Measuring the Impact of Travel Behavior in an Urban Form on Location Affordability in Rawalpindi-Islamabad, Pakistan

Abu-Baker Rafat KHAN*[1], Tomohiko YOSHIDA*[2]

Abstract:

Housing and transportation studies have continuously supported the theory of location affordability (LA). Residents living in proximity to transit and other facilities spent less income share on transportation costs, offsetting higher housing costs. However, the broader thesis argues that urban form measures and travel patterns could also determine LA, demanding empirical exploration in the Southern hemisphere. This study in the Rawalpindi-Islamabad Metropolitan Area (RIMA) addresses the impact of travel patterns to service facilities on the combined housing and transportation (H+T) costs using 435 valid samples acquired by a door-to-door questionnaire survey. The approach included; 1) Three-box plot analyses for housing costs, transportation costs, and the H+T costs, 2) Cross-tabulation and Chi-square test of travel patterns, and 3) Multivariate regression analysis. The multivariate regression demonstrated that the household characteristics significantly impacted H+T costs, and when moving away from the city-core, the average H+T cost increased substantially. Additionally, frequent public transportation (PT) usage and walking to the utility stores were positively associated with H+T costs compared to the travel time to reach PT and education facilities. The findings suggest that policymakers consider affordable locations with high proximity to service facilities when establishing affordable housing schemes.

Keywords: *housing and transportation, location affordability, travel patterns, urban form*

1. Introduction

Urbanization has been a growing phenomenon in developing nations for more than two decades. As a result, economic and spatial development has been restructured away from the city center, causing urban sprawl. This sprawl has led to high vehicle ownership in the transportation sector, and car usage is growing, whereas there is a decrease in bus rapid transit (BRT) access. After housing

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*[1] Doctoral Student, Graduate School of Policy Sciences, Ritsumeikan University

*[2] Professor, College of Policy Sciences, Ritsumeikan University

E-mail:*[1] ps0205hv@ed.ritsumei.ac.jp

*[2] tyoshida@sps.ritsumei.ac.jp

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costs, transportation cost is considered the most significant expenditure from a household income. Therefore, locating housing units in areas associated with low transportation costs could substantially help residents save their household income. Policymakers should consider this factor when considering a policy for subsidized housing units for low-income households.

The emerging concept of location affordability (LA) was developed in the US to determine affordable locations across neighborhoods. Some have even insisted on incorporating the LA Index (LAI) into decision-making criteria when establishing public housing for low-income households. The LAI, which consists of combined housing and transportation (H+T) costs, was improved after methodological flaws were fixed, and it received official approval for implication purposes (Haas et al., 2016). Though this model is well-practiced in the northern part of the globe, no attention has been given to it in South Asian countries.

Since transportation cost is highly associated with household income and residence location, it significantly affects low-income groups. Households usually make trade-offs by either prioritizing affordable housing in a less accessible area with high transportation costs or an expensive house in a city center with lower transportation costs (Fenton et al., 2013). This substantial share of the H+T costs, socio-demographic and economic indicators, housing size and ownership, and access to service facilities construct the overall LA.

Large cities in Pakistan have reported rapid population growth resulting in extreme suburbanization (Khalil and Nadeem, 2019) and high vehicle ownership. This suburbanization in the Rawalpindi-Islamabad Metropolitan Area (RIMA) has led to an acute shortage of affordable housing for disadvantaged groups in the center of the city. Though Pakistan's housing policy in 2001 dictated several land development features to meet housing demand (Salman et al., 2018), transportation and urban form indicators that can impact affordability were absent in such policies. With this policy gap, public and private developers have been struggling to meet the affordable housing demand with proximity to service facilities, especially transit. Further, the high correlation of vehicle ownership with its usage validated the development of suburban private gated communities for the high-income population, leaving behind the disadvantaged groups.

This study of housing, transit, and the influence of urban form on travel behavior in the RIMA is being conducted in response to the high demand for affordable housing, continuous urban sprawl without transit access, and lack of land-use integration policies. Its objectives are twofold; 1) to determine whether the residential location of the household is affordable for them or not using LAI, and 2) to address the impact of travel patterns to service facilities on household combined H+T costs. It contributes academically by adding to the literature on the relationship between housing, transit, and urban form by incorporating travel patterns indicators to service facilities. These results can help establish an innovative objective to promote residential-based transit-oriented development (TOD), thus expanding the existing knowledge regarding LA measures and housing choice.

The remaining paper is organized as follows: Section Two explains the previous studies' concept of LA and empirical evidence. Section Three describes the impact of urban form on LA. The methodology is discussed in Section Four. Section Five unfolds the results of the analyses, with Section Six discussing the results. Lastly, Section Seven concludes the paper.

2. Global Perspective on Location Affordability

The Center for Neighborhood Technology first introduced LA to improve the Housing and

Transportation Affordability Index criteria. This criterion was later used to develop LAI for policymakers to strategically determine affordable sites for mixed-income groups. The benchmark of 45% of the overall LA comprises 30% housing expenses plus 15% transportation expenses (HUD, 2017; 2019). This H+T index was not only utilized in developed cities such as Washington DC (CNT, 2010), Paris (Coulombel, 2018), and London (Cao and Hickman, 2017), but also in developing cities such as Qom city, Iran (Isalou et al., 2014), Mexico (Guerra and Kirschen, 2016) and Indonesia (Dewita et al., 2019). In these studies, the evidence showed that an area was affordable (less than 30%) for the households living in the city periphery when measuring only housing costs. Still, when combined with transportation costs, the expense rose to more than 45%, making it less affordable for households in the same region. One study in Paris also concluded that low-income groups preferred living in the city suburbs when considering only the housing expenditure (Coulombel, 2018). At the same time, integrating transportation costs into the calculation showed that moving near a city-core eases H+T costs (Coulombel, 2018). Furthermore, Dewita et al. (2019) incorporated urban form variables such as the distance to the city center and residential density to determine the affordability of a location by assessing the combined H+T costs. Their boxplot analysis indicated that housing costs among formal/private housing units are much higher than informal/public housing. The data envelopment analysis (DEA) concluded that government housing units and informal settlements were much more affordable than formal housing units (Dewita et al., 2019).

Even though the LAI has received criticism (Guerra and Kirschen, 2016), this concept is still growing. The LAI has been examined in various studies on housing choice vouchers (Tremoulet et al., 2016), TOD-induced transportation expenditure (Dong, 2019; Renne et al., 2016), neighborhood affordability and resilience of the housing market (Wang and Immergluck, 2019), foreclosure housing crisis in the US (Hartell, 2016) and neighborhood opportunity and LA (Acevedo-Gracia et al., 2016). Wang and Immergluck (2019) explored the relationship between LA and US national housing foreclosure recovery by examining 300 metro areas. They concluded that high LA caused foreclosure decline in highly dense central cities compared to suburban areas. They suggested establishing affordable housing schemes near transit and determining more affordable locations near high-density urban markets. The housing choice voucher study highlighted that low-income participants could live in locations with affordable neighborhoods. However, the H+T cost analysis was somewhat inadequate, which could have been due to low transportation costs (Tremoulet et al., 2016).

Similarly, the H+T Affordability Index has also been proven instrumental when calculating housing affordability in different regions. The study in Iran used this index to validate LA measures among central and suburban districts (Isalou et al., 2014). Their descriptive analyses suggest that housing costs were much higher for central district residents with proximity to several facilities. In contrast, the transportation costs and the combined H+T costs were much higher for the subdistrict residents with high access deprivation. Overall, recent studies have proven the significance of transportation costs and access to transit and other facilities when measuring housing affordability. This access to services in various geographical locations refers to location efficiency (Henry and Goldstein, 2010). Residents usually prefer making trade-offs between H+T costs when considering family income and access to facilities (Khamr, 2011).

3. Urban Form, Travel Patterns, and Location Affordability

(1) Urban Form and Location Affordability

The majority of the studies that have examined the interrelationship between transportation systems and land development, and the impact of transportation expenditures on LA among households at different spatial scales, have mainly focused on hundreds of United States (US) metropolitan areas. Only two known studies one on Qom Iran (Isalou et al., 2014) and the other on Bandung, Indonesia (Dewita et al., 2019), focused on the said interrelationship in developing cities. This study in RIMA, Pakistan, also contributes insight into the developing region to analyze H+T costs, household dynamics, and travel patterns with family income across neighborhood differences comprehensively.

As stated earlier, H+T costs make up the most dominant expense from the household income. These costs are highly influenced by household characteristics, housing location, proximity to transit services, and access to jobs, education, and other facilities that determine the travel mode choice. Smart and Klein (2018) argue that household characteristics stand out as dominant factors that significantly impact transportation costs in the LAI model compared to other urban form indicators, including a compact city center and mid-urban and suburban regions. They determine that transit and other urban attributes can significantly affect transportation costs when controlling for household characteristics. Similarly, other studies have also shown consistent empirical results that, though urban form attributes are essential to the calculation, they are secondarily crucial to individual and household characteristics (Ewing and Cervero, 2001; 2010; Stevens, 2017).

The LA studies determined that multiple accessibility measures, synergized with urban form indicators, are essential to measuring transportation costs. Smart and Klein (2018) attempted to criticize the practice of measuring LA using complex accessibility measures as independent variables to determine the dependent variable of transportation expenditure, which is "imperfectly predicted". Even though they used a simplified accessibility measure using data from the Panel Study on Income Dynamics (PSID), only a singular indicator drives the individual-based PSID data. Moreover, previous studies (Boarnet et al., 2011; Cervero and Kockelman, 1997) explicitly demonstrated that multiple accessibility indicators are necessary at various geographical scales to determine the impact of urban form on travel mode choice and travel behavior. That is why regressing only job accessibility is not enough, and analyzing access to other non-work facilities such as education, health, transportation, and other facilities is essential. Using household surveys to investigate the impact of travel patterns on public facilities and transportation expenditure, the current study in RIMA aims to fill this gap.

Recently, Makarewicz et al. (2020) attempted to improve the method adopted by Smart and Klein (2018) by doing two analyses on the same PSID data across the American states. First, they looked for the patterns in household incomes across various urban forms. Following this analysis, they conducted an Ordinary Least Squares (OLS) regression for multiple variant analysis to determine household transportation expenditure by taking urban forms, transit access, and household characteristics as independent variables. With 8,004 samples in hand, they divided the households into four blocks (urban, mid-urban, suburban, and rural), with suburbs being overrepresented in the overall sample. After conducting an OLS regression analysis, they made several essential observations. Though mean housing expenditure was higher amongst households from urban areas, the mean transportation cost was higher amongst families from suburban areas with lower incomes (Makarewicz et al., 2020).

Furthermore, the H+T cost trade-off results support the hypothesis of LA, stating that the H+T costs decrease from suburban/rural to urban areas. It shows that housing prices fluctuate with the availability of neighborhood opportunities. However, the neighborhood opportunity and housing affordability trade-off among low-income families with children is a weak relationship (Acevedo-Garcia et al., 2016). Other than income, status as a single parent and a couple without children also influence transportation costs. Deka (2015) analyzed the Consumer Expenditure Survey (CES), which showed that one-family owners of detached housing spent more on H+T costs than those living in attached housing, who spent less on transport. This furthers the research on the high housing costs burden associated with the tendency of households to make a trade-off by paying for housing and other necessary child-related commodities such as food, clothing, education, and health. Chetty et al. (2015) argued that children under 13 years of age living in low-poverty neighborhoods have better academic records, resulting in better income than their high-poverty neighborhood counterparts. This pattern is supported by substantial evidence showing capitalization on high-opportunity neighborhoods results in higher overall housing prices. However, the evidence for neighborhood trade-offs with transportation costs is limited. Few studies have paid attention to the relationship between TOD neighborhoods and transportation costs, while there have been extensive studies focusing on the travel pattern differences within and outside TOD areas. This is possible because household transportation costs cannot be easily obtained micro-spatially (Smart and Klein, 2018). That said, the LAI is the most comprehensive tool to determine relative affordability in different housing markets using the available H+T cost information.

(2) Urban Form and Travel Patterns

Other than household characteristics and urban form indicators, numerous researchers have empirically assessed and determined that built environment indicators such as walkability, proximity to transit services, educational and health units, and other recreational facilities determine travel mode choice and travel behavior. Several studies have referenced Cervero and Kockelman (1997) and adopted the three Ds, i.e., density, diversity, and design, and included a fourth D, demographics. The synthesis of fifty studies done by Ewing and Cervero (2001) clearly shows that socioeconomic indicators have a primary influence on trip frequency compared to the built environment. However, the built environment indicated a more substantial impact on trip length. Thus, the built environment remained dominant when assessing the overall and cumulative vehicle mileage traveled because the built environment affects the trip length and travel mode choice. Though most empirical methods examining the interrelationship of the built environment and travel patterns have no concrete conclusions, some concepts have been globally accepted. Two studies argued that the jobs-housing distance becomes shorter with higher population density, and the modal split to transit and walk increases (Hui and Yu, 2013; Kim and Brownstone, 2013). Similarly, mixed land use with high-opportunity neighborhoods enables residents to walk to work (Ding and Lu, 2016). Better road connectivity in an urban setting increases green travel modes (Sung et al., 2014), allowing residents to access multiple facilities during the same trip (Choi and Zhang, 2017). Though some TOD studies have stated no significant relationship between TOD neighborhoods and car ownership, it has been shown that moving to transit-rich areas significantly reduced car usage (Cao et al., 2019; Chatman et al., 2019). These studies have continuously proven that locally built environment characteristics influence household dynamics and travel patterns. This is because the density of public facilities, such as education, health, shopping, and entertainment, varies in different neighborhoods, depending on the distance away from the city center. By looking at these studies, RIMA also shows a similar case since the public facility densities are markedly increased when moving toward the city center. Mouratidis et al. (2019) argued that qualitative and quantitative studies had formalized the rationales, motivations, and drawbacks affecting the built environment's association with travel patterns, indicating a causal relationship between the two rather than only a correlation. Regardless, this emerging literature on urban form, travel patterns, and neighborhood income disparity has primarily focused on Western societies. For example, studies in US metropolitan areas showed that job accessibility and the travel mode used significantly impacted transportation expenditure (Makarewicz et al., 2020; Smart and Klein, 2018). In contrast, only a handful of empirical analyses took place in the southern hemisphere. This dearth of investigation calls for an extensive exploration of H+T costs integrated with the urban form in developing nations since the urban form's association with LAI is still a new and complicated topic.

4. Research Area, Data Collection, and Method

(1) Research Area: RIMA

Rawalpindi-Islamabad is one of the largest metropolitan areas in the Punjab province, with around four million people, growing annually at a 2% rate. RIMA has exercised various housing settlements: private and public developers establishing housing settlements mainly for middle and high-income groups to unplanned mixed-land settlements where low-income households usually construct low- and medium-rise houses.

One single-corridor formal bus rapid transit (BRT) service launched in 2015 exists in RIMA without any high-capacity feeders (Khan and Shiki, 2018). Adeel et al. (2014) stated that this BRT system provides access to only 8% of the population living within a 5-minute walking distance, indicating a complete lack of access for people living in remote areas. This lack could be why BRT fails to stimulate redevelopment around its corridor for residential purposes, triggering high vehicle ownership and decreasing resistance to gated community developments in suburban areas. Besides BRT, other low-quality public transportation and taxi-like private services exist in RIMA. This study could not provide visual information on such transportation services as there is no published government data stating the number of vehicles, service routes, and operation hours of these services. However, the cost of using such services is included in this research.

This study employed a quantitative approach to collect primary individual-based data to analyze LA and travel behavior to access service facilities across the urban form. Most of the indicators used in this study were borrowed from the Pakistan Living Standard Measurement Survey (PLSM), a district-level survey designed by the Pakistani government to measure the social living standard of the citizens. The service facilities in a built environment include four frequently used services such as utility stores, BRT, education, and health facilities. This study also included a fifth facility, drinking water plants (DWP from hereafter), which has not been used by previous travel behavior studies.

Local authorities in RIMA have established clean water plants in several neighborhoods to access water for drinking purposes for free. These plants are easily accessible in many residential areas, whereas other housing community residents either purchase gallons of water bottles at the supermarket or ask the markets to deliver the bottles to their homes every week. Therefore, this DWP differs from purchasing water bottles at grocery stores or supermarkets. The travel behavior was measured using three sub-variables: *Usage* (never, seldom, often, and frequently), *Time taken* in minutes (0-14, 15-29, 30-44, 45-60, and > 60), and *Mode choice* (walk, motorbike, car, and public transportation). Public transportation (PT) mode includes BRT, taxi-like services and other informal low-quality services. For this purpose, we chose nine sites to survey using a multi-clustered sampling approach.

The study sites were chosen based on the distance to the city center, distance to the BRT stations, housing density, and the household demographics indicated by the housing type (private housing scheme, public housing/apartment, and local self-built housing). The distances to the city center and BRT were calculated using the *distance tool* in ArcGIS 10.5.1. The density estimation was taken the same as calculated by Dewita et al. (2014), i.e., > 40 dwellings = high, 30-40 dwellings = medium, and < 40 = low. The study sites include S1-1 (Asghar Mall Scheme), S1-2 (Naya Mohalla), S1-3 (Askari 10), S2-1 (Bahria Town Phase 3), S2-2 (Ghauri Town), S2-3 (Pakistan Housing Authority apartments, or PHA G-11/4), S3-1 (PHA G-7/1), S3-2 (PHA G-7/2), and S3-3 (F-10). The list of sites and sample frequency is given in Table 1; their geographical locations are shown in Figure 1.

Sites S1-1, S1-2, and S1-3 were selected within 5 km of the city center. The first two sites were scattered and poorly developed informal settlements where people usually build their own multi-level houses on flexible plot sizes. They were highly dense, with better proximity to schools, shopping stores, offices, BRT, and main roads. Since these two sites are located within 500 meters of BRT, the residents can be considered TOD households (Dong, 2021). The third site was a formal gated housing site for ranking army personnel.

Three sites were selected within 5-10 km of the city center. Sites S2-1 and S2-2 were medium-

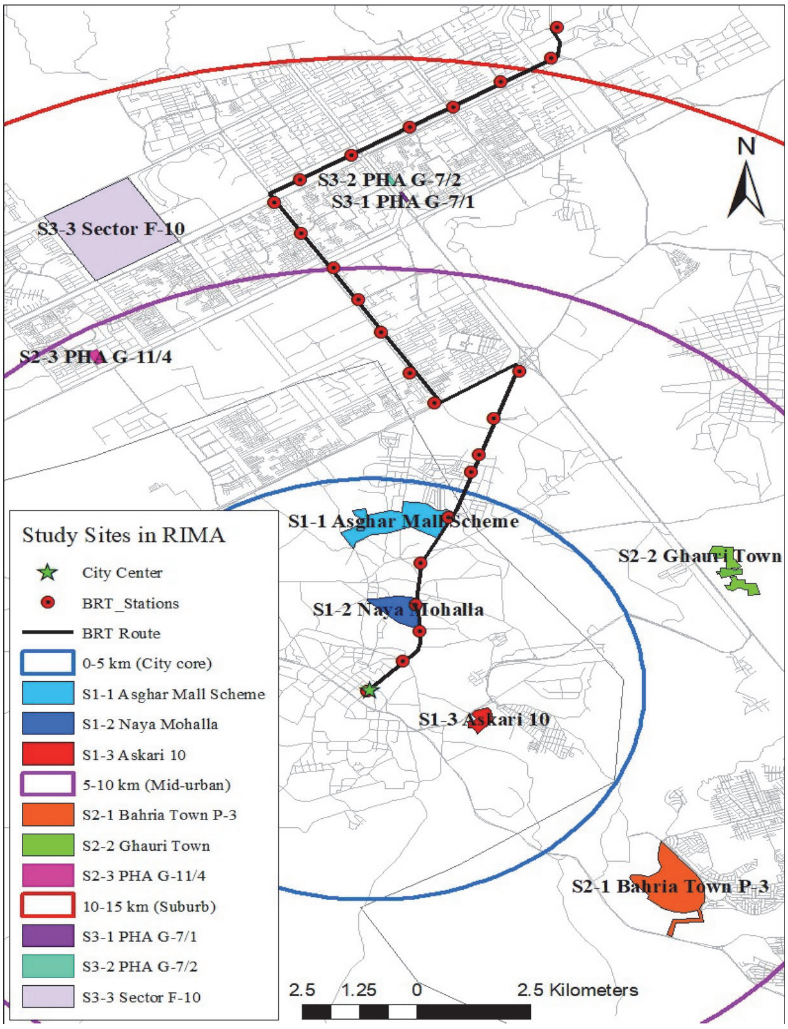

Figure 1. Spatial distribution of nine selected study sites in RIMA

density sites, and S2-3 was low-density. The former two sites were well-planned, private gated housing societies consisting of various luxurious houses of different sizes and eye-catching structures mainly for high-salary groups. The latter was public housing to accommodate government officials within 0-5 km from the nearest BRT station.

(2) Data Collection

Furthermore, three low-density sites were selected within 10-15 km. S3-1 and S3-2 were low-density sites comprising government-allotted public housing near BRT stations. These sites were mixed settlements with a dependence on motorized vehicles to access public facilities. Housing in S3-3 was somewhat similar to S2-1 (Bahria Town, phase 3); however, this site was not a gated community.

Within the selected sites mentioned above, a door-to-door household questionnaire survey was conducted from late February 2020 to early April 2020 in RIMA, Pakistan. These questionnaires were distributed to the households at their homes in the selected sites. The novel Coronavirus had newly emerged in Pakistan during this time, but it did not affect the data collected from households, enabling the samples to be analyzed as general cases. On average, the survey completion time was less than 10 minutes. All respondents were confirmed to be above 18 years of age. Due to time and accessibility constraints, 435 valid samples out of 500 (a response rate of 87%) were collected from households at nine sites across the three urban forms. At S1-3 (Askari 10), special permission was required from the authorities to enter the premises and approach houses to collect data due to safety reasons. The data gathered were self-reported and coded into SPSS (version 26) for advanced analysis.

Table 1. Study site based on distances to city center and BRT, density, and development type

	Name of study area	Distance to city center	Distance to BRT (km)	Sample Density	Development type	size
S1-1	Asghar Mall Scheme	0 - 5	0 - 5	High	Informal Self	48
S1-2	Naya Mohalla	0 - 5	0 - 5	High	Informal Self	49
S1-3	Askari 10	0 - 5	0 - 5	High	Formal Private	50
S2-1	Bahria Town	5 - 10	5 - 10	Medium	Formal Private	51
S2-2	Ghauri Town	5 - 10	5 - 10	Medium	Formal Private	52
S2-3	PHA Apt. G-11/4	5 - 10	0 - 5	Medium	Public	40
S3-1	PHA Apt. G-7/1	10 - 15	0 - 5	Low	Public	60
S3-2	PHA Apt. G-7/2	10 - 15	0 - 5	Low	Public	40
S3-3	Sector F-10	10 - 15	0 - 5	Low	Formal Self	45

1) Household Characteristics

Out of the total sample, 44% of the household heads were between 40 and 54 years, followed by 25% between 25 and 39 years. Furthermore, male respondents constituted 90% of the household heads as compared to their counterparts. This number is quite understandable as Pakistan is a gender-segregated society. Since age and gender are not significantly associated with LA analysis, they are not included in Table 2, which summarizes the variations among descriptive socioeconomic and demographic characteristics across the urban form.

Three socio-demographic characteristics were considered for this research. Household size was the largest among the respondents living in the mid-urban area, with a mean value of 5.4 household members, compared to the other groups. Both mid-urban and suburban respondents had their houses built with an average of around five rooms (number of rooms) compared to the 3-room homes of city-core residents. In the same capacity, mid-urban residents, on average, had more children (approximately three children) as compared to residents of city-core and suburban areas. Household size and the number of children show a positive impact on transportation costs (Makarewicz, 2020).

Similarly, we adopted three socioeconomic characteristics in this study. Mid-urban residents showed the highest mean monthly income of Pakistani Rupees (PKR) 178,822, with the highest mean housing costs of PKR 57,252, compared to the lowest mean income among city-core respondents, PKR 46,490. Though city-core respondents showed the lowest housing costs among other groups, their housing costs percentage with shared income was the highest, i.e., 48.3%.

The vehicle ownership variable was calculated based on the number of motorbikes and cars owned by one household family. Since Pakistan's cultural practices include extended family members in one house, some respondents owned multiple vehicles in one family. Households in the city-core mostly owned motorbikes (71.4%), compared to around 31% of mid-urban and about 13.1% of suburban families. On the contrary, respondents living in mid-urban and suburban areas owned cars (about 98% each) more than city-core households (51.7%). It is clear that well-off families mostly own cars.

Table 2. Descriptives of households' dynamics across urban forms

Household dynamics	City-core (n=147)	Mid-urban (n=143)	Suburban (n=145)	Total (n=435)
Socioeconomic characteristics				
Total income (m)	PKR 46,490	PKR 178,822	PKR 167,467	PKR 130,317
Number of vehicles (m)	0.8	0.7	0.9	0.8
Motorbike ownership (%)	71.4	30.8	13.1	38.6
Car ownership (%)	51.7	97.9	97.9	82.3
Housing ownership (%)				
(Owner/Renter)	38.2/29	37.7/27.5	24.1/43.5	1
Household expenditure				
Housing costs (m)	PKR 21,173	PKR 57,252	PKR 45,338	PKR 41,089
Transportation costs (m)	PKR 4,615	PKR 14,706	PKR 11,693	PKR 10,291
Housing costs (%)	48.3	34.8	29.2	37.1
Transportation costs (%)	11	9.3	7.8	9.4
H+T costs (%)	59.4	43	37	46.6

Notes: One US dollar is equivalent to 160 Pakistani rupees (PKR). m = mean values.
% = mean percentage values.
Motorbike and car ownership mean percentages for those respondents who chose "YES" in a survey.

Additionally, respondents were asked about housing ownership for the property that they were living in at the survey time. Surprisingly, the data revealed that around 40% of the respondents residing in the city-core reported being house owners compared to 24.1% of the suburbanites. Even though such residents had low incomes, their housing ownership was the highest amongst the three groups.

2) Housing and Transportation Costs Measures

Previous studies focused on analyzing the data for a household-level mortgage for house owners and rent payments for house renters (Li et al., 2018; Saberi et al., 2017; Aljoufie and Tiwari, 2020). One study analyzed only monthly housing rent payments (Mattingly and Morrissey, 2014). Aljoufie and Tiwari (2020) also included utility costs such as water, electricity, and sanitation bills as monthly housing costs because these costs also use a share of the household income. In this RIMA case study, we asked the households to include rent payments, utility bills such as electricity, gas, water, and garbage bills, and monthly housing maintenance under housing costs. The mortgage concept is not common in Pakistani cities; therefore, it was excluded from the study. For transportation costs, some studies used technical tools to measure the mean commuting costs for a certain distance traveled, provided the data's availability. Besides fuel, operational costs, and taxi bills, vehicle-owning costs were also included in determining overall household transportation expenses (Aljoufie and Tiwari, 2020). PT costs were excluded from the analysis in Jeddah due to a significantly low mode share percentage (Aljoufie and Tiwari, 2020).

However, in this RIMA case study, we calculated both private and PT costs. The costs for public services include ride fares to frequently used service facilities in question. Occasional visits to relatives, recreational parks, and other places were excluded from the study. The costs for private vehicles include fuel, parking cost, vehicle maintenance, and yearly tax. The vehicle purchase cost was excluded from the study to avoid bias because more well-off households can afford a car. Table 2 demonstrates the descriptives of housing costs, transportation costs, and H+T costs across city-core, mid-urban, and suburban groups in RIMA. The analysis shows that mid-urban respondents spent more than PKR 50,000, which is the highest mean amount compared to the residents of other regions. However, the mean percentage of housing costs with income share was significantly high amongst city-core respondents, reflecting the influence of low income.

Regarding transportation costs, Table 2 revealed that the mid-urban households spent PKR 14,706 on transportation, the highest mean among the groups. However, city-core residents reported the highest mean percentage of transportation expenses, considering income share, among the groups. Additionally, the combined H+T costs were also substantially high (> 45%) among the dense city-core residents, making this area extremely hard to afford. This proves that transportation costs affect overall H+T costs, as shown in Bandung, Indonesia (Dewita et al., 2019). The residents with minimum income and higher expenses in the inner-city reported high unaffordability (Dewita et al., 2019). Additionally, since RIMA is a developing region, small-engined economical motorbikes are extremely popular. One point worth mentioning is that motorbike ownership and its usage is observed more among city-core households in the RIMA context than in other groups where car ownership is high. This pattern is quite similar to other developing cities but different than Western culture.

(3) Method

The research analysis is divided into two parts using primary data. First, we looked at significant differences in household expenditures between house owners and renters by performing a One-way analysis of variance (ANOVA) test. Then, three boxplots of housing, transportation, and combined H+T costs across nine study sites were designed to illustrate which site exceeds the H+T affordability threshold and which can be considered affordable. After that, the Cross-tabulation and Chi-square analysis of travel pattern indicators from the city center to suburban groups determined the significant differences in household travel behavior across the three groups. Second, we designed the multivariate linear regression model to predict the impact of travel pattern measures on H+T costs**.**

1) Urban Form and Travel Patterns

Besides the household characteristics, it was also essential to determine the travel pattern to service facilities in a built environment that directly impacts transportation costs. Therefore, cross-tabulation of travel patterns, that is, travel frequency, travel time, and travel mode, across three groups (city-core, mid-urban and suburban), was conducted to determine the difference in the travel pattern among families in different geographical locations. Though recent studies primarily focused on travel distance, travel time, and travel mode as travel characteristics (Mouratidis et al., 2019; Næssa et al., 2018), this study adds travel frequency to have a comprehensive assessment of the H+T costs. Additionally, the chi-square test provides the significance of travel pattern differences. See Table 4 for the summary; the numbers show frequencies and the respective percentages.

2) Linear Regression Model for H+T Costs Estimation

Two linear regression models were designed to predict the H+T expenditure for RIMA families to determine the impact of urban household characteristics and travel patterns. Both models had actual H+T costs as the dependent variable. The robust standard error test and multicollinearity for mean variances were calculated. The R-squared or R^2 values represent the proportion of explained variance at a 95% confidence level and are presented along with the overall output (see Table 5).

Model 1 includes mid-urban, suburban (city-core as reference), and household dynamics when controlling travel patterns. This model helps predict the strength of the impact of the explanatory variables on H+T costs in the context of household dynamics. Since the urban form predictor is a categorical variable, dummy variables for mid-urban and suburban with a value of "1" and city-core as reference "0" were created. The variables "Motorbike" and "Car" ownership, as indicated in Table 2, were combined into one variable called "vehicle ownership" to avoid creating more dummies. If the respondents owned either a motorbike, a car, or both, the variable was coded as "1", otherwise "0". Distance to BRT was excluded from the analysis since it did not show substantial differences amongst the respondents.

Adding on to Model 1, Model 2 includes travel patterns to service facilities, which predicts the overall H+T cost share. Two of the travel behavior indicators, i.e., usage frequency and travel time, were treated as ordinal variables; whereas mode choice was treated as a categorical variable. Therefore, additional dummy variables for all the modes, i.e., walk, motorbike, and PT with a value of "1" and car dummy as reference "0" were created. This method is preferred when performing linear regression having independent variables as categorical (Myers and Well, 2003). Upon including the dummy variables in the regression model, the analysis represents the relationship of dummy variables with the dependent variable (in this case, H+T costs), controlling for the reference variable (Alkharusi, 2012). After testing for multicollinearity and non-significant results among the travel pattern indicators, DWP and health facilities were excluded from the final regression model. Similarly, the homoscedasticity test resulted in removing several mode choice dummy variables as their tolerance value was nearly 1, indicating heteroscedasticity (Klein et al., 2016). Only "walk to utility store" was included as a mode choice predictor in the model.

5. Results

(1) Location Affordability Analysis: H+T Costs Across Urban Form

The element of urban form clarifies the variation in H+T costs among the mixed-income groups in the context of urban form. For that purpose, another descriptive analysis was conducted to calculate housing, transportation, and combined H+T cost among house owners and renters. Using one-way ANOVA, the significant differences were tested for housing expenditure across urban forms for each household type, i.e., owner and renter (see Table 3).

The differences in the H+T expenditure between house owners and renters were not significant. However, the data indicates that, regardless of the housing tenure, respondents living in the city-core spent a large amount of monthly income on H+T expenditure, compared to other groups. Table 2 indicates that the percentage difference between the house owners and renters is more negligible within the city-core and mid-urban samples than in suburban samples (where renters are overrepresented). Also, housing expenditures show complications among house owners such as inherited properties, maintenance, and mortgages. Therefore, the interpretation focuses on the housing expenditure pattern among renters since the housing expense among such households includes monthly rent, utilities, and other commodities.

The differences in the range of housing costs, transportation costs and the combined H+T costs among home renters were much higher between city-core and mid-urban households, i.e., for housing costs; PKR 20,033 - PKR 53,649 = PKR 33,616, for transportation costs; PKR 4,378 - PKR 14,088 = PKR 9,710, and for combined H+T costs; PKR 24,412 - PKR 67,737 = PKR 43,325, as compared to the differences between mid-urban and suburban households, i.e., for housing costs; PKR 53,649 - PKR 45,8777 = PKR 7,772, for transportation costs; PKR 14,088 - PKR 2511,567 = PKR 2,521, and for combined H+T costs; PKR 67,737- PKR 57,444 = PKR 10,293.

However, in the context of shared income, the differences in the expenditure are less significant (i.e., for housing costs: 49.9% in the city-core, 33.5% in mid-urban, and 30.4% in suburban). It was worth noting that the mean housing costs among renters were lower than that for the owners, except among the suburban group. This difference could be because of the low rent with a small housing size. On the contrary, in other developing cities such as Qom, Iran, the average family income decreased when moving from the central district to suburban New Town (Isalou et al., 2014).

Theoretically, when moving from suburban areas to the city center, housing expenditure increases with the decrease in transportation costs as an H+T trade-off, as Makarewicz et al. (2020) confirmed using PSID data. However, in the RIMA context, combined H+T costs were significantly higher among mid-urban households and were reported lowest among city-core families. This gap is because of the income distribution among families in different geographical locations and other household characteristics that may influence the overall expenditure. Though the city-core sample indicated a larger family size and more children than in the suburbs, their car ownership was significantly low. Additionally, travel behavior and facilities usage can explain the differences in transportation expenditure across urban forms (see Table 4).

Table 3. Mean differences in housing and transportation expenditure by urban form for house owners and renters

Housing ownership	Household expenditure	City-core (n=147)	Mid-urban (n=143)	Suburban (n=14)	Total (n=435)	*p*
Owners	Housing costs	PKR 21,960	PKR 59,640	PKR 44,455	PKR 41,599	***
	Transportation costs	PKR 4,778	PKR 15,116	PKR 11,900	PKR 10,396	***
	H+T costs	PKR 26,738	PKR 74,756	PKR 56,355	PKR 51,994	***
	Housing costs (%)	47.3	34.0	27.2	37.4	***
	Transportation costs (%)	10.4	9.0	7.8	9.3	***
	H+T cost (%)	57.7	43.0	35.0	46.7	***
Renters	Housing costs	PKR 20,033	PKR 53,649	PKR 45,877	PKR 40,526	***
	Transportation costs	PKR 4,378	PKR 14,088	PKR 11,567	PKR 10,177	***
	H+T costs	PKR 24,412	PKR 67,737	PKR 57,444	PKR 50,704	***
	Housing costs (%)	49.9	33.5	30.4	36.9	***
	Transportation costs (%)	11.9	9.6	7.8	9.5	***
	H+T costs (%)	61.8	43.1	38.2	46.4	***

Notes: H+T costs = Housing and Transportation costs.
One US dollar is equivalent to 160 Pakistani rupees (PKR).
$p < 0.001$

The boxplot in Figure 2 demonstrates the minimum, maximum, and mean values of housing costs from the shared income across the selected sites. The plot consists of the housing costs percentage on the x-axis and the nine locations on the y-axis. Overall, the figure shows a steady decline in housing costs from the first site (approximately 50%), which is closest to the city center, to the ninth site (about 25%), far from the city center. Recalling the 30% housing costs benchmark, sites from S1-1 to S2-2 were beyond the standard, having S1-1 reaching up to around 50% of the monthly income, making the location unaffordable for most. On the other hand, households living at sites S2-3 to S3-3 had housing costs below the 30% benchmark, with site S3-3 at the lowest housing costs, making these sites affordable for particular households. Therefore, it shows that urban form significantly impacts housing costs.

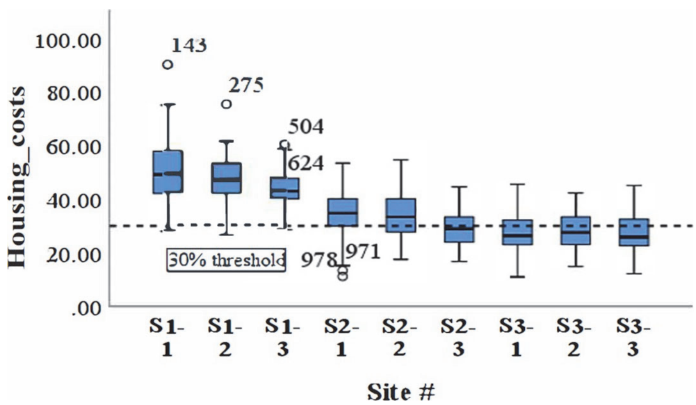

Figure 2. Summary of housing costs as a percentage of income across nine selected sites

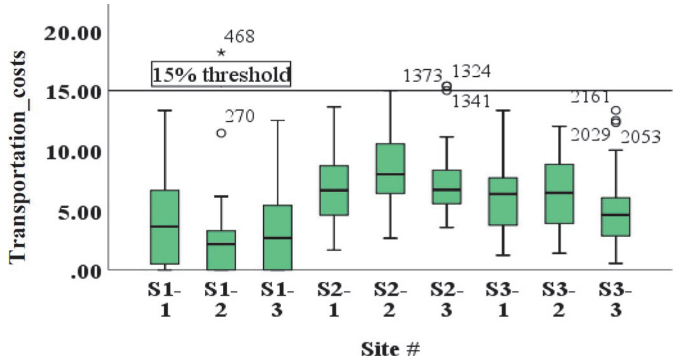

Figure 3. Summary of transportation costs as a percentage of income across nine selected sites

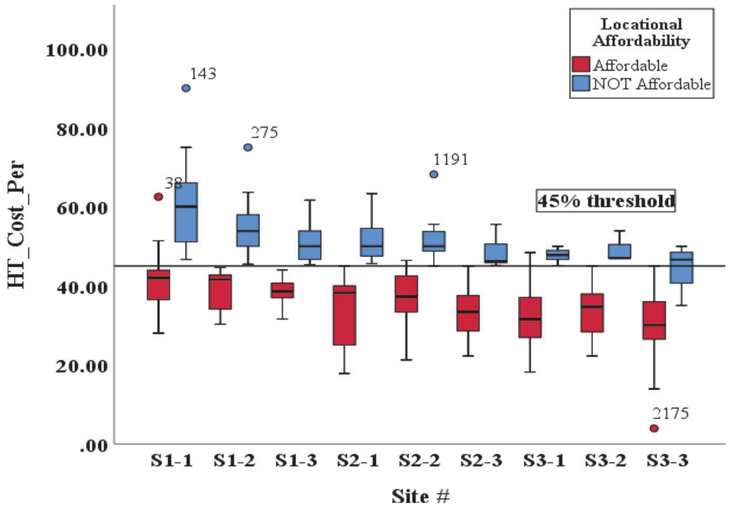

Figure 4. Clustered boxplot of combined H+T costs compared with location affordability

Note: HT_Cost_Per = Housing + Transportation costs percent

Figure 3 illustrates the transportation costs in the shared income across the nine sites. Surprisingly, the findings revealed that the transportation costs in all the sites were well below the 15% threshold, with site S1-2 having the lowest transportation costs (less than 5%) and Site S2-2 having the highest transportation costs (10%). This means that the location of the sites did not have a significant impact on the transportation expenditure. Generally, PT such as BRT and informal services are very economical. Also, students are sometimes compensated with a free ride when commuting in a school/college uniform. However, mid-urban residents usually ride the more expensive taxi-like services due to a lack of other transportation options.

The H+T costs were calculated using a clustered boxplot analysis (see Figure 4). The H+T costs percentage from shared income was placed on the x-axis, and study sites on the y-axis, to compare LA differences among the households across the urban form. The study sites are divided into two groups, i.e., Affordable and NOT Affordable, based on the percentage of the H+T costs of the shared income of households living in those sites. The Blue cluster is those with H+T costs >45% (NOT Affordable), and the Red ones have H+T costs <45% (Affordable). The analysis showed that site S3-1 was the most affordable location, with 19.5% of respondents having <45% of their income going to H+T costs. This is probably because these are comprised of publicly developed housing where government officers reside. Though they are located 10 kilometers away from the city center, they are relatively closer to the BRT; hence, they reported low H+T costs. On the other hand, 21.5% of respondents from sites

S1-1 and S1-3 each showed "NOT Affordable" results. Site S1-1 was an unplanned mixed-land area where low-income households resided. Despite high proximity to the city center, BRT, and other public facilities, the housing costs of such households were calculated as unaffordable, probably because they were low-income. In comparison, site S1-3 was a planned gated housing society located near all the service facilities. This site was determined as "NOT Affordable", probably because of high housing maintenance and dependence on a private automobile to go outside the community.

(2) Urban Form and Travel Patterns

This section examines the travel pattern differences in accessing public facilities from the city-core to suburban regions. The cross-tabulation and chi-square test in Table 4 indicate significant differences in the travel patterns between the highly-dense city-core areas and mid-and low-density mid-urban and suburban areas.

1) Travel Frequency

The whole sample "Frequently" used the DWP; clean water is necessary when living in a community. Table 4 shows that the majority visited Utility stores and PT "Often" (206 versus 147 respondents). The city-core respondents were dominant visitors for both facilities among the three groups. Out of the total sample, 114 households "Never" used PT; those living away from the city-core "Never" or "Seldom" used this facility. Additionally, 343 respondents "Frequently" visited Education facilities, having a mid-urban sample as the dominant group (around 36%). Further, 40.2% of city-core residents "Never" sent their children to schools outside the neighborhood. Lastly, most of the sample "Seldom" visited Health facilities, whereas only 80 respondents used such facilities "Often". Those living in suburban regions visited such facilities the least.

2) Travel Time

The time taken to access various facilities also varied significantly depending on the residents' location. All three groups did not report a significant difference in travel time to reach the DWP, indicating better proximity to residential areas. Most suburban households took "15 to 29 minutes" to reach Utility stores, compared to the other groups that spent "< 15 minutes". The city-core groups had educational and health facilities within 15 minutes of walking distance compared to those living in suburban areas, mainly low-density gated communities. High-density city center neighborhoods could provide easy access to schools, colleges, or universities to 82.4% of households compared to the children of only 40 households of the suburban group who traveled more than an hour.

3) Travel Mode

Like travel time, people prioritize a particular travel mode depending on their geographical locations. It is clear from Table 4 that those living in the city-core mainly "Walked" or rode "Motorbikes" to reach most of the facilities, compared to mid-urban or suburban samples who mainly used "Cars". Also, 119 households could access any PT service within walking distance. This could be why 46.7% of city-core children used PT to go to Education facilities.

Additionally, the frequent visits to the said facilities, long travel distances, and travel mode choices would substantially impact the household transportation costs among urban form groups. Walking or taking BRT would result in low transportation costs. Whereas frequent car usage to visit all the facilities would result in high transportation costs. Therefore, these differences in travel characteristics and their impact on household H+T costs make multivariate analysis compulsory to determine the association's significance in the RIMA context.

In sum, it is evident that the city-core group traveled less and walked to their destinations due to the highly dense, compact, and mixed settlement of this location than those living in low-to-midly-dense residential areas. Another significant difference in commuting patterns between urban form groups is the travel mode choice; city-core residents walk or ride motorbikes more than suburban residents, who use their cars.

(3) Multivariate Regression Analysis

Similar to the previous studies, urban form and household housing and transportation costs are statistically significant in RIMA. These associations are robust after including a variety of household and travel pattern indicators. Two OLS regression models, presented in Table 5, demonstrate the household expenditure on housing and transportation, both private and public. Model 1 comprises urban form indicators, including mid-urban and suburban dummies representing the kilometers to the city center as well as the population density of the study sites and socioeconomic characteristics. This predicted approximately 75% combined H+T costs ($R^2 = 0.742$) with controlled travel pattern indicators. After adding travel pattern indicators in Model 2, the R^2 moved to 0.792, predicting around 80% of the variance in H+T costs. Besides the primary finding of the OLS analysis that geographical location has a substantial impact on household H+T costs, we attempted to provide the principal findings of the relationship between geographical location, travel patterns, and H+T costs in the RIMA context.

1) The relationship of urban form and household indicators with H+T costs

The results indicate that all the predictor variables were significantly associated with H+T costs, having monthly income as the strongest predictor, i.e., 0.692 impact factor, followed by the mid-urban dummy. One unit increase in the distance from the city center to mid-urban increases the H+T costs by PKR 17,312 (*b*-value in Table 5), compared to less dense suburban areas, i.e., PKR 4,527. Further, the negative association of the number of children with H+T costs indicates that rich households tend to have fewer children, decreasing the number of trips per person in one household. It may also be because the child expenses, such as education and health, do not substantially affect high incomes. Though weakly associated, the number of rooms, representing housing size, is statistically related to the household H+T expenditure. This may be because well-off households live in gated communities and spend more on maintaining their houses along with purchasing high-quality commodities for family members. Also, wealthy households tend to choose neighborhoods away from the city center with low proximity to local markets and other amenities, which contradicts the Mexico City dynamics (Guerra, 2014; 2015) but agrees with such studies that car owners tend to drive more. In contrast, vehicle ownership in Model 1 is not statistically associated with H+T costs.

2) The travel indicators matter to H+T costs despite a complicated relationship

Other than the traditional travel behavior indicators used in travel satisfaction studies, i.e., travel time and travel mode, this study found that frequent PT usage was positively associated with household H+T costs. Similarly, walking to Utility stores showed a positive relationship as well. Whereas the time taken to reach PT and Education facilities indicated a negative statistical connection with H+T costs (see Table 5). This could be because of the high usage of taxi-like services due to no access to other PT services. In the RIMA context, the central households tend to use PT services such as formal BRT, and other PT more; thus, having high transportation costs. Guerra (2017) also indicated that diverse land use helps households accomplish more daily activities without traveling long distances. However, our study shows high PT usage among city-core residents, which is the opposite of what Guerra (2017) argued in his study in Mexico City. Similar to other developing cities, households usually hire private transportation services that act as school minibuses to send their children to schools away from the residential zone in RIMA. In contrast, H+T costs increase by around PKR 5,000 when walking to Utility stores. This could be because driving to large-scale supermarkets or mini grocery stores does not robustly impact high-income households in RIMA. The point worth noticing in Model 2 is that, after adding travel predictors, the effective sizes of the mid-urban and suburban dummies significantly increased. Additionally, unlike Model 1, the association of vehicle ownership became statistically significant with H+T costs in Model 2; however, the relationship is negative. It means that having a car and its frequent usage is not a burden to overall household H+T costs, which is theoretically possible amongst wealthy families. The central low-income households tend to walk to several facilities as they live in densely populated areas. Also, it takes less time to access any transportation service, especially BRT, than in less densely populated regions. Households may also drive less in congested areas to avoid long traffic jams, long travel times, and parking constraints. In RIMA, car owners are cautious about theft, even in the daytime. From the perspective of policymaking, higher usage of PT is not undesirable in developing cities. Frequent travel using PT indicates active economic and social participation along with less environmental pollution and road accidents. Since RIMA is facing rapid urbanization, developers should focus on diversifying the service facilities and residential areas by improving the land-use policies. This change could increase the modal split to transit services, even amongst high-income groups, and encourage green travel modes.

6. Discussion

The study initially proposed the assessment of H+T costs and their association with housing characteristics and travel patterns. Consistent with the LA studies, household dynamics remain the most significant indicator affecting the overall H+T costs when controlling travel characteristics (Table 5). The urban form dummies, representing kilometers to the city center, also showed a direct relationship. The H+T costs significantly increase when moving from highly dense city-core areas to moderately dense mid-urban areas but less so when moving towards peripheral suburban areas around 15 kilometers away from the city center. This reflects on the difference in the residential selection and household dynamics. Since many central households do not own cars in RIMA, dependence on PT is quite common. Additionally, the city center provides highly diverse mixed land opportunities, and low-income households tend to keep their trips short. This is a unique finding in a developing city context. Other studies indicate that high-income households choose to live near the city center, a transit-friendly neighborhood, but whether they are pro-transit compared to cars is different.

The box plot analyses of housing costs, transportation costs, and combined H+T costs examined across the study sites (see Figures 2, 3, and 4) indicate that city-core residents spent more than 45% of their shared income on H+T costs, showing a higher unaffordability pattern than other groups. Households do not necessarily need to own a car to travel due to BRT stations' proximity (see Figure 1). However, site S1-2 can be a suitable option for low-income groups when looking at their economic and travel conditions. Thus, specific housing development is essential around site S1-2 near the city center with better proximity to BRT to accommodate low-income and extremely low-income families. Similarly, locations near S3-1 and S3-2 can also be considered affordable. Families with moderate incomes living in mid-urban areas are likely to find a suitable place to rent in those areas; however, these sites will be further away from BRT. Such areas need attention to extend the BRT corridor for better transit access, employment and education opportunities, and recreation facilities to avoid lengthy travel time and usage of private cars.

The findings of high household income and low H+T costs in relation to the shared income when moving away from the city center contradict the results highlighted in the Qom, Iran study (Isalou et al., 2014), where the H+T cost differences between the central district and suburban town were investigated. They concluded that similar to Western societies, the housing costs are much higher among the city center households who earn more than those living in suburban regions. Further, H+T costs are much higher among suburbanites due to high transportation costs (Isalou et al., 2014). Though RIMA and Qom are developing areas, this interesting result indicates significant variance in the urban paradigms, reflecting household dynamics and travel.

The study further investigates the influence of urban form on travel patterns. Here, travel patterns can be used as a mediator. The cross-tabulation (Table 4) suggests that people often use private vehicles to reach most public facilities when living away from the city-core. Such groups also never used BRT due to inadequate access (Khan and Shiki, 2018), resulting in longer travel times. In RIMA's case, the central residents helplessly send their children to schools within 5 km of the neighborhood, reflecting the household income or concerns about poor education quality. These residents usually visit small-scale health clinics located within the unplanned and scattered area within walking distance compared to the well-off car users. However, neighborhoods near the city center could easily access BRT and other PTs to visit various frequently used facilities.

Since some facilities such as hospitals, supermarkets or universities are outside the residential location, car usage and trip duration tend to increase. Again, consistent with the travel behavior studies, both living in the city center and the high-density facilities available in a neighborhood result in short distances and usage of green services. The research in the Oslo metropolitan area (Mouratidis et al., 2019) also indicated that 30% of the compact city residents walked to reach the main destination, compared to 50% of suburban car users. The substantial differences in the current study call for city densification policies to have more public facilities to increase densities and control the urban sprawl by limiting the travel distances, thus resulting in the modal split to green services and overall less transportation expenditure.

After housing costs, transportation is the second-largest as Makarewicz et al. (2020) stated, but it did not appear significant in the RIMA context. Though low-income households living in the city-core spent extensively on transportation, the overall share in income does not exceed the 15% threshold. This means that, regardless of the geographical location, the average transportation costs cannot determine location-efficient sites so that families could save more money from transportation costs by relocating.

The limitations in this study can be addressed by future research for housing development near the city center and transit to reduce H+T costs. Though this research used only five facilities and three travel indicators to mediate the household expenditure, future studies can add other urban facilities, and such factors as the desire to relocate near transit, trip satisfaction, and other growing numbers of walkability measures. These indicators are already established but not yet comprehensively utilized as

Table 4 Travel behavior with urban form to access public facilities.

Travel indicators	City-core	Mid-urban	Suburban	Total	Travel indicators	City-core	Mid-urban	Suburban	Total
DWP					**Education**				
Usage					*Usage***				
Frequently	147 (33.8)	143 (32.9)	145 (33.3)	435 (-)	Never	37 (40.2)	20(21.7)	35(38)	92(-)
Time Taken					Frequently	110 (32.1)	123(35.9)	110 (32.1)	343 (-)
0-14 min	144(34.0)	136 (32.20)	142 (33.60)	422 (-)	*Time Taken*** (n=343)*				
15-29 min	3 (23.1)	7 (53.8)	3 (23.1)	13 (-)	0-14 min	84 (82.4)	18 (17.6)	0 (0)	102 (-)
*Mode****					15-29 min	26 (49.1)	27 (50.9)	0 (0)	53 (-)
Walk	19 (100)	0 (0)	0 (0)	19 (-)	30-44 min	0 (0)	50 (96.2)	2 (3.8)	52 (-)
Motorbike	75 (84.3)	11 (12.4)	3 (3.4)	89 (-)	45-60 min	0 (0)	25 (26.9)	68 (73.1)	93 (-)
Car	53 (16.2)	132 (40.4)	142 (41.2)	327(-)	> 60 min	0 (0)	3 (9)	40 (93)	43 (-)
Utility store					*Mode*** (n=343)*				
*Usage****					Walk	3 (-)	0 (0)	0 (0)	3 (-)
Seldom	34 (51.5)	20 (30.3)	12 (18.2)	66 (-)	Motorbike	27 (-)	0 (0)	0 (0)	27 (-)
Often	77 (37.4)	74 (35.9)	55 (26.7)	206 (-)	Car	37 (16.7)	84 (38)	100 (45.2)	221 (-)
Frequently	36 (22.1)	49 (30.1)	78 (47.9)	163 (-)	PT	43 (46.7)	39 (42.4)	10 (10.9)	92 (-)
*Time Taken****					**Health unit**				
0-14 min	147 (51.8)	78 (27.5)	59 (20.8)	284 (-)	*Usage*				
15-29 min	0 (0)	65 (43)	86 (57)	151 (-)	Seldom	123 (34.6)	119 (33.5)	113 (31.8)	355 (-)
*Mode****					Often	24 (30)	24 (30)	32(40)	80 (-)
Walk	51 (77.3)	15 (22.7)	0 (0)	66 (-)	*Time Taken****				
Motorbike	63 (86.3)	7 (9.6)	3 (4.1)	73 (-)	0-14 min	121 (59.6)	89 (29.1)	23(11.3)	203 (-)
Car	33 (11.1)	121 (40.9)	142 (48)	296 (-)	15-29 min	26 (11.2)	84(36.2)	122 (52.6)	232 (-)
PT					*Mode****				
*Usage****					Motorbike	55 (90.2)	3 (4.9)	3 (4.9)	61 (-)
Never	0 (0)	63 (55.3)	51 (44.7)	114 (-)	Car	67 (19.2)	140(40.1)	142 (40.7)	349 (-)
Seldom	2 (2)	39 (38.6)	60 (59.4)	101 (-)	PT	25 (100)	0 (0)	0 (0)	25 (-)
Often	81 (55.1)	36 (24.5)	30 (20.4)	147 (-)					
Frequently	64 (87.7)	5(6.8)	4 (5.5)	73 (-)					
*Time Taken*** (n=321)*									
0-14 min	147 (49.5)	61 (20.5)	89 (30)	297 (-)					
15-29 min	0 (0)	19 (79.2)	5 (20.8)	24 (-)					
*Mode*** (n=321)*									
Walk	119 (56.7)	0 (0)	91 (43.3)	210 (-)					
Motorbike	27 (90)	3 (10)	0 (0)	30 (-)					
Car	1 (1.2)	77(95.1)	3 (3.7)	81 (-)					

Notes: Chi-square for DWP usage could not be calculated because 100% of the sample used this facility. DWP = Drinking water plants
PT = Public transportation.

Table 5 OLS models of household housing and transportation expenditures

Explanatory variables	Model 1		Model 2	
	b	Beta	*b*	Beta
Urban form (*refer. City-core*)				
Mid-urban	17312***	0.279	35266***	0.568
Suburban	4527**	0.073	24527***	0.397
Socio-demographics				
Number of children	-1253**	-0.065	-1299**	-0.067
Number of rooms	1390**	0.065	1096**	0.051
Socioeconomics				
Monthly income	0.206***	0.692	0.189***	0.637
Vehicle ownership	-2281	-0.033	-3165**	-0.046
Travel behavior to access service facilities				
Frequency usage				
PT			6930***	0.250
Time taken				
PT			-6928**	-0.054
Education			-2041**	-0.089
***Modes used* (*refer. Car*)**				
Walk to Utility store			5166**	0.064
(Constant)	16483**		3702**	
R2	0.742		0.792	

Notes: b = unstandardized coefficients. Beta = standardize coefficients. PT = Public transportation.
**p < 0.05. ***p < 0.001.

mediators in LA studies. Also, the said indicators can be incorporated into this study's model as well as previous studies that showed an improvement in the LA context (e.g., Dewita et al., 2019; Guerra et al., 2016; Makarewicz et al., 2020).

7. Conclusion

Similar to the studies done by Isalou et al. (2014) and Dewita et al. (2019) among developing cities, this research also supports the thesis that LAI can determine housing affordability to some extent, and transportation costs must be incorporated into the housing costs analysis to determine affordable locations comprehensively. Most of the studies have not adequately synergized the urban form indicators and travel patterns to examine H+T costs. Using individual-based samples from RIMA households, this study contributes to both LA and travel behavior literature by, 1) using travel pattern as a mediator to associate an urban form with H+T costs, and 2) adding travel frequency, which is often ignored, to the travel pattern indicators. This input of travel patterns clarified the causal mechanism with a detailed explanation of the impact of neighborhood structure on transportation expenditure.

The study outcome is threefold. 1) Compared to mid-urban and suburban households, housing in two sites near the city center showed the highest unaffordability when considering LAI. This could be because of low income and high cost, as Dewita et al. (2019) indicated in the Indonesian context. 2)

Neighborhood density and proximities to PT and the city center showed a positive modal split towards green services compared to severe car dependency in suburban regions. 3) Other than the household dynamics, the relationship of urban form to H+T costs was also primarily explained by travel patterns, i.e., travel frequency, time taken, and mode choice. The compact-dwellers and low- and middle-income residents walk or use PT to access desired facilities. A higher frequency of PT usage showed a positive correlation with the overall household H+T costs. This case is the same with suburbanites who tend to drive more to enjoy the city facilities. This study attempted to improve the single variable approach of Smart and Klein (2018) by including three groups ranging from the city-core to suburban, based on the distance to the city center, and contributed to the model used by Makarewicz et al. (2020) by adding multiple accessibility predictors as well as travel frequency.

Though the study tried its best to collect a sample representing RIMA households, it is limited to a relatively small sample size due to the time constraints and privacy concerns of the residents. Therefore, including more sites with unique geographical features as well as rural areas in the city outskirts and slum settlements could give insight into the influence of location and household dynamics on H+T costs. RIMA is facing urbanization at the city-core and sub-urbanization at the outskirts, encouraging the developers to provide all the necessary facilities to the households of the suburban gated communities and leaving low-income group densities behind. This is why national housing policies in Pakistan must include LAI integrated with compact city policies so that policymakers will consider the development of housing and service facilities for the needy.

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