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Residential Density and Traffic Congestion in the Harare Metropolitan Region

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Abstract

This study sought to establish the relationship between residential density and traffic congestion. The study adopted a cross-sectional survey design and a mixed method approach. Data was collected from 384 households in Harare Metropolitan Region using structured questionnaires and semi-structured interviews. Structural Equation Modelling was used to test the relationship among residential density, vehicle miles travelled and traffic congestion. The findings revealed that there is a direct relationship between residential density and traffic congestion. In addition, the study also confirmed that vehicle miles travelled mediates the relationship between residential density and traffic congestion. Theoretical and practical implications emanating from the study are discussed.

Keywords: Land-use, Residential density, Traffic Congestion, Vehicle Miles Travelled.

1. Introduction

People's activities are influenced by land-use patterns, such as where they live, work, and spend their leisure time, which creates a requirement for physical travel between various locations (Morar & Bertolini 2013). The desire to travel between these many locations, depending on activity selections, is what drives transportation or travel demand (Alaigba, et al. 2017; Patel et al. 2019). Transport has the uniqueness of interacting intimately with all other land-uses and this interaction produces diverse transportation problems with traffic congestion as the most visible manifestation (Kop, 2016). However, this interaction is not an issue clear and scientifically solved (Colonna et al. 2012; Alaigba et al, 2017; Zhang et al. 2017; Patel et al. 2019; Kanyepe et al, 2021). According to Engelfriet (2015), sprawl-like land-uses are characterized by low-density, segregated land-uses, and poor street connectivity, which leads to more vehicle miles traveled (VMT) and, as a result, higher levels of congestion than compact development.

Ewing and Bartholomew (2017) notes that compact, mixed-use development is inherently more efficient and sustainable, requiring less land and lowering private vehicle use rates by bringing people and activities closer together, as well as providing densities capable of supporting walking and effective transit services. In Africa, the colonial development control philosophy, combined with strict racial segregation, provided a foundation for the enforcement of rigid standards and the establishment of dual systems in urban areas (one for European settlers and the other for African workers) (Wekwete, 1995). Similarly, Toriro (2008) contends that pre-colonial Zimbabwean planning frameworks were primarily designed to serve the capitalist and selfish interests of the settler community by maximising the productive capacity of space utilisation at the expense of the interests of local communities, and thus do not necessarily represent public interest. The post-colonial urbanisation trajectory in Harare can be compared to post-World War II development trends in the United States and the United Kingdom. Cities such as Detroit, Boston, Massachusetts, and Michigan in the United States, and Birmingham and Bristol in the United Kingdom, experienced massive suburbanization of the middle classes into the periphery, which was accompanied by the dispersal of retail, office, and industrial activities from central business districts to shopping malls, office parks, and industrial parks (Di Gaetano & Klemanski, 1999).

According to Marondedze and Schütt (2019), the highly generous plot sizes, particularly in low and medium density regions, and the high levels of urbanization in Harare are often 'bursting at the seams.' In the similar line, Munzwa and Jonga (2010) and Muchadenyika (2017) say that Harare is evolving towards and is now integrating with Ruwa in the east, Epworth in the south-east, Chitungwiza in the south, and Norton in the west. This has altered the spatial link between dwellings and businesses, stores and other destinations in the Harare Metropolitan Region, increasing the distances between these activities (Marondedze & Schütt, 2019). Weitz et al. (2003) have observed that the separation between residence, work places and other destinations have been blamed for about one third of the enhancement in driving.

However, initiatives to minimize vehicle kilometers traveled, such as decentralization of activities, have shown mixed results. Because it is so far from most residential areas, the HighGlen shopping centre in Highfields, for example, has struggled to attract many customers. It does, however, draw the more affluent consumers from the adjacent Mufakose district of Marimba Park, who can afford to drive to the city (Human Rights Watch, 2007; Tinashe, 2012). The Central Vehicle Registry (CVR) processed 14 470 second-hand vehicles imported into Zimbabwe in 2017, according to a study produced by the Zimbabwe Motor Industry Development Policy (ZMIDP) (2018). Mbara (2015) claims that the proliferation of second-hand automobiles coupled with parking challenges, has exacerbated traffic congestion in Harare. However there has been little agreement among planners and policy makers on what actions should be taken or, indeed, whether special initiatives are warranted hence this study intent to investigate the relationship between residential density and traffic congestion in the Harare Metropolitan Region.

2. Literature review

This section explores relevant literature on effect of residential density on traffic congestion. To explore the influence of residential density on traffic congestion, this paper follows the general principles of the Utility Maximisation Theory, Activity Pattern Model, Systems Theory and Lowry Model. The key independent variable of this study is Residential Density (DEN), Traffic Congestion (TC) represents the dependent variable while Vehicle Miles Travelled (VMT) represents the mediator as show on Figure 1.

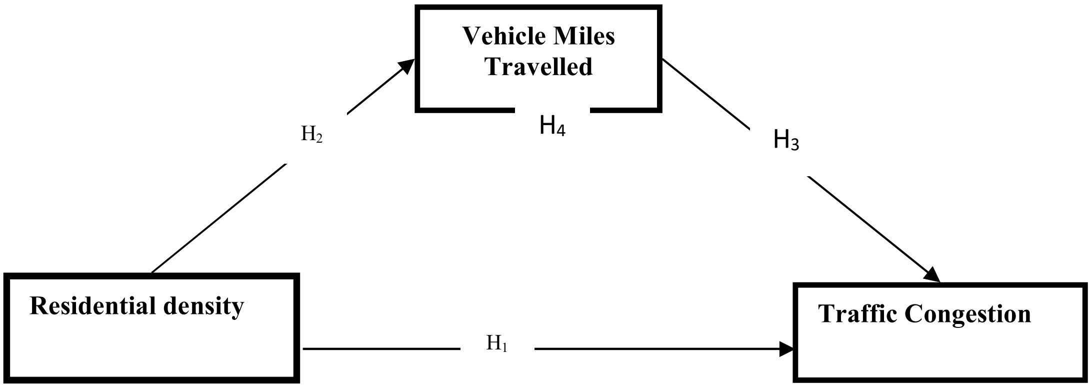

Figure 1: The relationship among residential density (DEN), traffic congestion (TC) and vehicle miles travelled (VMT)

Source: Researchers

3. Hypothesis development

An empirical study is conducted to verify the influence of residential density on traffic congestion by use comprehensive survey data in Harare Metropolitan Region.

3.1 Relationship between residential density and traffic congestion

Shubho and Neema (2014) note that traffic congestion is a function of land-use, hence the way land is used affects its development and the character of traffic on the streets and highway network. Correspondingly, Fernando (2001) observes that developments attract and produce high traffic volumes. By the same token, Lugalia (2018) argues that haphazard developments exacerbates traffic congestion. Kuzmyak (2012) and Ewing et al., (2018) suggest that to understand the effects of residential development on traffic congestion, it is important to consider residential density in terms of other land-use characteristics such design, destination to transit, distance accessibility and diversity. Ewing and Bartholomew (2017) suggest that it is important to support residential density with services such shopping and provide adequate pedestrian facilities to reduce vehicle trip generation and major traffic impacts. A residential density with diversified or different land-uses can reduce vehicle trip length by bringing potential destinations closer together (Zhang et al., 2012; Kim & Brownstone, 2013).

Earlier studies by Gordon, Kumar and Richardson (1989) and Izraeli and McCarthy (1985) have found that residential density is positively related to traffic congestion. Contrary-wise, Malpezzi (1999) found a negative relationship while Ewing et al (2003) found that residential density and traffic congestion are not related. According to Sarzynski et al. (2006), denser urban areas with a concentration of activities have higher auto volumes and traffic delays. Bovy and Salomon (2002) describe traffic congestion based on supply and demand by addressing interrelated factors such as transportation supply, socio-demographic factors, spatial urban structure, and economic factors while taking into account urban structure. Conventional wisdom on land use and traffic congestion assert that low-density housing encourages longer commutes with higher trip frequency, imposing a higher level of traffic congestion (Mitchell & Rapkin, 1954; Hursta, 1964; Downs, 1992). To summarize, the following hypothesis is adopted in this paper:

Hypothesis 1: Residential density (DEN) has positive effect on traffic congestion (TC)

3.2 Relationship between residential density and Vehicle Miles Travelled

Despite the on-going intellectual debate, the fundamental principle that urban density impacts vehicle miles travelled is acknowledged by many scholars and supported by empirical findings from different contexts (Wilfred et al., 2015; Ewing et al. 2016; Gulhan & Ceylan, 2016). Vehicle Miles Travelled is also influenced by several other factors, particularly residential location choice. For several decades, scholars have struggled with the issue of residential self-selection, by which households or individuals may choose their place to live centred upon their travel choices (Mokhtarian & Cao, 2008). Hence, controlling for self-selection effects has been a critical part of proving the directionality and causality between residential density and Vehicle Miles Travelled. Gordon et al (1989) argue that residential development positively influences Vehicle Miles Travelled. In the same vein, Ogra (2015) opine that high density residential settlement can influence mode choice by making other means of transportation such as public transport usage, walking and cycling more attractive than private automobiles.

Admittedly, Song et al. (2017) argue that the use of public transport by urban residents is positively related to commuting times and built-up areas, thus suggesting the importance of public transport in easing urban transport problems. After controlling for the effects of self-selection, a number of studies found that there is a statistically significant relationship between residential density and VMT, even if the magnitude of the impact is marginal (Choi 2018). Brownstone and Golob (2009) used a system of structural equations to control for self-selection biases and found a small but significant association between residential density and fuel usage. The relationships between residential density and VMT give reliability to the claims of new urbanists who believe pedestrian friendly environments, compact and mixed-use residential areas can reduce car dependency through bringing activities and people closer together and also proving densities which support the use of sustainable modes of transport such as walking and transit (Kusumastuti & Nicholson, 2017). A good balance and mixture of land-use in a given urban tract can reduce individual Vehicle Miles Travelled (Spears & Boarnet, 2014; Duranton & Guerra, 2016). Correspondingly, Geyer and Quin (2018) posit that mixed land-use is a sound solution to all kinds of typical urban related problems like congestion, deprivation and crime. The proposition is that people who live in areas with varied land-use might reduce car dependency and encourage walking and cycling.

Moreover, people who live in areas with diverse land-use significantly increase their walking frequency and use walk mode choice for work trips and non-work trips (Soteropoulos, Berger, and Ciari 2019). In addition, Maharjan et al. (2018) concur that living in areas where stores and shopping facilities are nearby could significantly increase shopping walking trips. Similarly, Bahadure and Kotharkar (2015) observe that the proximity of residential location to commercial centres plays a critical role in promoting walk mode share for non-work trips. Concerning the use of public transport, Jain et al. (2020) and Robertson et al. 2015) found that diverse land-use promotes the frequency of using public transport. In contrast, Saghapour (2013) studied land-use diversity in Shiraz City, Iran and found that it does not significantly reduce trip length but does significantly reduce vehicle usage. By the same token Liu and Lawell (2016) consented that the mixture of land-uses promotes vehicle use, particularly in high-income and extremely big cities.

Another residential density factor which influences VMT as observed by Na et al., (2017) is the balance between jobs and housing. Jiangping et al. (2014) notes that a residential location is considered balanced when residential and employment opportunities are nearly equivalent. In that respect, when there is an imbalance between jobs and housing, people will travel longer distances, suggesting that they need to enrich job opportunities in residential locations (Sultana, 2015). Veillette et al. (2018) argues that residents who live farther away from transit stations use private vehicles and are less likely to use public transport. Accordingly, reduced distance to transit stations can significantly reduce vehicle trips and encourage a strong shift from driving to public transit and also encourage transit users to walk or use bicycles rather than driving (Davis et al. 2015). To sum up, this paper adopts the following hypothesis:

Hypothesis 2: Residential density (DEN) has positive effect on vehicle miles travelled (VMT)

3.3 Relationship between Vehicle Miles Travelled and Traffic congestion

Vehicle Miles Travelled (VMT) is regarded at the prime outcome of the combination of trip length, car ownership, mode choice and trip frequency (Handy et al, 2012; Asad, 2013; Sardari, 2018). Handy (2015) assert that the rise in VMT increases roadway capacity where traffic congestion is present called “induced travel”. She further construed that the basic economic principles of demand and supply states that capacity decreases travel time, lowering the “price” of driving; and when prices go down, the quantity of driving goes up too. A 10% increase in capacity increases VMT by 3% in the short-run and 6-10% in the long-run. Capacity increases in the long-run can increases VMT in numerous ways such as a shift from other modes to driving, longer driving trips and more frequent trips (Handy, 2015; Byun et al, 2017). The long term effects of capacity increases on VMT are associated with land-use developments (Handy 2015). For instance, when people and business move to more distant locations or when land-use patterns become more isolated in response to increase in capacity, VMT responds likewise (Department for Transport 2018). In respect to car ownership as a component of VMT, Fiedler t al, (2017) note that the increasing use of private vehicles results in demand for parking and road capacity. They further remark that the use of private vehicle is unsustainable. In support of this view, Sardari et al. (2018) reiterate that the interruption of traffic movement is visible when demand for road capacity exceeds the present capacity of the road element, resulting in traffic congestion.

The availability of travel modes is different and people can choose the mode they desire to complete a trip based on comfort, security, reliability, trip distance, vehicle in time, time reliability and cost (Friman, Lättman & Olsson, 2020). The desire to use private vehicles increases more as the city is prone to traffic congestion (Cullen, 2019; Moyano et al., 2021). Prior studies suggest that shorter vehicle trips reduce Vehicle Miles Travelled (Saville-Smith et al, 2015; Geyer & Quin, 2018). Ewing et al (2018) and Barrington-Leigh and Millard-Ball (2019) remarked that higher travel frequency increases the likelihood of traffic congestion. Sardari et al (2018) discovered an inverse association between VMT and traffic congestion near household dwelling locations using disaggregated 2009 NHTS data. Increases in VMT, on the other hand, have been linked to increased levels of traffic congestion, energy consumption, and road accidents, (Levy et al., 2010). Based on this analysis, this paper adopts the following hypothesis:

Hypothesis 3: Vehicle miles travelled (VMT) has positive effect on traffic congestion (TC)

3.4 Mediating Role of Vehicle Miles Travelled

The most intuitive explanation on the relationship between residential density and traffic congestion is one that uses VMT as a mediator. A sizeable number of studies have explored the relationship between residential density and traffic congestion (Izraeli & McCarthy, 1985; Gordon et al, 1989; Sarzynski et al, 2006; Wang, 2010; Lugalia, 2018; Sardari et al, 2018; Zhang et al., 2017). VMT is considered to be the bridging factor between residential density and traffic congestion (Ewing et al, 2013; Sardari et al, 2018). Residential density is associated with various aspects of VMT such as trip length, car ownership, trip frequency and mode choice (Cervero, 2013; Spears & Boarnet, 2014; Ogra, 2015; Wilfred et al. 2015; Duranton & Guerra, 2016, Ewing et al. 2016; Gulhan & Ceylan, 2016; Ewing & Bartholomew, 2017; Lu et al, 2018; Kusumastuti & Nicholson, 2017; Geyer & Quin, 2018). Choi (2018) observed that the modification of residential density can lead to changes in one or more aspects of travel, consequently VMT. Similarly, Ewing and Cervero (2010) emphasised that land-use factors such as density, diversity and accessibility have significant impact on VMT. Thwala et al (2012) echoed that lack of housing close to the city centre increases commuting time which results in a number of transport problems such as pollution and traffic congestion.

Hamidi et al. (2016) and Jing et al. (2018) acknowledged that sprawl-like developments characterised by poor street connectivity and poor distance accessibility lead to more frequent and longer trips requiring motorised vehicles and thus resulting in more overall traffic congestion. Likewise, Mattson (2020) argues that household density has a significant lower household trip frequency. In contrast, Ewing et al. (2018) noted that higher travel frequency is likely to happen in compact urban areas than in sprawling areas, resulting in higher levels of traffic congestion. Other scholars found that higher density leads to car dependency (Engelfriet & Koomen, 2018; Belton-Chevallier et al., 2018). Another important aspect on how VMT mediates the effect of residential density on traffic congestion as addressed by Ewing et al. (2003), is the conflicting forces presented by the distribution of jobs and housing. The association between jobs-housing ratios and VMT, particularly the characteristics of commuting trips has been discussed in a number of studies (Spears et al., 2013; Zheng et al., 2021). Gordon and Lee (2003) have noted that job-housing is a critical factor for congestion and travel time. Beenackers et al. (2018) pointed out that higher density neighbourhoods with better access to jobs are associated with low rates of motorisation and consequently low traffic disturbances. In the same way, Choi (2018) argued that a greater balance of jobs and housing can bring housing closer to work places and other destinations, thus reducing car trip length for both commuting and daily trip purposes such as shopping, and recreation. Based on this analysis, this paper adopts the following hypothesis:

Hypothesis 4: Vehicle miles travelled (VMT) has a mediating effect between residential density and traffic congestion (TC).

4. Research methodology

The population for this study was comprised of 530668 households in Harare Metropolitan Region (ZimStats, 2017). Stratified and convenience sampling were applied to select 384 households out of 530668 households in Harare Metropolitan Region. The researcher stratified the sample based on socio-economic characteristics of residential areas. A household travel survey has been conducted in all residential areas in the Harare Metropolitan Region wherein respondents were offered one technique of completing the survey that is a self-administered hard copy questionnaire. The survey was designed to gather information residential characteristics, travel behaviour and their perceptions on traffic congestion. Exploratory factor analysis (EFA), structural equation modelling (SEM) was applied to address research objectives and hypothesis. The data were analysed using SPSS 21, Amos version 21. The map of Harare Metropolitan region is shown on Figure 2.

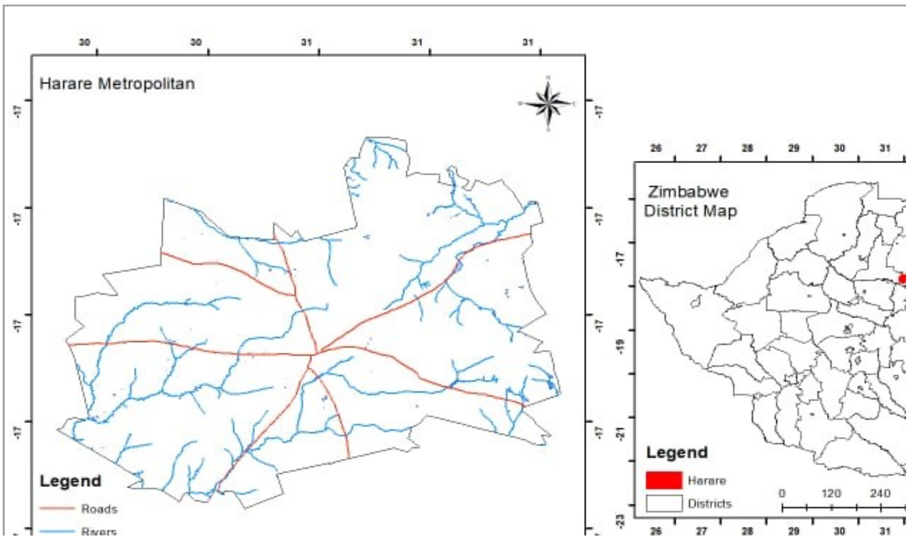

Figure 2: Harare Metropolitan Region

5. Results

Descriptive statistics for study variables used in the model is presented on Table 1. The study used arithmetic means (M) and standard deviation (SD) to rate responses on a five-point like scale of 1-5 (1 = strongly disagree, 2 = disagree, 3 = neutral 4 = agree, 5 = strongly agree). The standard deviation relates to the extent to which responses provided by respondents are consistent or the extent to which responses are distributed around the mean.

Table 1: Descriptive Statistics for survey data

Item	Code	Mean Score	Standard Deviation
Traffic Congestion	TC1	4.32	0.975
	TC2	4.31	0.779
	TC3	4.26	0.790
	TC4	4.21	0.798
Vehicle Miles Travelled	VMT1	4.21	0.711
	VMT2	4.35	0.660
	VMT3	4.31	0.744
	VMT4	4.19	0.787
Residential Density	DEN1	3.41	0.797
	DEN2	4.57	0.781
	DEN3	4.24	0.906
	DEN4	4.09	0.965
	DEN5	2.32	1.059

Source: Survey data (2021)

Using SPSS version 20, reliability and validity tests were performed to improve the research questions. Table 2 shows that the Cronbach's value of each variable is greater than 0.8 indicating that the data gathered was reliable. Results for factor loadings, Average Variance Extracted (AVE) and composite reliability were greater than 0.5 as per the recommendations of Fornell and Larcker (1981). This means that the preconditions for convergent validity were satisfied and achieved. The rotated component matrix solution gave 3 components namely residential density (DEN), vehicle miles travelled (VMT) and traffic congestion (TC). The total variance explained of 64.441% was registered which was way above the recommended limit of 60% (Atalay et al., 2013).

Table 2: Construct, number of items and Cronbach's (α)

Construct	Number of Items	Cronbach's alpha (α)
DEN	5	.871
VMT	4	.801
TC	4	.911

Source: Research Data (2021)

5.2 Hypothesis Testing

Hypothesised relationships (H_1, H_2 and H_3) were tested in AMOS version 21 using SEM technique. Maximum Likelihood Estimation (MLE) was used to estimate the structural model. The values of GFI, AGFI, NFI, TLI and CFI indicate a good fit when close to 1 (Bagozzi, Richard & Yi, 1988; Fornell & Larcker, 1981; Nasution, Mavondo, Jekanyika and Oly, 2011) whilst RMSEA must be in the range of 0.05 to 0.10 for a model to be accepted (Monteiro and Soares 2017). In line with these recommendations, the structural model indicated satisfactory model fit indices (CMIN//DF = 3.179; GFI = .891; AGFI = .903; NFI = .939; TLI = .840; CFI = .811 and RMSEA = .041). Table 3 shows results of hypotheses tests.

Table 3: Summary of Hypothesis Test Results

Hypotheses	Hypothesised Relationship	SRW	CR	Remark
H_1	Residential density → Traffic congestion	.269	11.996***	Supported
H_2	Residential density → Vehicle Miles Travelled	.414	19.335***	Supported
H_3	Vehicle Miles Travelled → Traffic Congestion	1.227	21.944***	Supported

Source: Survey Data (2021)

Table 3 indicate that H_1, H_2 and H_3 were statistically supported. The implication of these findings is that there is sufficient statistical support for direct relationships between residential density (DEN), traffic congestion (TC) and vehicle miles travelled (VMT). This suggests that residential density influences vehicle trip frequency, vehicle ownership, vehicle trip distance and mode choice. In addition, residential density was found to have a positive influence on traffic congestion suggesting that traffic congestion is a function of residential density. For instance, rising residential units will induce more traffic flow towards them in during peak periods resulting in travel delays and reduction in travel speeds. In addition, lack of affordable housing close to work increases commute time hence traffic congestion as working families move far from work to find affordable housing. The study results also indicate that vehicle miles travelled has a positive relationship with traffic congestion suggesting that excessive dependency on vehicles influence traffic flow.

Through fully-vetted measurement models, the analysis turned to test the mediating effect of Vehicle Miles Travelled on residential density and traffic congestion. James, Mulaik and Brett (2006) suggested that the mediation effects should be confirmed by a structural model based upon significance path coefficients. The structural model for H_4 indicates satisfactory model fit indices (CMIN//DF = 2.150; GFI = .908; AGFI = .865; TLI = .9308; CFI = .867 and RMSEA = .039). Table 4 presents results for the mediation effect of Vehicle Miles Travelled on the effect to residential density on traffic congestion. Table 4 shows results on the mediation effect of vehicle miles travelled on the effect of residential density on traffic congestion.

Table 4: Indirect effect analysis

Hypothesis	Path	Path Coefficient	Results/ Comments
H_4	DEN → VMT → TC	0.508***	Partial mediation

Note: ***Significant at p<0.001
Source: Survey Data (2021)

As can be seen on Table 4 show H_4 was supported suggesting that vehicle miles travelled partially mediates the effect of residential density on traffic congestion. This implies that when a residential area is far away from the CBD, people tend to be auto dependent to access economic activities, the excessive use of vehicle results in traffic congestion. Figure 3 indicates the structural model that was used to test the effect of residential density (DEN) on traffic congestion (TC).

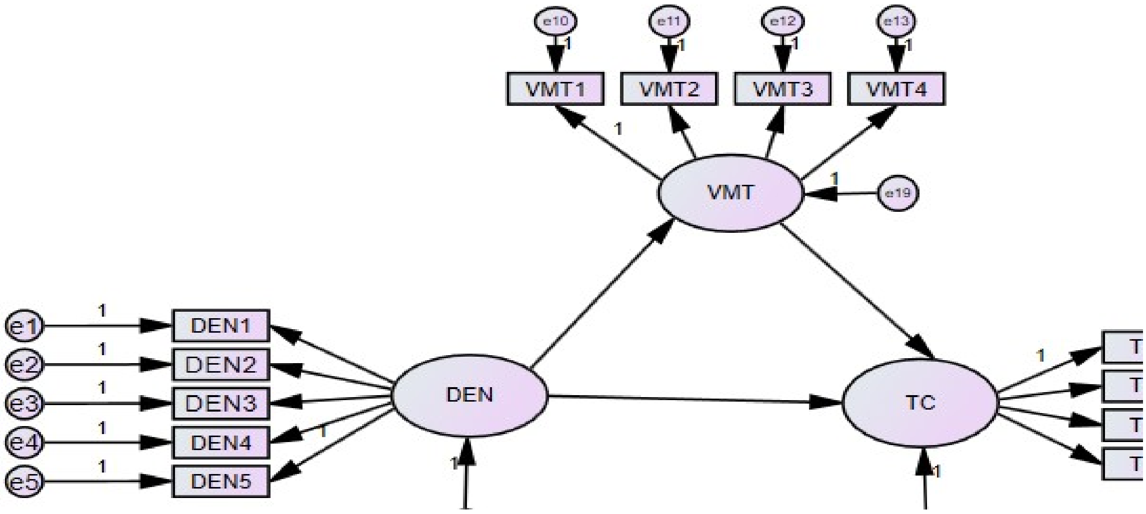

Figure 3: Model for DEN, VMT and TC

Source: Survey data (2021)

6. Discussion

This research has added to the current body of knowledge in a variety of ways. Our total contribution consists of developing and testing a conceptual model that incorporates residential density, VMT, and TC. First, we discovered evidence of a direct influence of residential density on traffic congestion, implying that residential density reduces traffic congestion. The basic tenets denote that 'traffic congestion is a function of land use' (Mitchell and Rapkin, 1954, Hursta, 1964). The surrounding land-uses of the highways have an impact on the rapid rise of traffic volume and its concentration in a given region. For example, the Transport and Housing Bureau (2013) claims that when residential units rise, more traffic would flow toward them during the evening rush hour. Apart from that, increased development in a variety of land uses will both attract and create a large volume of traffic. Thus, it is clear that the longer distance to transit, poor design of pedestrian and cyclist facilities, job-housing imbalance, poor land-use mix and lack of affordable housing close to the CBD have worsened the traffic situation in Harare Metropolitan Region.

The results from this study are in conformity with the majority earlier studies such as those of Zhang, Sun, Yao, and Rong (2017); Ewing et al. (2016); Gulhan & Ceylan (2016); Wilfred et al. 2015; Cervero, 2013; Kuzmyak (2012); Wang (2010); Downs (2004); Ewing, Pendall and Chen (2003); Gordon, Kumar and Richardson (1989) and McCarthy (1985) which indicate that residential density has positive impact on traffic congestion. This consolidates the position of this finding that are consistent with a majority of both earlier and recent studies, attaining conclusive results as more studies report similar findings. To understand this relationship, a huge number of studies considered compact, sprawl-like land-uses, job-housing balance and mixed land-use rather than simply density.

Second, we found support for direct effect of residential density on vehicle miles travelled that signified that residential density is positively related to car ownership, the number of vehicle trips generated, mode choice and the trip distance. A similar pattern of findings has been reported in a number of empirical findings such as study by Bhat et al. (2016) that residential density has positive impact on vehicle miles travelled. This consolidates the position of this finding that are consistent with a majority of both earlier and recent studies, attaining conclusive results as more studies report similar findings.

Third, we found support for direct effect of vehicle miles travelled on traffic congestion that specified that traffic congestion in Harare Metropolitan Region is a product of vehicle trip distance, number of vehicle trips generated, vehicle ownership and mode choice. As a result, VMT influences travel time, speed and can cause delays. In addition, an increase in the number of vehicles destructs the free flow of traffic. This result ties in well with other previous findings wherein Mbara (2015) argue that traffic congestion in Harare is a result of the influx of second-hand vehicles. The Central Vehicle Registry (CVR) processed 14 470 second-hand vehicles imported into Zimbabwe in 2017, according to a study produced by the Zimbabwe Motor Industry Development Policy (ZMIDP) (2018). According to CVR figures, at least 510 275 used automobiles were imported into the nation between 2007 and the end of the first quarter of 2017. According to ZINARA (2018), the country has approximately 1.2 million cars. During the multi-currency system, people's actual disposable personal income increased, which explains the rise in car use and ownership. Higher levels of automobile ownership and an increase in the proportion of households owning multiple vehicles are the effects of higher income on passenger vehicle travel; these trends, in turn, not only increase trips and travel but also reduce the number of trips taken by transit or walking and increase the number of discretionary trips.

Lastly, we found support that vehicle miles travelled partially mediates the relationship between residential density and traffic congestion. This suggests that residential density do not directly affect traffic congestion but rather via vehicle miles travelled. Rather than a direct causal relationship between residential density and traffic congestion, this study holds that traffic congestion increase when people generate more vehicle trips, own-vehicles, commute longer distances and drive frequently from their homes to the CBD. Thus, VMT clarifies the effect of residential density on traffic congestion. This result ties well with several empirical studies wherein Ewing et al, (2013); Ewing and Hamidi (2014); Ewing, Tian and Lyons (2017); Ewing and Bartholomew (2017); Guo et al, (2020) that vehicle miles travelled mediates the effect of residential density on traffic congestion. This consolidates the position that this finding is consistent with a majority of empirical studies.

According to conventional wisdom, sprawl-like development marked by widely distributed, low-density housing or employment patterns results in more frequent and longer trips requiring vehicles (particularly automobiles), and hence increased overall traffic congestion. Harare is known for its urban sprawl and informal settlements on the outskirts of the city. This means that people in Harare especially those with high incomes will be forced to use their vehicle to commute to the urban centre. As more people are driving, the more vehicles there are on the roadways during peak hours. Higher number of vehicles eventually results in traffic congestion.

7. Theoretical and practical implications

Although an agreement has been formed on the connection between residential density and traffic congestion, the degree and importance of such a link is still unknown, implying that the methodologies employed to study this issue may be inconsistent. It is worth noting that there are not many empirical studies on the relationship between residential density and traffic congestion in Sub-Saharan Africa, notably in Zimbabwe. Therefore, the findings of this study are essential since they provide new knowledge and add to the already existing knowledge. In addition, the study contributed to the thin land-use-transportation literature by investigating a potentially important mediator. Furthermore, the results of this study can be transformed into an array of indicators that can inform policy-makers in transport and urban planning. This is achieved by enlightening them about the appropriate characteristics that can be utilised as policy tools in reducing traffic congestion.

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