WALKING IN SMART CITY

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ABSTRACT

With new technology advancements, citizens have become more involved and cities have become more responsive in recognizing demands and providing solutions and services. Although technology plays an important role in smart cities but not all services in a smart city are technology based. On the other hand, in recent decades, people tend to live in communities that provide better quality of life and are more receptive to their needs. The preference for living in walkable neighborhoods has grown remarkably in 2017, in compare to previous years and residents of walkable neighborhoods show more satisfaction regarding their quality of life (Strategies, 2017). Accordingly, our aim in this research is to study the relationship between smart characteristics of the neighborhood and pedestrian activity. Three streets in Fort Worth, TX were selected using site selection survey and number of pedestrians were counted in 62 block faces of these streets. A smart score index was created based on smart city domains by Neirotti et al. (2014) to evaluate these streets. Built environment characteristics and urban design features were used as control variables in Poisson Regression Model. The results show that higher smart score has higher association with pedestrian volume.

INTRODUCTION

While in recent years, residents of walkable neighborhoods show higher satisfaction of their quality of life, cities are taking advantage of developments in technology for increasing citizen involvements, recognizing demands and providing services in faster and more reliable ways. Walkable communities have been recognized as dynamic engines of economic growth, social interaction, health and safety in recent years (Florida, 2012). Smart neighborhoods have become hubs for start-up firms and their employers because walkability and pedestrian amenities make them attractive for young techies who are willing to live, work and play in those settings. Furthermore, in today's digital era, cities have applied technology-based solutions to improve the quality of life for their citizens. However, the relationship between smart characteristics of the neighborhood and walkability emerges as the gap in the walkability literature.

The gross built environment characteristics and design features of neighborhoods have been extensively studied in recent years and results show that characteristics such as proximity to parks and imageability promote walkability (Cohen, et al., 2007; Ewing & Handy, 2009; Ameli, Hamidi, Garfinkel-Castro, & Ewing, 2015). Furthermore, Information and Communication Technologies (ICT) generate an interconnected network of citizens, businesses, transportation options, and services. Although, utilizing technology in every aspect of urban life has facilitate data collection and providing services for cities, but not all programs for improving quality of life in smart cities are digital-based. Digital-based programs and solutions along with non-digital smart components create Smart Communities and Smart Cities (Cocchia, 2014; Dameri, 2014; Neirotti , De Marco, Cagliano, Mangano, & Scorrano , 2014). Neirotti et al. (2014) provide a comprehensive definition for smart city initiatives. Collecting data from 70 cities around the world, they characterized these initiatives based on six main domains: natural resources and energy, transport and mobility, buildings, living, government, and economy and people.

For the purpose of this study, three street sections were selected in City of Fort Worth based on the site selection survey. Meanwhile, a neighborhood walkability checklist was created to study the relationship between smart characteristics of neighborhood on walkability. This checklist consists of three sections: neighborhood smartness, neighborhood design, and control variables. The neighborhood smartness section includes digital-based components and non-digital smart components based on aforementioned domains defined by Neirotti et al. (2014) to evaluate smartness of each street. In addition to smart score, built environment characterizations and urban design features were included in the model. Gross built environment characteristics were achieved from walk score website and Geographic Information System (GIS). The urban design features related to walkability were measured using Ewing and Handy (2009) walkability index. The number of pedestrians was counted in each street section as the dependent variable. Poisson Regression Model was used to study the relationship between neighborhood smartness and walkability. This method is used for dependent variables that are counts.

The results of the study show that the higher the smartness of neighborhood, the higher the influence of such characteristics are on pedestrian volume along with urban design and built environment characteristics enhance walkability. Using the results of this research, the aim is to recognize effective components of smart and introduce a framework to facilitate adaption of intelligent technologies and solution for smarter communities that enhance quality of life and promote walkable environment.

Key words: Smart City, Urban Design, Walkability, Quality of life

LITERATURE REVIEW

Quality of life in walkable neighborhoods

Recent findings in fields of economy and health shows the walkable neighborhoods are vibrant engines of economic growth and health. Residents of walkable neighborhoods show higher satisfaction of the quality of life in their neighborhoods. Great body of research, in recent years, has recognized important characteristics of walkable neighborhoods. Surveying 1726 adults in 32 neighborhoods in Seattle, WA, and Baltimore, MD, shows more residents' satisfaction in neighborhoods with diversity of land uses, proximity of destinations, attractive aesthetics and greater pedestrian/ traffic safety (Lee, et al., 2016). Another study in California studied characteristics related to higher level of neighborhood satisfaction between traditional and suburban neighborhoods. The result of this study shows that aesthetic attractiveness and safety of the neighborhood are the most important neighborhood characteristics for residents. However, residents of the traditional neighborhoods show higher satisfaction (Lovejoy, Handy, & Mokhtarian, 2010). Several researches show the significant association of built environment characteristics such as land use diversity and street connectivity (Cervero & Duncan, 2003; Saelens, Sallis, & Frank, 2003; Saelens & Handy, 2008; McConville, Rodriguez, Clifton, Cho, & Fleishhacker, 2011). The aesthetic attractiveness can be measured with urban design feature of neighborhood (Lynch, 1960; Jackson, 2003; Ewing, Handy, Brownson, Clemente, & Winston, 2006; Adkins, Dill, Luhr, & Neal, 2012). In the literature review below, we took a look at previous studies on the association of built environment characteristics and urban design feature with walkability of the neighborhood. Then we reviewed smart city literature to define a smart walkability framework to determine smart characteristics of neighborhoods that attract and comfort pedestrian and associated with higher walking and higher quality of life satisfaction.

Built environment characteristics

Researchers in transportation, planning health, and behavioral studies have recognized the influence of neighborhood's built environment characteristics on walking behavior of residents. Extensive reviews of literature related to built environment and walking in past decades show the significant association of density, land use mix and destination proximity with walking (Saelens & Handy, 2008). Transportation researchers argue that residents of sprawling neighborhoods are less likely to walk compare to those living in denser neighborhood with greater street connectivity, and mix of land uses and destinations in proximity (Saelens, Sallis, & Frank, 2003; Cervero & Duncan, 2003; Ewing & Cervero, Travel and The Built Environment, 2010; Hajrasouliha & Yin, 2015). Such attributes can be seen in traditional neighborhoods with higher density of residential units and diversity of land uses in walkable distances. Besides, the grid layout of traditional neighborhoods provide direct path from origin to destination. Residents of such neighborhoods that provide greater mixture of offices and commercial land uses in proximity of residential land uses walk more (Cervero & Duncan, 2003; Saelens, Sallis, & Frank, 2003). A meta-analysis of travel and built environment conducted by Ewing and Cervero (2010) shows that walking is highly related with diversity of land uses. This study also indicates that destination proximity and street connectivity are to important built environment characteristics associated with walking. According to literature, higher density, higher street connectivity, diversity of land uses, and proximity of destinations identify "walkable neighborhoods". Such neighborhoods have better pedestrian infrastructure such as street lighting and continues sidewalk and offer different routing options between two points (Jackson, 2003). Study of 32 neighborhoods in Seattle, WA, and Baltimore, MD, regions, shows that adults living in high walkable neighborhoods walk 34 to 47 minutes more per week compare to residents of low walkable neighborhoods (Sallis, et al., 2009). In another study in Montgomery County MD, McConville et al. (2011) Surveyed 260 individuals to investigate the relationship between walking and neighborhood land uses. The result shows higher density and diversity of land uses such as offices, retail stores, groceries and bus stops are positively associated with walking. The important note here is that majority of articles investigating the association of walking and built environment separated purpose of walking to walking for transportation and walking for leisure. However, this study does not separate walking based on purpose and focuses on walking in general.

Urban Design Features

In addition to gross built environment characteristics, urban design features of streets play an important role in promoting walking. Busy streets, pleasant sceneries, trees and landscaping attract pedestrians (Jackson, 2003; Adkins, Dill, Luhr, & Neal, 2012). Kevin Lynch (1960) discovered that color, form, arrangement define the quality of space and makes them memorable and distinguishable. He says, “It is that shape, color, or arrangement which facilitates the making of vividly identified, powerfully structured, highly useful mental images of the environment”. This “Imageability” attracts people and provides them pleasant experience. Mehta (2014) adds human scale and enclosure factors to imageability to evaluate the pleasurability of public spaces in Tampa Florida. Human Scale is related to size, texture and articulation of physical elements that corresponds to size of humans and human’s walking speed. In addition, Enclosure defines the space and evokes sense of safety and comfort. Enclosure refers to boundaries of space and the degree to which streets or public spaces are defined by physical elements such as buildings, walls, edges, etc. Study of four public spaces in Tampa, Florida, shows the significant influence of human scale characteristics of the environment, enclosure of complexity of the space in attracting pedestrians (Mehta, 2014). The complexity refers to diversity and combination of forms and physical elements, ornamentation and activities defines the richness of the environment (Ewing & Handy, 2009; Mehta, 2014).

Using rating of video clips by an expert panel, Reid Ewing et al. (2006; 2009) identified and operationalized five urban design qualities related to walkability. These urban design qualities are imageability, human scale, enclosure, complexity and transparency. They provided guideline to measure these five urban design qualities based on 20 streetscape features. Using this guideline, study of 588 street segments in New York City shows that proportion of first floor with windows and proportion of active uses significantly increases pedestrian walkability (Ewing, Hajrasouliha, Neckerman, Purciel-Hill, & Greene, 2016).

However, there are several neighborhood characteristics make walking experience pleasurable and not listed in these two main groups. One example is safety supported by video surveillance cameras or extra security officers. Several studies indicate that feeling of safety and higher number of video surveillance cameras attracts pedestrians and promote walking. On the other hand, in today’s smart era, new advancements in technology has helped cities to recognize the needs and provide smart solutions to improve quality of life for residents.

Accordingly, we found the relationship between smart characteristics of the neighborhood and walkability as the gap in walkability literature and smart city literature. This study aims to examine the association of smart characteristics of the neighborhood and walkability in addition to built environment characteristics and urban design features. However, due to lack of a universal definition for “smart” and it is important to know that this paper does not aim to define smart cities. However, first we provide a background on definition of smart cities and define a framework for evaluating smart characteristics of neighborhoods related to walkability.

Walkable Neighborhoods in Smart Era

The idea of smart cities emerged after increasing population in urban areas, following the economic boom and technological developments of last decades of twentieth century. The advancement in information technology and communication introduced new ways of recognizing demands and managing services to improve quality of life for residents.

Smart City has a broad definition and numerous researchers tried to provide a universal definition for Smart City and conceptualized it as digital city, intelligent city, real-time city, green city, sustainable city, etc. (Komninos, 2006; Hollands, 2008; Kitchin, 2014; Albino, Berardi , & Dangel, 2015; Harrison & Donnelly, 2011; Finger & Razzaghi, 2017). Several of such studies focused on the digital aspect of smart cities and define smart city as an interconnected city that implement technological based solutions and use Information and communication technology to create connection between all elements of the city (Hollands, 2008; Chourabi, et al., 2010; Kitchin, 2014; Finger & Razzaghi, 2017). Neirotti et al. (2014) argue that Smart cities aim to optimize the use of urban resources, tangible and intangible, to increase liveability and improve quality of life. Although, information and technology are key elements of smart cities but not all components of smart cities are technology based. Changes in urban living environments and investments in human capital play important role in increasing liveability and improve quality of life (Giffinger & Gudrun, 2010). Smart cities aim to optimize the use of urban resources, tangible (i.e. built environments, infrastructure and natural resource) and intangible (i.e. knowledge capital, human capital, etc.) (Neirotti , De Marco, Cagliano, Mangano, & Scorrano , 2014). A comprehensive definition of smart city includes all digital and non-digital initiatives that work together to improve quality of life for residents. However, such definition for smart city includes a vast variety of resources and a collection of single initiatives creates a smart city (Cocchia, 2014).

Moreover, in order to better define smart city, several studies define categories and classified these resources and initiatives (Harrison & Donnelly, 2011; Chourabi, et al., 2010; Neirotti , De Marco, Cagliano, Mangano, & Scorrano , 2014). Reviewing the smart city literature, Neirotti et al. (2014) classified smart city key elements into six domains and provided definition for thirteen sub-domain. Then they analyzed the application of these domains in launched projects in 70 cities across the world. For the purpose of this study, we used definition of these 13 domains to analyze the smart neighborhood characteristics related to walkability. Figure 1 shows classification of Smart City domains and sub-domains provided by Neirotti et al. (2014).

Table 2
Classification of Smart City domains and sub-domains.

Domain	Sub-domain	Description
Natural resources and energy	Smart grids	Electricity networks able to take into account the behaviours of all the connected users in order to efficiently deliver sustainable, economic, and secure electricity supplies. Smart grids should be self-healing and resilient to system anomalies
	Public lighting	Illumination of public spaces with street lamps that offer different functions, such as air pollution control and Wi-Fi connectivity. Centralised management systems that directly communicate with the lampposts can allow reducing maintenance and operating costs, analysing real-time information about weather conditions, and consequently regulating the intensity of light by means of LED technology
	Green/renewable energies	Exploiting natural resources that are regenerative or inexhaustible, such as heat, water, and wind power
	Waste management	Collecting, recycling, and disposing waste in ways that prevent the negative effects of an incorrect waste management on both people and the environment
	Water management	Analysing and managing the quantity and quality of water throughout the phases of the hydrological cycle and in particular when water is used for agricultural, municipal, and industrial purposes
	Food and agriculture	Wireless sensor networks to manage crop cultivation and know the conditions in which plants are growing. By combining humidity, temperature, and light sensors the risk of frost can be reduced and possible plant diseases or watering requirements based on soil humidity can be detected
Transport and mobility	City logistics	Improving logistics flows in cities by effectively integrating business needs with traffic conditions, geographical, and environmental issues
	Info-mobility	Distributing and using selected dynamic and multi-modal information, both pre-trip and, more importantly, on-trip, with the aim of improving traffic and transport efficiency as well as assuring a high quality travel experience
	People mobility	Innovative and sustainable ways to provide the transport of people in cities, such as the development of public transport modes and vehicles based on environmental-friendly fuels and propulsion systems, supported by advanced technologies and proactive citizens' behaviours
Buildings	Facility management	Cleaning, maintenance, property, leasing, technology, and operating modes associated with facilities in urban areas
	Building services	Various systems existing in a building such as electric networks, elevators, fire safety, telecommunication, data processing, and water supply systems. Computer-based systems to control the electrical and mechanical equipment of a building
	Housing quality	Aspects related to the quality of life in a residential building such as comfort, lighting, and Heating, Ventilation and Air Conditioning (HVAC). It includes all that concerns the level of satisfaction of people living in a house
Living	Entertainment	Ways of stimulating tourism and providing information about entertainment events and proposals for free time and night life
	Hospitality	Ability of a city to accommodate foreign students, tourists, and other non-resident people by offering appropriate solutions to their needs
	Pollution control	Controlling emissions and effluents by using different kinds of devices. Stimulating decisions to improve the quality of air, water, and the environment in general
	Public safety	Protecting citizens and their possessions through the active involvement of local public organisations, the police force, and the citizens themselves. Collecting and monitoring information for crime prevention
	Healthcare	Prevention, diagnosis, and treatment of disease supported by ICT. Assuring efficient facilities and services in the healthcare system
	Welfare and social inclusion	Improving the quality of life by stimulating social learning and participation, with particular reference to specific categories of citizens such as the elder and disabled
	Culture	Facilitating the diffusion of information about cultural activities and motivating people to be involved in them
	Public spaces management	Care, maintenance, and active management of public spaces to improve the attractiveness of a city. Solutions to provide information about the main places to visit in a city
Government	E-government	Digitizing the public administration by managing documents and procedures through ICT tools in order to optimise work and offer fast and new services to citizens
	E-democracy	Using innovative ICT systems to support ballots
	Procurement	Allowing the public sector improving procurement procedures and the associated contract management, with the purpose of assuring best value for money without decreasing quality
	Transparency	Enabling every citizen to access official documents in a simple way and to take part in the decision processes of a municipality. Decreasing the possibility for authorities of abusing the system for their own interests or hiding relevant information
Economy and people	Innovation and entrepreneurship	Measures to foster the innovation systems and entrepreneurship in the urban ecosystem (e.g. presence of local incubators)
	Cultural heritage management	The use of ICT systems (e.g. augmented reality technologies) for delivering new customer experience in enjoying the city's cultural heritage. Use of asset management information systems to handle the maintenance of historical buildings
	Digital Education	Extensive Use of modern ICT tools (e.g. interactive whiteboards, e-learning systems) in public schools
	Human capital management	Policies to improve human capital investments and attract and retain new talents, avoiding human capital flight (brain drain)

Figure 1. Description of Smart City domains and sub-domains *(Neirotti , De Marco, Cagliano, Mangano, & Scorrano , 2014)*

Based on descriptions provided in Figure. 1, we verified smart neighborhood characteristics related to walkability and evaluated and scored each if the three study based on its smart features. We defined our hypothesis for this study as "smart neighborhood characteristics in addition to built environment and urban design feature increases walkability". To sets our hypothesis in three streets in Fort Worth, TX and evaluated walkability of these streets based on the built environment, urban design features and neighborhood smartness.

METHODOLOGY

Study Area

To select the study area, we designed an anonymous preference survey and asked volunteer respondents to select three streets in Fort Worth Texas that they prefer to walk. Out of 150 distributed survey 50 people responded and selected their walkable streets in Fort Worth. Main Street in downtown area, W Magnolia street and W7th street have the highest ranking among all streets in Fort Worth. Based on the result of the survey. We selected our study areas as below.

Main Street – Main Street in downtown area is ½ mile long locating between Fort Worth Convention Center and Tarrant County Court. This street consists of 9 street segment and 18 block faces.

W Magnolia Street – W Magnolia Street between Hemphill Street and 8th Avenue is ¾ mile long and consists of 14 street segment and 28 block faces.

W7th Street – W7th Street locates west of downtown area and is ¾ mile long, between W7th Street Bridge on Trinity River and University drive. This street consists of 16 block faces.

The street segment is defined as the portion of the street between each intersection and the block face is one side of the street when the block is on the right side and the street is on the left side.

Dependent Variable

Number of pedestrian is the dependent variable for this study. We used Moving Observer Method for manually counting pedestrians in field. In this method, the observer walks in one selected direction and counts all pedestrians he or she passes. The count will be repeated in the opposite direction and the number of pedestrian. In this study, we counted the number of pedestrian as we walked along each block face of these streets. We did the pedestrian count in morning (11AM – 12PM) and evening (6PM to 8PM), on week days and weekends. The average number of pedestrians counted is used as the dependent variable in our final model.

Independent Variables

Urban Design Features

For the purpose of this study we measured the urban design features in each block face based on the method used by Ewing et al. (2006; 2009; 2016) used for quantifying urban design features and measuring urban design qualities related to walkability in New York City. Using ratings of video clips by an expert panel, Ewing et al. (2006; 2009) operationalized five urban design qualities based on 20 urban design features. These urban design qualities are Imageability, Enclosure, Human Scale, Transparency, Complexity and the description is provided in Table 1. In this study, more than 130 features of streetscapes were measured using video clips. These features were then tested for associations with urban design quality ratings by the expert panel. Twenty features proved significant in one or more models. We used field manual and measurement tool used in this study to evaluate urban design characteristics of each block face. The field manual and

Urban Design Features Related to Walkability	
Imageability	
	Number of courtyards, plazas, and parks
	Number of major landscape features
	Proportion historic building frontage
	Number of buildings with identifiers
	Number of buildings with non-rectangular shapes
	Presence of outdoor dining
	Number of people
	Noise level
Enclosure	
	Number of long sight lines
	Proportion street wall
	Proportion street wall
	Proportion sky
	Proportion sky
Human Scale	
	Number of long sight lines
	Proportion windows at street level
	Average building heights
	Number of small planters
	Number of pieces of street furniture and other street items
Transparency	
	Proportion windows at street level
	Proportion street wall
	Proportion active uses
Complexity	
	Number of buildings
	Number of basic building colors
	Number of accent colors
	Presence of outdoor dining

measurement tool used are available on website of Active Living Research ***(Active Living Research, n.d.).***

Table 1. Urban Design Characteristics & Their Features provided by Ewing et al. (2006)

The urban design features of each block face were measured manually in the field and five urban design quality were computed and tested in the model. However, only the significant ones are chosen for using in the final mode

Built Environment Characteristics

Built environment characteristics were mainly collected from secondary sources, EPA Smart Location Database, Census data, American Community Survey (ACS), City of Fort Worth and North Central Texas Council of Governments (NCTCOG). In addition, the Geographic Information System (GIS) was used to compute variables for this study.

In addition, Walk Scores presents destination accessibility in our model. Walk Score is an Internet-based platform that rates the walkability of a specific address on scale of 0 to 100 by accumulating the number of nearby stores and amenities within an extended walking distance. Thirteen destinations included in measuring walkability are groceries, restaurants, bar and coffee shops, libraries and book stores, fitness centers, drug store, clothing or music stores, schools, cinemas, parks, and hardware stores. For this study, we got address of the approximate midpoint of each block face using Google Street View and then entered into the Walk Score web site to acquire a score for each segment. This platform also provides transit score for each of the entered addresses.

Smart neighborhood Characteristics

To define smart neighborhood characteristics, we used the descriptions provided in figure 1. by Neirotti et al. (2014) and we identified smart neighborhood characteristics related to walkability based on field observation and smart city literature. The description of these smart features is provided in table 2. We then add up the number of smart characteristics each street has and names it smart score and include it in the model for each street.

Neighborhood Smart Characteristics		
Natural Resources		
		Programs that promotes other type of transportation mode other than car for reducing emission (info from www.parkingit.com)
People Mobility Total		
		Public Transportation – Number of Transit Stations
		Public Transportation – Transit Score
		Bike Sharing Program
		Availability of bike thoroughfare plan (https://fortworth.bcycle.com/printable-map)
		Bike promoting app
		Existence of Bike Lanes
		Free Valley Parking Program
		Car Charging Station
		Push to walk button at Cross Walks
		Proper Side Walk – continuous, proper pavement, 6ft wide min.
Living		
	Entertainment	
		Social Media Activities
	Hospitality Total	
		Number of Tourist Info Centers
		Diversity of Neighborhood Tours (Scooter, walking, Carriage, etc.)
		Diversity of Events (events for all ages, groups, cultures, etc.)
		Community Event Center
		Public Space Management (Street cleaning, etc.)
	Public Safety	
		Car Patrol
		Bike Police
		Pedestrian Police
		Camera and Video Surveillances

Table 2. Smart Neighborhood Characteristics

Poisson Regression Model

For the purpose of this study, we counted number of pedestrians in in 60 block faces in 3 streets in Fort Worth. There are two type of models that is used for dependent variables that are counts with several small values, few large values and no negative value, Poisson Regression and Negative Binominal Regression. The distribution of the pedestrian counts dictates which model to use. Poison regression is used when the counts of dependent variable is equally dispersed and the variance has the same value as the mean and negative binominal regression is used when the dependent variable is overdispersed and the variance of counts is greater than the mean. The average number of pedestrian for 6 round of count is curved to the nearest number. The dependent variable in our model, number of pedestrians, range from 0 to 24, with several small numbers, few mean and large values and no negative numbers. In our model, the mean is 4.68 and standard deviation is 5.29, which shows the overdispersion of the dependent variables.

Accordingly, the negative binomial regression seems the best fit but because our sample size is small (N=60), the negative binomial regression shows biased results. For small samples, the Poisson regression is less biased and provides a better result. Accordingly, we used Poisson Regression Model to explain the relationship between built environment characteristics, urban design features and smart neighborhood characteristics variables and number of pedestrians in 60 block faces of three walkable streets in Fort Worth.

We used SPSS 25 software to estimate the Poisson regression of pedestrian counts. Because we calculated the Smart Score for each street, we include the Smart Score variable separately in the model as categorical variable and built environment and urban design variables were include as continues variables in the model. Table 3 includes the variables used in the final model.

Smart Score, one urban design variables, and three built environment proved significant in 95% level. Smart Score for Main Street with highest smart score and highest number of smart neighborhood characteristic is positively related to higher number of pedestrians with high significance of 0.002. Urban design variable, Complexity, ranges from 4.25 to 9.58 with mean value of 6.09 and standard deviation of 1.127 and Human Scale ranges from 0.99 to 9.09 with mean of 3.20 and standard deviation of 1.46. Built environment characteristics, block length, walk score and transit score have significant relationship with number of pedestrians. Block length ranges from 190.73 and 912.48 with mean value of 276.83 and standard deviation of 136.04. Walk score ranges from 48 to 91 with mean value of 71.033 and standard deviation of 9.57. Transit score Block ranges from 35 to 62 with mean value of 46.45 and standard deviation of 8.71.

	Variables	Coefficient	Standard Error	P Value
	Intercept	-9.130	1.8475	.000
Smartness	Magnolia St. Smartness (Smart Score=9.00)	1.830	.5768	.002
	W7th St. Smartness (Smart Score=15.00)	2.068	.7433	.005
	Main St. Smartness (Smart Score=16.00]	0[a]	.	.
Built Environm	Block Length	.001	.0006	.016
	Walk Score	-.021	.0088	.020
	Transit Score	.138	.0304	.000
Urban Design	Imageability	.015	.0524	.776
	Enclosure	-.046	.0978	.638
	Human Scale	.101	.0509	.047
	Transparency	.226	.1702	.184
	Complexity	.433	.0725	.000
Likelihood ratio chi-square (df)		560.05 (10)		N=62

Table 3. Poisson Regression Model of Number of Pedestrians in 62 Block Faces

Our Poisson regression model has highly significant likelihood ratio chi-square of 560.05 with 3 degrees of freedom indicates that the model is a significant fit. Three built environment characteristics - block length, walk score and transit score are significantly related to number of pedestrians. While block length and transit score are positively related to pedestrian count as expected, walk score has negative sign in our model. Land use diversity, intersection density and number of jobs is not significant in the model.

Two significant urban design features in our model are Complexity and Human Scale with expected positive sign. This is a novel finding, to our knowledge this is the first time that human scale and complexity are significant indicators of walkability using this method. The previous studies in New York and Salt Lake that used same method found Transparency and Imageability significantly related to walkability (Ameli, Hamidi, Garfinkel-Castro, & Ewing, 2015; Ewing, Hajrasouliha, Neckerman, Purciel-Hill, & Greene, 2016)

The Smart Score is significant and positively related to number of pedestrians. The result also shows the more smart score a neighborhood has, the larger effect the smart characteristics of neighborhood have on attracting pedestrians.

DISCUSSION & CONCLUSION

This study has used pedestrian counts in 62 block faces in Fort Worth, TX to explain the relationship between built environment characteristics, urban design features and smart neighborhood characteristics and pedestrian volume. Our model shows that transit score, block length and walk score are the significant built environment characteristics that are associated with walkability. Although, transit score and block length have expected positive relationship with number of pedestrians, our model shows a minor negative effect for Walk Score. The latter may be due to the minor difference between walk score between each block face. Majority of the block faces in our study area are have high walk score which may have resulted in a biased result. In addition, the built environment characteristic such as land use diversity and intersection density are associated with walking in previous studies (Saelens, Sallis, & Frank, 2003; Cervero & Duncan, 2003; Ewing & Cervero, Travel and The Built Environment, 2010; Hajrasouliha & Yin, 2015), our model does not show significant relationships between these variables and number of pedestrians. The other reason for differences between literature and our results may be due to the fact that we used number of pedestrians in our model rather than reported individual walking trips and the purpose for these trips. This can also be related to the special characteristic of the study area. Main Street is located in the middle of downtown Fort Worth with Sundance Square in the middle. Compare to the other 2 study area, Main Street in downtown and Sundance Square are regional destinations. Sundance Sq. is privately owned with diversity of events all around the year and special accommodation for visitors i. e. there are 8 free valet parking stations around Sundance Squares which facilitates parking for visitors. People come to Sundance Square for events, they walk around the Main to go to Water Garden, located south of downtown along with Main and use restaurants in the area. Although, Main Street might have lower number of stores, lower walk score and lower diversity of land-uses compare to other 2 study areas but has higher number of pedestrians. The urban design characteristics, Complexity and Human Scale significantly explain the pedestrian activity. The model shows than higher human scale and complexity associated with higher volume.

Although Magnolia Street was selected as the top choice among survey respondents, it has the lowest number of pedestrians. Magnolia St. has the shortest block length, which based on our model, has negative effect on attracting pedestrians. Furthermore, based on the site observations, this street does not have proper lighting at night and proper landscaping for shadows during the day and overall it is a quiet street compare to the other two study areas. Another difference between Magnolia Street and other two sides is that both of those streets have plaza (Sundance Sq. in Main) and park (Trinity Park at W7th St.). The highest number of pedestrians was counted in segments near these amenities. Several studies show that access to parks and plazas increases pedestrian activity.

In addition to built environment and urban design characteristics, our model shows that higher the smart score has higher influence on pedestrian activity. Meaning that higher number of smart characteristics a street has, the stronger role such features, either technology based or non-technology based, have in attracting pedestrians. This is a novel finding for both planners and practitioners. The other interesting note related to smart score is that, the SPSS software, did not include the smart score for the Main Street in the model with highest Smart Score. This may also be explained by the special contexts of this street. Private management, several events year round, lighting design, several social media accounts covering activities and events in Sundance Sq. and etc., attracts people from other cities in the region. However, the result of our study shows that smart neighborhood characteristics in West 7th St. with higher Smart Score have higher association with pedestrian activity.

The implications of this study for planning practice is that in addition to urban design features and built environment characteristics, there are several smart neighborhood characteristics that can be used to increase pedestrian activities. Not all these smart features are technology base but they are also non-technology based with all aiming is making walking experience enjoyable, comfortable and safe for pedestrians. Several programs in each of the smart domains can be defined and implemented in selected streets to increase vibrancy. Another important smart tool is delivering information and covering the events. In our study areas, several social media channels are informing and covering events in downtown (Main St. and Sundance Sq. area) in addition to local restaurants and businesses but for Magnolia St. only some local businesses and restaurants are active in social media and there are few neighborhood or community social media coverage. The reason for this may be due to the private management of downtown Fort Worth that invest in advertising and introducing the area region wide and nationwide.

In conclusion, urban planners and developers can create more walkable neighborhoods by defining smart neighborhood framework using technology base and non-technology base solutions. The smart neighborhood programs may vary based on neighborhood contexts and demands but with a smart framework and smart management, cities can develop walkable neighborhoods.

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