is satisfying.	

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