The Impacts of Interactive Accessibility Information on Residential Location Choice and Travel Behavior: An Experimental Study

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Abstract

Due to the impact of increasing road congestion and automobile dependency, and rising concerns with urban sprawl and pollution, there is a critical need to develop effective strategies that can foster more sustainable travel behavior. Information intervention strategies have been widely applied to influence short-term travel behavior (e.g. route choice), but rarely been found effective to affect long-term travel behavior (e.g. sustainable mode choice). This paper proposes an interactive accessibility information intervention strategy to study the impacts of interactive accessibility information on residential location choice and downstream travel behavior. An interactive online accessibility mapping application (a key component of the proposed strategy) is designed and developed to provide users personalized accessibility information based on their travel needs and assist their residential location decision-making process. To evaluate the effectiveness of the proposed strategy, an experiment is designed with participants selected from the population relocating to Tippecanoe County, Indiana. Participants in the experimental group have the access to the interactive online accessibility mapping application before they make residential location choice, while participants in the control group do not. Residential location choices and travel behaviors of all participants were collected two months after they confirmed relocation. The results show that participants in the experimental group increased the importance of accessibility in their residential location decision-making process, selected housing in neighborhoods with better access to different potential destinations using different modes of transportation (including walk, bicycle, public transit, and automobile), traveled less by automobile (lower automobile mode share and shorter average travel time), and chose walk and public transit more often compared to participants in the control group. In addition, the interactive online accessibility mapping application is built on generally variable data with straightforward development and implementation processes, thereby can be readily replicable throughout a range of metropolitan context by planners and policy-makers. The proposed strategy can also be beneficial to relocating population by reducing the mismatch between their preferred residential locations and their selected residential location, and enabling more sustainable travel behavior.

Keywords: information intervention; residential location choice; travel behavior

INTRODUCTION

Travelers' decisions regarding transportation can be conceived of along a long term to short-term spectrum. In the long-term, individuals decide on residential location, vehicle ownership, and work destination. Over a shorter time period, people make decisions regarding parking purchase and non-work destinations. Choice of modes may be a day-to-day decision, while choice of routes may be altered virtually instantaneously. Despite this broad range of time frames, current strategies for the dissemination of transportation information concentrate at the short-term end of the spectrum (Peeta and Mahmassani, 1995; Paz and Peeta, 2009). For example, real-time information on current roadway congestion and transit operations (Kenyon and Lyons, 2003; Ben-Elia and Shfitan, 2010) can be relevant to day-to-day mode and route choices, but will rarely affect decisions made over longer time frames. At the extreme, many changeable highway message signs deliver information too late even for the shortest-term route-choice decision to be altered, and even the route-altering potential of earlier delivery of such information may be small (Al-Deek et al., 1998).

An information intervention strategy designed to improve the sustainability of people's travel behaviors would ideally work along the full time-scale range, particularly since longer-term decisions frequently constrain the shorter-term options. Yet not enough is known either about the choices at varying time scales to information interventions, or about the "downstream" impact of longer-term choices on those made over the shorter term. Strategies based on up-to-the-minute transportation information, while desirable for multiple reasons, have demonstrated limited capacity to alter travel behavior in a significantly more sustainable direction (Caspar et al., 2006).

This study seeks to develop an information intervention strategy intended for the full range of transportation-relevant decisions and test its impacts on the general population. An interactive online accessibility mapping application (http://web.ics.purdue.edu/~guo187/mp/nextrans.php) is designed and developed to enable the proposed interactive accessibility information intervention strategy. Users are prompted to enter their work locations and asked to rate the importance of six different trip purposes including work related, healthcare related, social or recreational related, restaurant related, education related, and retail or grocery shopping related trips. The application identifies five personalized levels of accessibility zones for the user for a range of transportation modes: walk, bicycle, public transit, and automobile. Such information allows participants to visualize five levels of accessibility using four transportation modes based on their work locations and the importance of six trip purposes. An experiment is designed to evaluate the effectiveness of the proposed information intervention strategy with participants selected from relocating population to Tippecanoe County, Indiana. Participants in the experimental group were exposed to the interactive online accessibility mapping application designed to assist their residential location and transportation-relevant decision-making process, while participants in the control group did not have the access. Statistical analysis is provided to detect whether there are statistically significant differences between experimental group and control group exist in four types of outcome variables, including the importance of factors affecting residential location decision, the chosen residential location's accessibility to different trip purposes, weekly drive-alone trips, and the share of trips by multiple transportation modes.

The remainder of the paper is organized as follows. The next section describes previous studies on understanding the impacts of information on residential location decision-making process and travel behavior. After that, the experiment mechanism, design and implementation are discussed. Then, the methods used to design the proposed interactive online accessibility mapping application are described. Next, the study results are discussed to demonstrate the effectiveness of the proposed information intervention strategy and impacts of accessibility information on residential location choice and travel behavior. The last section provides some concluding comments.

LITERATURE

Traditionally, residential location decision-making process has been studied under the assumption of rational choice behavior (e.g. Muth, 1969; Hechter and Kanazawa, 1997). Under such assumption, individuals have complete information related to residential location choices available and the ability to process such information. Individuals make their residential location decision by comparing the available choices and performing trade-offs among different contributing factors. Four key categories of contributing factors that influence residential location decision-making process have been identified in previous studies (e.g. Kim et al., 2005; Prashker, et al., 2008), including property physical characteristics, neighborhood environment, transportation accessibility, and decision-makers' characteristics. Transportation accessibility quantifies the ability to access various potential destinations from a property. Previous studies have shown that transportation accessibility related factors, including work commute time and distance (e.g. Molin et al., 1999; Zondag and Pieters, 2005; Bayoh et al., 2006) and commuting cost (e.g. Anas, 1985), are important factors that affect residential location decision-making process. However, several recent studies (e.g. Chorus et al., 2006; Rodriguez and Rogers, 2014) found that rational choice behavior assumption used in aforementioned studies is unrealistic in residential location decision-making process due to lack of information or the ability to process it for individuals, especially for the relocating populations (Guo et al., 2015).

Palm and Danis (2001), Schwanen and Mokhtarian (2004), Chorus et al (2006), and Simonsohn (2006) have shown that most of the relocating populations may lack the information of commuting costs (or unable to process it) and over predict the ease of adaptation to a long commute, thereby tend to experience longer average commute time in a new city compared to what they did in previous cities. Simonsohn (2006) also found that the mismatch between the preferred commute time and the actual commute time at their initial residential location in the new city could lead them to move again within the city. These studies show that residential location choice has a significant impact on downstream travel behavior. In addition, residential location decision-makers often lack of information in terms of the choice set of all possible alternatives, and the precise attributes of transportation accessibility. This often leads to a mismatch between selected residential location and transportation needs of individuals or family, thereby results in longer commute time and higher automobile dependency.

There is a vast body of literature designing effective information intervention strategies that can enable more sustainable travel behavior. Majority of studies (e.g. Kenyon and Lyons, 2003) concentrated at the short-term end of the spectrum of transportation information on travel behavior. Previous studies (Caspar et al., 2006; Rodriguez et al. 2011) found that strategies based on short-term transportation information, have demonstrated limited capacity to foster more sustainable travel behavior. Some studies attempted to use economic disincentives (Foxx and Hake, 1977; Jakobsson et al., 2002), environmental and financial travel feedback program (Tertoolen et al., 1998; Fujii and Taniguchi, 2005), social marketing program (Cooper, 2007), and moral motivation program (Shannon et al., 2006; Eriksson et al., 2008) to reduce automobile usage and dependency, and increase mode share of other modes of transportation (walk or public transit). However, some travel behaviors (for example, mode choice) have been found to be habitual behavior (Aarts et al., 1997; Guo, 2011; Rodriguez et al., 2014), and such behaviors are difficult to alter if once established. Hence, the effective duration of the aforementioned programs are often very short, and it is difficult to identify robust strategies to enable more sustainable travel behavior (Graham-Rowe et al. 2011).

Recently, Rodriguez and Rogers (2014) conducted an experimental study to evaluate the effects of accessibility related information on residential location choice and travel behavior. Accessibility related information intervention was provided to student population in the experimental group to assist them on their residential location decisions. The resulting outcomes illustrated that students with information select residential locations that are closer to campus and their automobile usage is also significantly reduced compared to students without information. While Rodriguez and Rogers (2014) illustrate the likely effects of accessibility related information on residential location choice and travel behavior, three key barriers exist to their strategy for the general population. First, the accessibility related information provided in their study is fixed and limited. Only the locations of shopping malls and the university were provided, and other potential destinations (e.g. retail or recreational locations) were not included. Second, their study population is limited to university graduate students who tend to be young and independent, and may be more susceptible to information and changing habits. Such an information delivery strategy may not be replicated in the general population. Third, the residential location decision made by the participants is limited to the context in which they often choose renting over purchasing a home, and their lease is renewed annually or semiannually; the potential long-term impact of accessibility related information on residential location choice may not be observed. Hence, there is a practical need to develop an information intervention strategy intended for the full range of transportation-relevant decisions and test its impacts on the general population.

To address these limitations, this study proposes an interactive accessibility information delivery strategy to examine the impacts of accessibility information on residential location choice and travel behavior. The proposed strategy enables users to receive personalized accessibility information using an interactive online accessibility mapping application. The effectiveness of the proposed strategy is tested in an experiment designed to capture the impacts of interactive accessibility information on residential location choice and travel behavior of participants recruited from the population relocating to Tippecanoe County. The next two sections describe the experiment design and implementation, and the methods used to create the interactive online accessibility mapping application, respectively.

EXPERIMENT DESIGN AND IMPLEMENTATION

This study designs an experiment to study the impacts of interactive accessibility information on residential location choice (long-term impact) and downstream travel behavior (short-term impact) through interactive accessibility information intervention intended for residential location and transportation-relevant decisions. Figure 1 illustrates the flow of the experiment.

As shown in Figure 1, the experiment flow contains two phases, including Phase I (before participants relocated to Tippecanoe County) and Phase II (after participants relocated to Tippecanoe County). Tippecanoe County is located in the northwest quadrant of the Indiana State, U.S. with about 170 thousand people in year 2010 (U.S. Census Bureau, 2010). It consists of five towns (Battle Ground, Clarks Hill, Dayton, Shadeland and Otterbein) and two cities (Lafayette and West Lafayette). Over half of the population in Tippecanoe County is located in Lafayette (38.9%) and West Lafayette (17.1%, excluding students in Purdue University). Students in Purdue University (located in West Lafayette) represents 40% of population in Tippecanoe County, and only about 3% of the population is located in five towns.

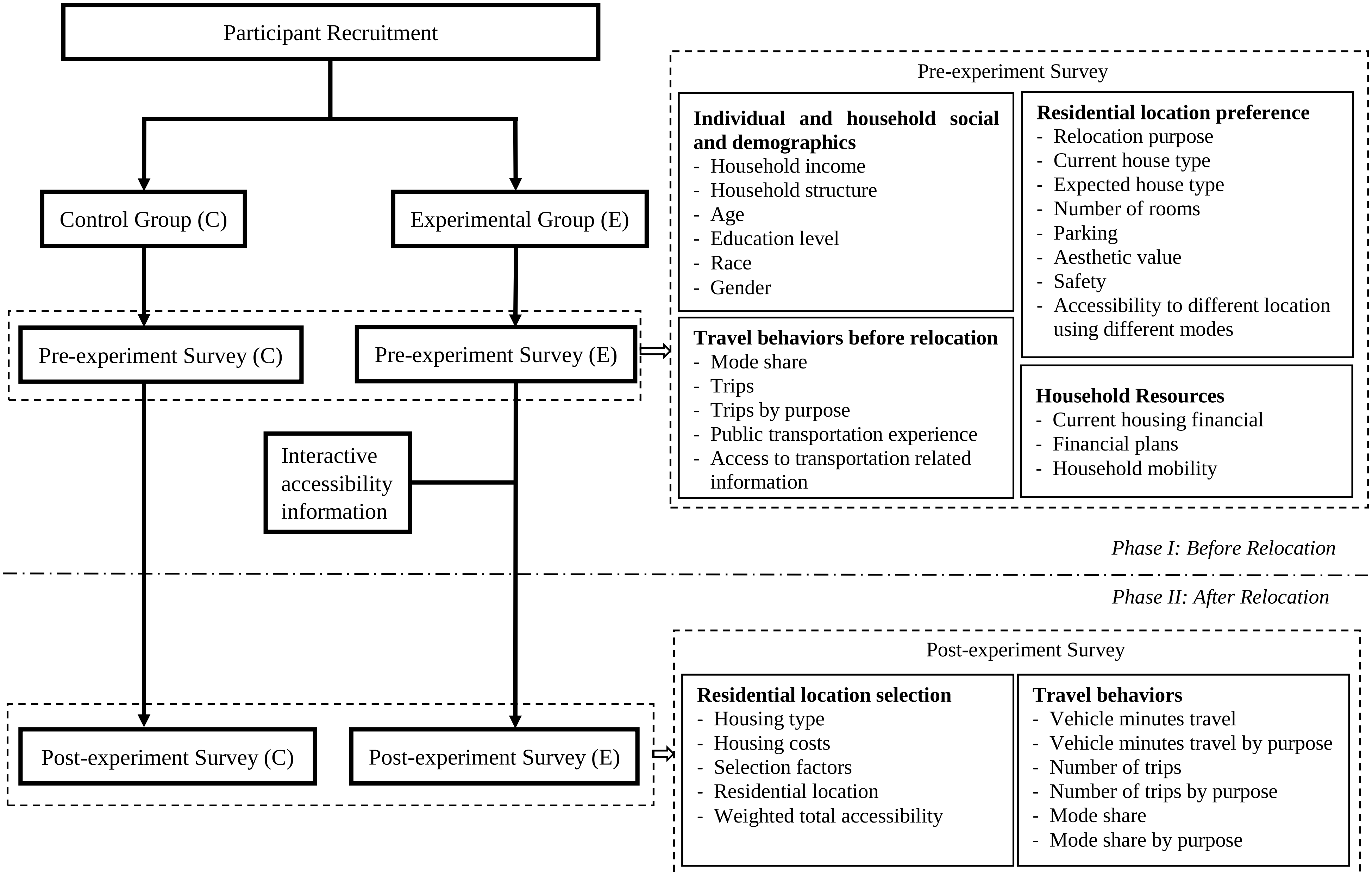

Figure 1. Experiment flow.

Participants are recruited from the population relocating to Tippecanoe County. The study's focus on the relocating population (relocators) offers two principal benefits. First, participants will make many long- and short-term choices that can be observed. Second, transportation decisions are often described as habitual behavior (Matthies et al., 2002) under which even choices that could in principle vary on a day-to-day basis (e.g., getting into a car to drive to work) are rarely meaningfully reconsidered. A residential relocation, by contrast, is a moment at which a new set of habits is likely to take hold. For this reason, relocators may be more amenable to information-based intervention than the general population. The study participants were reached by contacting employers in the Tippecanoe County area between January-April, 2014, to distribute recruitment emails to newly-hired employees who would start work in fall, 2014. Participants agreeing to join the study were randomly assigned to control and experimental groups. Participants in the experimental group were exposed to the interactive online accessibility mapping application designed to assist their residential location and transportation-relevant decision-making process, while participants in the control group did not have such access.

In Phase I, two pre-experiment surveys, conducted from January 2014 to April 2014, were used to access both the stated residential location preference of the participants before they relocated to the Tippecanoe County, their travel behavior before the relocation (including modes, destinations, parking choices, vehicle ownership and access) and other social and demographic characteristics. The only difference is the pre-experiment survey for the experimental group contains access information to the interactive online accessibility mapping application, while the pre-experiment survey for the control group does not. The details of the pre-experiment surveys can be accessed via https://purdue.qualtrics.com/SE/?SID=SV_8qAcmdU6L050LmB (control group), and https://purdue.qualtrics.com/SE/?SID=SV_e9esAuD1Kis8wXH (experimental group).

In Phase II, two post-experiment surveys were delivered to control and experimental groups two months after participants confirmed their relocation. In the post-experiment surveys, conducted from August 2014 to October 2014, the information of the importance of different factors that affect to their residential location choices, their travel behavior after relocation, and self-reported residential location choices. One more question was added in the post-experiment survey for the experimental group and asked participants to rate the usefulness of the interactive online accessibility mapping application on a scale of 1-5, where 1 indicates not useful and 5 indicates extremely useful. The post-experiment survey can be accessed via https://purdue.qualtrics.com/SE/?SID=SV_dbqFxfB2gwgQM0B (control group), https://purdue.qualtrics.com/SE/?SID=SV_6xIknIURCaVyxa5 and (experimental group).

Four sets of outcome variables, included in post-experiment surveys, were selected to explore the impacts of interactive accessibility information on residential location choice and travel behavior. The first two outcomes are related to residential location choice and the other two are related to travel behavior: (i) the importance of factors affecting residential location decision; (ii) the chosen residential location's accessibility to different trip purposes; (iii) weekly drive-alone trips, measured in minutes travelled; and (iv) the share of trips by multiple transportation modes. The first set of outcome variables was based on a participant's assessment of the importance of 11 individual factors affecting their residential location decision at the time of pre-experimental survey and at the time of post-experiment survey. The second set of variables includes the values of six types of individual accessibilities (work, healthcare, social and recreational, restaurant, educational, and retail and grocery accessibility) for the neighborhood selected by participants and the weighted accessibility. The third set of variables includes average travel time of one drive-alone trip and weekly drive-alone trips, measured in minutes. The fourth set of variables was based on the mode choice self-reported in the post-experiment surveys.

INTERACTIVE ACCESSIBILITY INFORMATION INTERVENTION

The interactive accessibility information intervention in this study is provided through an interactive online accessibility mapping application. Users are prompted to enter their work locations and asked to assign weights to six different trip purposes including work related, healthcare related, social or recreational related, restaurant related, education related, and retail or grocery shopping related trips. The sum of those assigned weights are one hundred. The application identifies neighborhoods with five personalized levels of accessibility for the user for a range of transportation modes: walk, bicycle, public transit, and drive. Each neighborhood represents a census block group (U.S. Census Bureau, 2010), and a total of 102 neighborhoods are included in the study area.

The work accessibility using different transportation modes is calculated by a floating catchment (FCM) method. The work accessibility (O_{nic}) of neighborhood *i* using mode *c* for participant *n* is calculated as follows. Given a neighborhood *j* identified by participant *n* as his/her work location, search all neighborhood *i* within a threshold value of travel time (t_{0c}) using a mode *c*. Then,

$$O_{nic} = f\left(t_{ijc}, t_{0c}\right) \tag{1}$$

where t_{ijc} is the travel time between *i* and *j* using mode *c*, and $f\left(t_{ijc}, t_{0c}\right)$ represents the travel time decay function. t_{ijc} was collected using Google Maps to computer the travel time between the centroid point of neighborhood *i* to neighborhood *j* using mode c. The purpose of the travel time decay function is to capture the inverse relationship between travel time and accessibility, and a kernel function is used to represent the travel time decay function:

$$\begin{cases} f\left(t_{ijc}, t_{0c}\right) = \frac{3}{4}\left[1 - \left(\frac{t_{ijc}}{t_{0c}}\right)^2\right], if\ t_{ijc} \leq t_{0c} \\ \quad f\left(t_{ijc}, t_{0c}\right) = 0\ if\ t_{ijc} > t_{0c} \end{cases} \tag{2}$$

A neighborhood's healthcare (H_{nic}), social or recreational (S_{nic}), restaurant (R_{nic}), education (E_{nic}), and retail or grocery shopping (G_{nic}) accessibilities using different transportation modes are calculated by calculated by a modified FCM method proposed by Guo et al. (2015). For example, the healthcare accessibility (H_{nic}) of neighborhood *i* using mode *c* for participant *n* is calculated as follows. Given a neighborhood i, search intended healthcare related destinations *k* within a threshold value of travel time (t_{0c}) using a mode *c*. Then,

$$H_{nic} = \sum_{j \in (t_{ikc} \leq t_{0c})} M_k f(t_{ikc}, t_{0c}) \tag{3}$$

where t_{ikc} is the travel time between the centroid point of neighborhood *i* and intended healthcare related destination *k* using mode *c*, and M_j is the weight of destination *k*. In this study, the weights of these intended destinations are assumed to be proportional to their physical areas. $f(t_{ikc}, t_{0c})$ represents the travel time decay function, and can be written as similar function used in Equation 2,

$$\begin{cases} f(t_{ikc}, t_{0c}) = \frac{3}{4}\left[1 - \left(\frac{t_{ikc}}{t_{0c}}\right)^2\right], if\ t_{ikc} \leq t_{0c} \\ \quad f(t_{ikc}, t_{0c}) = 0\ if\ t_{ikc} > t_{0c} \end{cases} \tag{4}$$

The threshold travel time for all four modes (walk, bicycle, public transit, and drive) to all destinations is defined as 30 minutes based on Luo and Qi (2009). The initial information of these destinations (including their locations and sizes) was collected via Reference USA database (Reference USA, 2014). The vendor verified the authenticity and accuracy of its recordings through telephone surveys and public records. The weighted accessibility of neighborhood i for participant n can be calculated by the following,

$$A_{in} = w_{no}O_{nic} + w_{nh}H_{nic} + w_{ns}S_{nic} + w_{nr}R_{nic} + w_{ne}E_{nic} + w_{ng}G_{nic} \quad (5)$$

And, $w_{no} + w_{nh} + w_{ns} + w_{nr} + w_{ne} + w_{ng} = 100$ (6)

where w_{no}, w_{nh}, w_{ns}, w_{nr}, w_{ne}, and w_{ng} are the weights assigned by the participant n to work, healthcare, social or recreational, restaurant, education, and retail or grocery shopping accessibility, respectively.

RESULTS

Only individuals who completed both pre-experiment and post-experiment surveys were included in the analysis. A total of 282 completed responses were collected, including 147 in the experimental group and 135 in the control group. As shown in Figure 1, the questions included in the pre-experiment surveys were classified into four parts: (1) individual and household social and demographics; (2) travel behaviors before relocation; (3) household resources; and (4) residential location preference. The first part of the survey was used to capture the participants' individual and household social and demographics. Of interest are the individual age, gender, education level, race, household structure, and household income. Table 1 illustrates the aggregated participants' individual and household social and demographics.

A key observation is that the majority of the participants in both control and experimental groups are Caucasian between age of 25 and 54 with high than high school degree with more than 2 automobiles in the household. About 50% of the participants in both groups were Caucasian, followed by Asian and African American. More than 80% of participants in both groups had higher than high school degree and the proportions of single and married participants (around 45%) are very similar. Over 70% of the participants are between age 25 and 54, and about 25% of the participants have children.

Tables 2 and 3 present participants travel behaviors and household resources available before relocation. As shown in Table 2, majority of the participants chose drive alone for both work and non-work related travels, not very frequently travel by public transit and access transportation related information more than 3 times a week. More than 70% of single work trips of the participants were made by drive alone mode, and only about 15% were made by public transit. For non-work trips, the most frequently used transportation mode by the participants was still drive alone mode (about 35%), but the shares of other modes were much larger compared to work trips. All the participants have public transit usage experience, but less than one third of them were still using public transit. Low public transit frequency, less comfortable travel, and unreliable public transit service were the three most important reasons that discourage participants to use public transit. Over 60% of the participants accessed transportation related information 3 or more than 3 times a week, and radio and television were the two most frequently used device to access the information.

Table 3 illustrates participants' household resources in terms of housing unit type and ownership at the time of pre-experiment survey, interested housing unit type, and expected ownership. Majority of the participants owned single-family detached home and expected to purchase a single-family detached home with mortgage in Tippecanoe County after they relocate.

Table 1. Social and economic characteristics of the participants

	Control Group (N = 135)	**Experimental Group (N = 147)**
Gender		
Male	50.4%	52.4%
Female	49.6%	47.6%
Race/Ethnicity		
African American	14.8%	21.1%
Asian	23.7%	13.6%
Hispanic/Non-white	8.9%	6.8%
Hispanic/White	5.2%	4.1%
Caucasian	47.4%	54.4%
Other	0%	0%
Marriage Status		
Married	44.4%	47.8%
Single	45.2%	45.4%
Separated	3.7%	1.4%
Divorced	6.7%	5.4%
Education level		
Some high school	5.2%	7.5%
High school diploma	13.3%	11.6%
Technical college degree	25.2%	27.9%
College degree	29.6%	30.6%
Post graduate degree	26.7%	22.4%
Annual household income		
Under $14,999	5.9%	5.4%
$15,000 – $24,999	11.9%	13.6%
$25,000 – $34,999	15.6%	12.9%
$35,000 – $49,999	18.5%	17.0%
$50,000 – $74,999	16.3%	18.4%
$75,000 – $99,999	14.8%	13.6%
$100,000 or more	17.0%	19.0%
Age		
Under 25	16.3%	15.6%
25 – 34	29.6%	36.7%
35 – 44	31.1%	25.9%
45 – 54	13.3%	12.9%
Over 54	9.6%	8.8%
Average number of people living in a household	1.9	2.1
Percent of participants with children under 6	11.9%	15.0%
Percent of participants with children between 6 and 17	14.8%	10.2%
Average number of licensed and operable motor vehicles in a household	2.2	2.1

Table 2. Travel related behavior at the time of pre-experiment survey (the number in the parentheses is the percentage)

	Control Group (N = 135)	**Experimental Group (N = 147)**
Average number of single work trips per week		
Drive alone	7.84 (74.6%)	7.52 (71.5%)
Drive with passenger(s)	0.44 (4.2%)	0.88 (8.4%)
Public transit	1.70 (16.2%)	1.50 (14.2%)
Bicycle	0.37 (3.5%)	0.41 (3.9%)
Walk	0.15 (1.4%)	0.20 (2.0%)
Average number of single non-work trips per week		
Drive alone	5.04 (33.0%)	6.20 (38.9%)
Drive with passenger(s)	4.77 (31.2%)	4.57 (28.7%)
Public transit	1.35 (8.8%)	0.82 (5.1%)
Bicycle	1.41 (9.2%)	1.69 (10.6%)
Walk	2.71 (17.7%)	2.65 (16.7%)
Expected work-related parking behavior after relocated		
Monthly parking pass	20.0%	25.2%
Paid daily parking	3.7%	2.7%
Free parking provided by employer	18.5%	17.7%
Free street parking	38.5%	37.4%
Not driving to work	19.3%	17.0%
Public transit usage (percent)		
Still using	29.6%	25.2%
Not using, but has experience	70.4%	74.8%
No experience	0.0%	0.0%
Most relevant factor that discourage public transit usage		
Transit service is not frequent enough	27.4%	29.9%
Riding transit is not comfortable	22.2%	20.4%
Transit service is not reliable	20.0%	19.0%
Wait time at transit stops is too long	16.3%	15.0%
Do not have access to transit related information	7.4%	6.8%
Riding and waiting for transit feels unsafe	6.7%	8.8%
Others	0.0%	0.0%
Frequency of accessing transportation related information per week		
Never	12.6%	12.9%
Once or twice	19.3%	21.8%
3 – 5 times	30.4%	29.9%
Once a day	26.7%	24.5%
More than once a day	11.1%	10.9%
Most frequently used device to access transportation related information		
Radio	46 (39.0%)	42 (32.8%)
Television	28 (23.7%)	32 (25.0%)
Internet	26 (22.0%)	24 (18.8%)
Applications on cell phone	18 (15.3%)	30 (23.4%)
Others	0 (0.0%)	0 (0.0%)

Table 3. Current and expected housing after relocation at the time of pre-experiment survey (the number in the parentheses is the percentage)

	Control Group (N = 135)	**Experimental Group (N = 147)**
Current housing unit type		
Single-family detached home	48.9%	42.2%
Row house/townhouse	23.0%	32.0%
Apartment	28.1%	25.9%
Mobile home	0.0%	0.0%
Other	0.0%	0.0%
Ownership of current housing unit		
Owning without mortgage	8.9%	10.2%
Owning with mortgage	56.3%	65.3%
Renting	34.8%	24.5%
Relocation purpose		
Going to work	93.3%	94.5%
Attending school	6.7%	5.5%
Interested housing types (multiple choice)		
Single-family detached home	65.2%	63.3%
Row house/townhouse	33.3%	38.1%
Apartment	36.3%	31.3%
Mobile home	0.0%	0.0%
Other	0.0%	0.0%
Expected ownership		
Owning without mortgage	15.6%	14.3%
Owning with mortgage	57.0%	53.1%
Renting	27.4%	32.7%
Expected total costs if decided to own a house without mortgage		
Under $150,000	8 (38.1%)	11 (44.0%)
$150,000 – $199,999	11 (52.4%)	12 (48.0%)
$200,000 – $299,999	2 (9.5%)	2 (8.0%)
$300,000 – $499,999	0 (0%)	0 (0%)
$500,000 or more	0 (0%)	0 (0%)
Expected monthly mortgage if decided to own a house with mortgage		
Under $1,000	29 (57.1%)	33 (42.3%)
$1,000 – $1,499	47 (61.0%)	44 (56.4%)
$1,500 – $1,999	1 (1.3%)	1 (1.3%)
$2,000 or more	0 (0.0%)	0 (0.0%)
Expected rent if decided to rent a house		
Under $500	23 (62.2%)	30 (63.8%)
$500 – $749	11 (29.7%)	13 (27.7%)
$750 – $999	3 (8.1%)	4 (8.5%)
$1,000 – $1,499	0 (0.0%)	0 (0.0%)
$1,500 or more	0 (0.0%)	0 (0.0%)

Residential Location

The questions in the post-experiment surveys were classified into two parts: (1) self-reported housing type, ownership, and location in Tippecanoe County; (2) the importance of different factors that affect participants' residential location decision. Table 4 illustrates the aggregated self-reported housing type and ownership at the time of post-experiment survey.

Compared to their interested housing type and expected ownership at the time of pre-experiment survey (Table 3), majority of the participants in the experimental group (over 95%) found the same housing type they were interested and the housing ownership matched their expectation in Tippecanoe County, and the remaining participants chose to own a house instead of renting one. However, for participants in the control group, only about 70% of the participants found the same housing type they were interested and the housing ownership matched their expectation in Tippecanoe County, and more than 10% of the participants changed from expect to own a house to rent. It suggests that a significant portion of participants in the control group was unable to find residential locations that satisfied their needs, while majority of participants in the experimental group was able to find residential locations that satisfied their needs by exposing to interactive accessibility information intervention.

Participants in the experimental group expected to stay longer in their current property than the ones of the control group. It indicates that participants in the experimental group may be more satisfied with their residential location choices and less likely to change their house compared to participants in the control group after relocated to Tippecanoe County. It also shows that participants in control group may experience mismatch between selected residential location and transportation needs of individuals or family, and they are more likely to move to another residential location within Tippecanoe County. Therefore, they expected to stay for a short period of time in their current location compared to participants in the experimental group.

Figures 1 and 2 show the aggregated level of participants' self-reported residential location in Tippecanoe County for control and experimental groups, respectively. A key observation is that participants in the experimental group chose to live closer to downtown regions (downtown Lafayette and downtown West Lafayette) and their work locations. For participants in the experimental group, the estimated average distance to downtown Lafayette (the shorted network distance from the centroid point of the housing neighborhood to downtown) is about 20% shorter and the estimated average distance to downtown West Lafayette is over 30% shorter compared to control group. In addition, the estimated average distance to their work locations (the shorted network distance from the centroid point of the housing neighborhood to the centroid point of their work place neighborhood) is about 25% shorter for participants in the experimental group compared to participants in the control group.

Importance of Different Factors that Affect Respondents' Residential Location Decision

In the last part of pre-experiment surveys (before relocation) and second part of post-experiment surveys (after relocation), respondents were requested to rate the importance of various factors that affect their residential location decision on a scale of 1-5, where 1 indicates not important at all and 5 indicates extreme importance. Eleven factors were included and can be classified into three categories: (1) physical characteristics of housing unit (cost, number of bedrooms/bathrooms, and parking); (2) neighborhood environment (aesthetic value and safety); and (3) transportation accessibility (access to education, work, park/recreation/public facilities, restaurants, retail/grocery, and healthcare). In Table 5, the averages for participants in both control and experimental groups on the importance of different factors that affect respondents' residential location decision before and after relocation are presented.

Table 4. Housing after relocation at the time of post-experiment survey (the number in the parentheses is the percentage)

	Control Group (N = 135)	**Experimental Group (N = 147)**
Current housing unit type		
Single-family detached home	40.0%	46.2%
Row house/townhouse	25.9%	32.0%
Apartment	34.1%	21.9%
Mobile home	0.0%	0.0%
Other	0.0%	0.0%
Ownership of current housing unit		
Owning without mortgage	10.4%	10.2%
Owning with mortgage	54.1%	10.2%
Renting	35.6%	69.3%
Total costs if the ownership is owning without mortgage		
Under $150,000	2 (14.3%)	4 (18.2%)
$150,000 – $199,999	7 (50.0%)	10 (45.5%)
$200,000 – $299,999	5 (35.7%)	8 (36.4%)
$300,000 – $499,999	0 (0.0%)	0 (0.0%)
$500,000 or more	0 (0.0%)	0 (0.0%)
Monthly mortgage if the ownership is owning with mortgage		
Under $1,000	17 (23.3%)	32 (36.4%)
$1,000 – $1,499	44 (60.3%)	45 (51.1%)
$1,500 – $1,999	12 (16.4%)	11 (12.5%)
$2,000 or more	0 (0.0%)	0 (0.0%)
Rent if the ownership is renting		
Under $500	17 (35.4%)	11 (29.7%)
$500 – $749	14 (29.2%)	16 (43.2%)
$750 – $999	16 (33.3%)	10 (27.0%)
$1,000 – $1,499	1 (2.1%)	0 (0.0%)
$1,500 or more	0 (0.0%)	0 (0.0%)
Expected years of staying in the current property		
Less than 1 year	25.2%	17.7%
1 – 5 years	15.6%	10.9%
5 – 10 years	57.0%	68.0%
More than 10 years	2.2%	3.4%

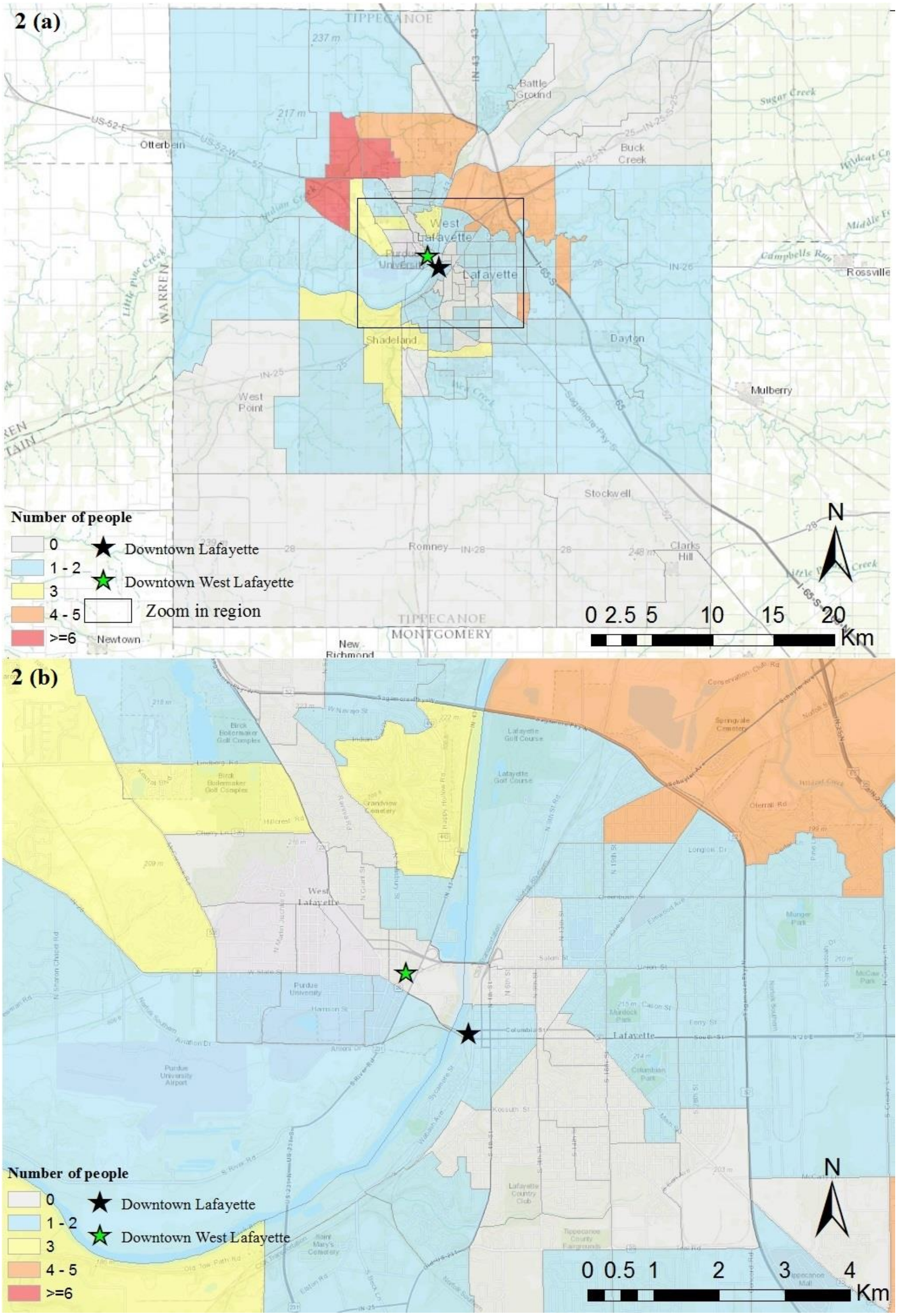

Figure 2. Self-reported residential location of the participants in the control group: (a) Tippecanoe County; (b) zoom in downtown regions of Tippecanoe County.

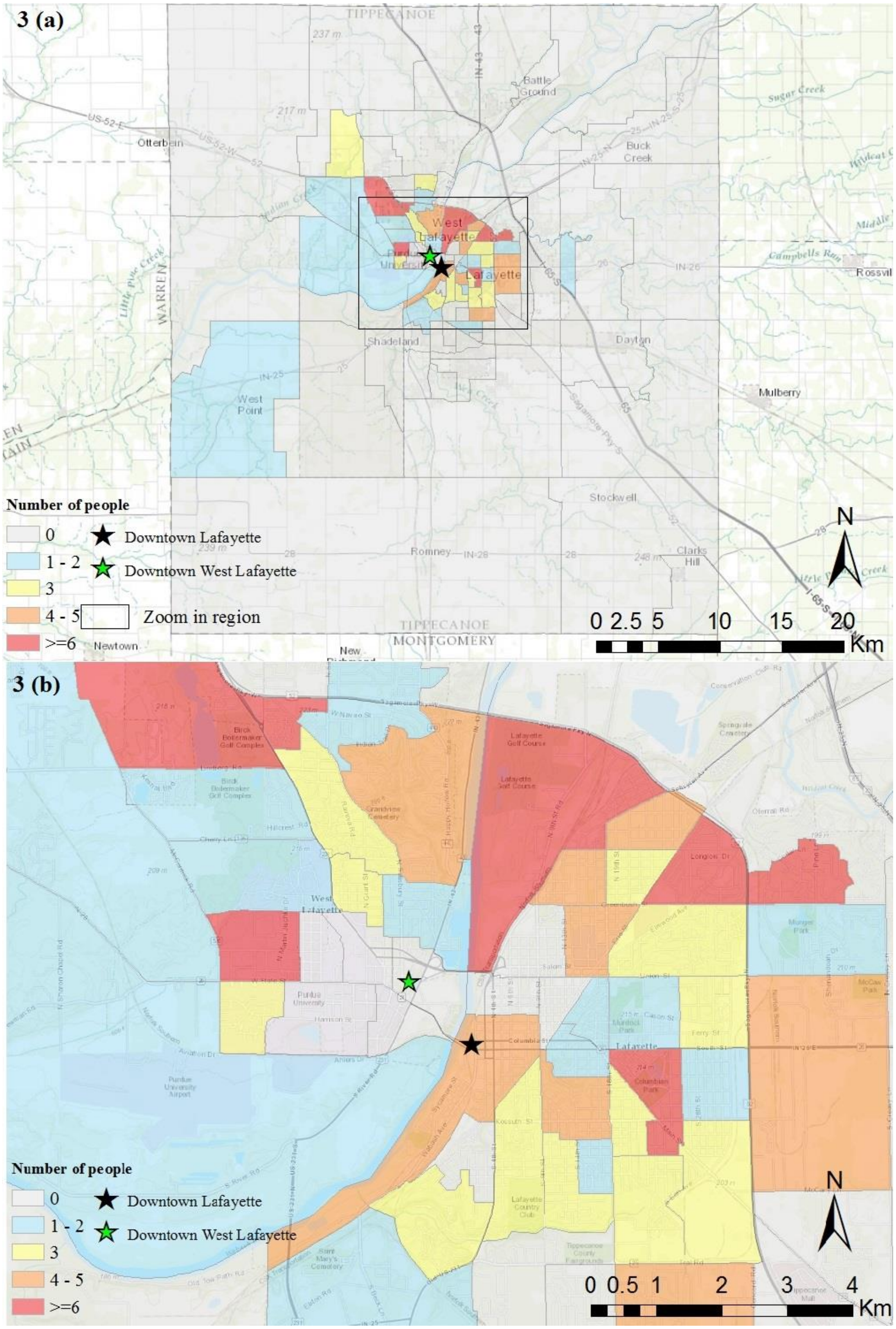

Figure 3. Self-reported residential location of the participants in the experimental group: (a) Tippecanoe County; (b) zoom in downtown regions of Tippecanoe County.

At the time of pre-experiment survey, participants in both groups have not received interactive accessibility information intervention. Cost of renting or buying (3.90 and 3.95, respectively), safety of neighborhood (3.21 and 2.99, respectively), access to work (3.03 and 2.99, respectively), and number of bedroom/bathrooms (2.97 and 3.01, respectively) are the top four factors that would affect participants' residential location decision in both control and experimental groups. For a *t*-test comparison of means of the individual factors at the time of pre-experiment survey for both groups, all factors (at the 0.05 level) were not statistically significant different. In addition, as done in previous studies (Guo et al. 2015), Spearman's rank correlation coefficients were used to analyze the statistical dependence for within-group ranking differences between control and experimental groups on these factors. The within-group ranking represents the relative ranking given on these factors based on the mean rating of each factors. The within-group ranking from control and experimental groups on factors that affect their residential location decision were found to be statistically significant correlated at the 0.01 level. Both these methods suggest a high degree of similarity between participants in the control and experimental groups on the important of factors that affect their residential location decision.

At the time of post-experiment survey, participants in the experimental group had been exposed to interactive accessibility information intervention, and the ratings of the importance of factors that affect their residential location decision reflect the self-reported residential location decision. Both *t*-test comparison and Spearman's rank correlation coefficients were used to compare the participants' ratings of these factors at the time of post-experiment surveys to their ratings at the time of pre-experiment surveys for both control and experimental groups. For a *t*-test comparison of means of the individual factors at the time of pre-experiment survey and at the time of post-experiment for control groups, all factors (at the 0.05 level) were not statistically significant different, while 4 out of 11 factors were significantly different for experiment group (at the 0.05 level. Among these 4 factors, 3 factors (access to education, parks/recreation/public facilities, and retail/grocery/other destinations) are related to accessibility of their residential location, and the average rating of the importance of all these three factors increased for experimental group. The largest ranking discrepancies for experimental group, 4 positions, occur for "parking availability" and "access to park, recreation, or public facilities".

The results (Table 5) show that there is high degree dissimilarity between the ratings of participants in the experimental group given to factors that affect their residential location decision before and after exposure to interactive accessibility information intervention. This implies that the proposed interactive accessibility information intervention has a significant impact on residential location decision made by participants in the experimental group, and influenced them to consider more about accessibility in their residential location decision-making processing.

Neighborhood Accessibility to Different Trip Purposes

In post-experiment surveys, participants were requested to identify the neighborhood (census block group) that their housing is located in Tippecanoe County. The reason to only ask for participants' neighborhood instead of their address is to protect their privacy. Table 6 illustrates the mathematical average of the accessibility of neighborhoods to six different trip purposes (work, healthcare, social/recreational, restaurants, education, and retail/grocery) and the weighted accessibility of neighborhood using four different modes, including automobile, public transit, bicycle, and walk.

Table 5. Importance of different factors affecting respondents' residential location decision

	At the time of pre-experimental survey			**At the time of post-experimental survey**			
	Control Group	Experimental Group	p-value	Control Group	p-value	Experimental Group	p-value
Physical characteristics of housing unit							
Cost of renting or buying	3.90	3.95	0.72	3.96	0.68	3.79	0.42
Number of bedrooms/bathrooms	2.97	3.01	0.74	3.02	0.73	2.95	0.86
Parking availability	2.55	2.51	0.79	2.74	0.20	2.22	0.02*
Neighborhood environment							
Safety of neighborhood	3.21	2.99	0.15	3.31	0.55	3.14	0.64
Aesthetic value	2.91	2.86	0.74	3.03	0.46	2.97	0.70
Transportation accessibility							
Access to work	3.03	2.99	0.79	3.06	0.86	2.88	0.31
Access to restaurants	2.58	2.48	0.39	2.67	0.45	2.74	0.16
Access to retail, grocery or other destinations	2.44	2.49	0.69	2.56	0.35	2.82	0.00*
Access to parks, recreation, or public facilities	2.39	2.37	0.91	2.45	0.66	2.85	0.00*
Access to education	2.36	2.44	0.65	2.27	0.56	2.82	0.00*
Access to healthcare	1.44	1.36	0.47	1.33	0.28	1.62	0.15

* denotes significance at a 95% level of confidence

Table 6. Average neighborhood accessibility to different trip purposes

Residential location accessibility	**Control Group (N = 135)**	**Experimental Group (N = 147)**	**p-value**
Accessibility to work:			
Automobile	72.75	89.63	0.67
Public transit	62.83	84.52	0.03*
Bicycle	65.11	86.93	0.07*
Walk	61.34	77.84	0.05*
Accessibility to healthcare:			
Automobile	50.24	57.21	0.62
Public transit	52.42	55.72	0.80
Bicycle	56.48	58.67	0.72
Walk	55.90	59.72	0.52
Accessibility to social and recreational activities			
Automobile	67.75	85.22	0.04*
Public transit	61.04	86.27	0.00*
Bicycle	62.69	82.64	0.05*
Walk	63.10	87.62	0.03*
Average accessibility to restaurants activities			
Automobile	70.25	82.56	0.40
Public transit	69.02	84.55	0.32
Bicycle	65.42	86.21	0.08*
Walk	67.53	87.00	0.09*
Accessibility to educational activities			
Automobile	72.42	74.62	0.75
Public transit	70.20	73.45	0.80
Bicycle	71.25	75.69	0.69
Walk	72.21	76.01	0.65
Accessibility to retail/grocery activities			
Automobile	64.38	88.34	0.04*
Public transit	66.71	87.63	0.06*
Bicycle	65.17	89.21	0.02*
Walk	66.08	90.26	0.01*
Weighted accessibility			
Automobile	67.74	80.60	0.00*
Public transit	64.43	81.23	0.00*
Bicycle	65.42	84.54	0.00*
Walk	67.22	82.10	0.00*

As shown in Table 6, the averages of all types of neighborhood accessibility for participants in the experimental group are higher compared to the averages of participants in the control group, especially for neighborhood accessibility using non-automobile modes. The results show that participants in the experimental group, who were exposed to interactive accessibility information intervention, chose neighborhoods with much better access to potential destinations compared to participants in control group without the intervention. This implies that the proposed interactive accessibility information intervention can assist participants to select neighborhoods with better access to their potential destinations, especially in terms of better neighborhood accessibility using non-automobile modes, including public transit, bicycle, and walk.

Weekly drive-alone trips and the share of trips by multiple transportation modes

In the last part of post-experiment surveys, participants were asked to provide their travel behaviors after relocation in terms of estimated average travel time of one drive-alone trips, and the average number of trips made per week to six different potential locations using five modes, including drive alone, drive with passenger(s), public transit, bicycle, and walk. Table 7 illustrates the aggregated travel behaviors of participants in the control and experimental groups.

Overall, 47.7% of the trips made by participants in the control group used drive-alone, 25.4% drive with passenger(s), 10.7% walk, 10.6% public transit, and 5.6% bicycle, while 38.2% of the trips made by participants in the experimental group used drive-alone, 25.7% drive with passenger(s), 17.8% walk, 13.1% public transit, and 5.3% bicycle. The results show participants in the experimental group had higher level of walk and public transit use, and lower drive-alone use compared to participants in the control group.

For individual trip purposes, participants in the experimental group have a shorter average travel time to all purposes compared to participants in the control group, and these differences were statistically significant for work, social/recreational, restaurants, and retail/grocery shopping trips. In addition, the mode shares of trips made by non-automobile modes (public transit, bicycle, and walk) are higher for participants in the experimental group compared to participants in the control group, especially for statistically higher walk use in social/recreational, restaurants, and retail/grocery shopping trips.

Additional tests have been done to examine whether certain subgroups among participants in the experimental group were more impacted by the interactive accessibility information intervention. Gender, age, nationality, household income, marriage status, automobile ownership, whether they were still using public transit at the time of pre-experiment survey, and frequency of accessing transportation related information per week.

No difference was found by gender, age, nationality, household income, whether they were still using public transit at the time of pre-experiment survey, and automobile ownership. The results show that participants who married and used the interactive online accessibility mapping application used drive with passenger(s) more often compared to participants who married and used the interactive online accessibility mapping application. This indicates that married participants may use the interactive online accessibility mapping application to find a housing location that meets the needs of other family members. Hence, they can make more coordinated travel plans after relocation.

The results also found that participants who accessed transportation related information more often and used the interactive online accessibility mapping application selected housing neighborhood with higher weighted accessibility. This suggests that participants who accessed transportation related information more often may use the interactive online accessibility mapping application more effectively in their residential location decision-making process.

Table 7. Comparison of travel related outcomes at the time of post-experiment survey

	Control Group (N = 135)	**Experimental Group (N = 147)**	**p-value**
Travel to work			
Average travel time of one drive-alone trip (minutes)	9.38	8.25	0.00*
Average weekly travel time of drive-alone trips (minutes)	93.47	81.85	0.00*
Percentage of trips using drive with passenger(s)	7.41	11.60	0.23
Percentage of trips using public transit	13.19	19.51	0.15
Percentage of trips using bicycle	3.26	3.68	0.84
Percentage of trips using walk	5.93	9.28	0.27
Travel to healthcare related trips			
Average travel time of one drive-alone trip (minutes)	11.33	9.44	0.60
Average weekly travel time of drive-alone trips (minutes)	24.25	21.50	0.68
Percentage of trips using drive with passenger(s)	29.41	31.25	0.91
Percentage of trips using public transit	5.88	0.00	0.32
Percentage of trips using bicycle	0.00	0.00	--
Percentage of trips using walk	0.00	6.25	0.32
Travel to social/recreational trips			
Average travel time of one drive-alone trip (minutes)	8.21	7.66	0.08*
Average weekly travel time of drive-alone trips (minutes)	32.65	27.60	0.04*
Percentage of trips using drive with passenger(s)	36.29	36.34	0.64
Percentage of trips using public transit	7.87	4.76	0.13
Percentage of trips using bicycle	15.23	13.53	0.44
Percentage of trips using walk	19.04	28.82	0.07*
Travel to restaurants related trips			
Average travel time of one drive-alone trip (minutes)	8.65	7.71	0.00*
Average weekly travel time of drive-alone trips (minutes)	36.15	30.32	0.00*
Percentage of trips using drive with passenger(s)	40.70	37.41	0.23
Percentage of trips using public transit	4.91	6.47	0.70
Percentage of trips using bicycle	1.75	1.80	0.74
Percentage of trips using walk	7.02	22.30	0.08*
Travel to education related trips			
Average travel time of one drive-alone trip (minutes)	8.93	8.11	0.72
Average weekly travel time of drive-alone trips (minutes)	52.29	45.47	0.84
Percentage of trips using drive with passenger(s)	32.69	28.68	0.92
Percentage of trips using public transit	15.38	14.73	0.87
Percentage of trips using bicycle	5.77	3.88	0.74
Percentage of trips using walk	12.50	12.40	0.84
Travel to retail/grocery shopping trips			
Average travel time of one drive-alone trip (minutes)	9.13	8.05	0.01*
Average weekly travel time of drive-alone trips (minutes)	19.29	16.19	0.00*
Percentage of trips using drive with passenger(s)	39.89	36.84	0.77
Percentage of trips using public transit	13.30	15.31	0.60
Percentage of trips using bicycle	0.00	0.96	0.16
Percentage of trips using walk	15.43	24.88	0.04*

CONCLUDING COMMENTS

This study aims to understand the impacts of interactive accessibility information on residential location choice (long-term impact) and downstream travel behavior (short-term impact). Previous studies on impacts of accessibility information on residential location choice and downstream travel behavior are limited in terms of accessibility information design, study population, and infeasibility to observe long-term impact of accessibility information. To address these limitations, an experiment was designed (Figure 1) to apply accessibility related information intervention to participants selected from the population relocating to Tippecanoe County, Indiana. Participants were randomly assigned to the control and experimental groups, and accessibility related information intervention was applied to participants in the experimental group before they relocated. An interactive online mapping application was designed for the intervention that allows personalized accessibility information been delivered to participants based on their travel needs. The impacts of interactive accessibility information on residential location choice and downstream travel behavior were observed and analyzed using four outcome variables of the control and experimental groups, including the importance of factors affecting residential location decision, neighborhood accessibility, drive-alone trips, and the share of trips by multiple transportation modes.

As illustrated by Tables 4 to 7, the proposed interactive accessibility information intervention proves to be an effective information-delivery strategy capable of affecting residential location choice and downstream travel behavior. First, participants with the intervention increased the importance of accessibility in their residential location decision-making process. Second, participants with accessibility information chose the neighborhoods with better overall access to potential destinations by public transit, bicycle, and walk, and especially with better access to restaurants, retail/grocery, and work. Third, the weekly travel time of drive-alone trips to different purposes for participants with accessibility information was 10%-16% less than participants without accessibility information. Fourth, participants with accessibility information used non-automobile transportation (walk, bicycle, and public transit) more often, and they used walk mode more often to social/reactional, restaurants, and retail/grocery shopping trips than participants without accessibility information. Fifth, the proposed intervention can also help relocating population to reduce the mismatch between selected residential location and transportation needs of individuals or family.

The proposed interactive online accessibility mapping application is built on generally available standard geographic and transportation data, and provides personalized accessibility information for multiple transportation modes (walk, bicycle, public transit, and automobile) through easily accessible platform. It is readily replicable throughout a range of metropolitan context, and can be beneficial to relocating population, planners, and policy-makers. It has the potential to increase the accessibility of individuals' residential choices, influence their travel behavior in terms of increasing non-automobile transportation usage and reducing automobile dependency, and reduce environmental impacts of their residential location and transportation choices.

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