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Identifying Micro-Level Determinants That Influence The Transportation Network Companies (Tncs) Growth Through Analysis Of Transportation Users' Preferences And Attitudes

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IDENTIFYING MICRO-LEVEL DETERMINANTS THAT INFLUENCE THE TRANSPORTATION NETWORK COMPANIES (TNCS) GROWTH THROUGH ANALYSIS OF TRANSPORTATION USERS' PREFERENCES AND ATTITUDES

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ABSTRACT

In the recent years, the use of Transportation Network Companies (TNCs) such as Uber/Lyft as a mode of travel has been growing at a significant pace. Despite the rapid growth of several TNC markets, analyses of potential and actual impacts of TNCs presence on preferences and travel patterns of TNC-aware users are still very limited. Such analyses require detailed trip data which are not easily available due to privacy concerns, as well as technical and financial feasibility issues.

To address some of these issues, the objective of this study was to document the factors that influence transportation users in the Birmingham, AL region to select TNCs such as Uber/Lyft for completing typical day trips. In order to meet the study objective, a travel diary questionnaire survey was developed in accordance with the Institute of Transportation Engineers (ITE) Manual on Transportation Engineering Studies and used to obtain information about travel preferences, typical trips, and demographic data. The Qualtrics Research Core tool was used to develop the questionnaire and administer the survey.

The questionnaire was used to survey over 451 transportation users in the Birmingham Metro Area. The survey participants provided detailed trip information for a typical 24-hr day along with demographic data and travel preference information. The analysis of responses shed light on users' awareness, usage and proliferation of TNC

services in the region. The survey responses were used to understand the leading reasons and conditions driving the use of TNCs services in the Birmingham Metro Area.

The document introduces the scope of the study, describes the study approach, discusses findings from the analysis of responses, and summarizes conclusions, and impacts. The findings provide high-resolution micro-level indicators of travel preferences and behaviors in a TNC-served area, which is a much-needed type of information for researchers and planning agencies.

Keywords: Transportation Network Companies (TNC); travel preferences; mode choice; Uber/Lyft; questionnaire survey; travel patterns; Birmingham, AL

DEDICATION

I want to dedicate my work to my parents and my sisters for their love and constant moral support throughout my life.

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure *page*

LIST OF ABBREVIATIONS

AL	Alabama
ALDOT	Alabama Department of Transportation
API	Application programming interface
CA	California
DC	District of Columbia
FTA	Federal Transit Administration
IRB	Institutional Review Board
ITE	Institute of Transportation Engineers
LLC	Limited liability company
MA	Massachusetts
NHTS	National Household Travel Survey
NY	New York
STRIDE	Southern Transportation Research, Innovation, Development and Education Center

TNC	Transportation Network Companies
TRB	Transportation Research Board
TX	Texas
UAB	University of Alabama at Birmingham
US	United States
VMT	Vehicle miles traveled
WA	Washington
ZIP	Zone Improvement Plan

CHAPTER 1

INTRODUCTION

In the recent years, Transportation Network Companies (TNCs) such as Uber/Lyft have led to an expansion of on-demand ride sharing or ride hailing transportation options. The rapid growth of the TNC market increases the need for analyses and documentation of the impacts of TNCs' presence on preferences and daily travel patterns of TNC-aware transportation system users. However, most of the TNC companies show reluctance towards sharing data about their business operations including the trip numbers on typical days and origins/destinations of such trips. Moreover, details related to their customers are protected to ensure their privacy.

Given that detailed TNC use data are not available in the Birmingham area, this study collected information about transportation users' preferences and travel patterns. Then it analyzed such data to identify the influence and impact of TNCs on the travel demand and behavior of Birmingham metro area.

Objective

The objective of this study is to understand current travel preferences and practices of transportation users in the Birmingham Metropolitan Area and document their attitudes toward TNC use as a travel mode of choice. To meet this objective, we developed a comprehensive travel diary questionnaire survey and used it to survey a TNC-aware population sample of 451 respondents in the Birmingham Metro Area.

The survey requested participants to report detailed trip information for a typical day (i.e., 24-hr travel diary) including origin and destination of each trip, travel time, trip purpose and travel mode used. Demographic data were also obtained and used in the analysis and interpretation of survey findings. The analysis helped to identify indicators that contribute to the use of TNCs and, thus, can create a shift in the travel pattern of TNC-aware populations when TNC services are available in a region.

Necessity of the Study

Travel attitudes and preferences of transportation users vary considerably from place to place thus localized studies are very important in order to understand the behavior and attitudes of transportation users based on their preferences, mode availability and accessibility, cultural differences, and local characteristics. For example, the Birmingham metro area is a medium size city with limited transit options serving a population that is highly automobile dependent. The presence of the University of Alabama at Birmingham just south of the Birmingham downtown creates a unique environment for potential spread of TNC use. Thus analysis of Birmingham transportation users' preferences and attitudes is very important for understanding the determinants that influence the transportation network companies (TNCs) growth in the region and study the impacts of TNC use on traffic congestion, parking needs, environmental impacts, and user convenience and satisfaction. This, in turn, can help the City of Birmingham and local transportation authorities to develop plans for serving the city residents and visitors better in the future.

Brief of the Chapters

Literature Review

This chapter begins with the history of Transportation Network Companies on the United States transportation system and follows with the growth of the TNCs over the time. The chapter also discusses earlier studies on users' perspectives towards TNCs and summarizes results obtained from other studies about the demographic characteristics of TNC users.

Methodology

This chapter presents the methodology used to design and develop the survey of Birmingham transportation users. It also describes the eight blocks on the survey and some of the features Qualtrics Research Core that were used to collect the data and validate the responses. Moreover, the chapter introduces the area of interest to the survey, and the sample size determined to properly represent the population of Birmingham metro area.

Survey Pretesting and Data Validation

On this chapter, the actions taken to pilot test and refine the survey were described. The initially developed survey had to go through two phases for the validation of ZIP code for ensuring that respondents reside within the survey area, and to assure that they are providing the correct data and not making up any trips. Moreover, this chapter explains the actions taken to clean the survey in order to eliminate inaccurate responses. Inaccurate responses included those that reported different home location at different blocks of the survey, or report zero distance trips, and/or zero-time duration trips.

Data Analysis and Results

This chapter presents the results from the analysis of survey data and divides them into four subchapters. Those sub-chapters discuss demographic data of respondents, user preferences towards TNCs, TNC trip characteristics and facility preferences for the transportation system.

Conclusion, Application and Recommendations

This chapter summarizing study conclusions and provides some suggestions for future work related to TNCs on Birmingham and on other regions.

CHAPTER TWO

LITERATURE REVIEW

This chapter offers an introduction on the use of Transportation Network Companies as a mode of transportation in U.S. and the launch of this services in the Birmingham metro area. The literature also introduces earlier studies on transportation users' perceptions towards TNCs that were conducted in distinct metro areas with different population density and TNC services.

Transportation Network Companies

According to the Federal Transit Administration (Transportation Network Companies, 2020), Transportation Network Companies provide the "Use of online platforms to connect passengers with drivers and automate reservations, payments, and customer feedback". Through Transportation Network Companies, a traveler can select the preferable size of the vehicle, choose the option to share with others, or reserve the full vehicle through the providers' app. Drivers with personal non-commercial vehicles can register their automobile and themselves as a provider under these companies. Sometimes, taxi companies who provide services through an app with the rider are also considered as Transportation Network Companies.

In the initial stage, TNCs introduction as an app-based mobility system with only ride-hailing options was defined as "ride-sharing" services. It was debated by Ryals et al (2014), as users did not actually share a ride with another person going to the same location

by using those app-based mobility options. Mostly, those services were used by the TNC drivers to provide mobility to certain app users from the origin to destination with convenience, mostly like a taxi service. But later, those companies introduced the option of sharing a ride along with a cost-saving incentive for users thus expanding the previous ride-hailing options on the app-based mobility services. In 2013, the California Public Utilities Commission defined these services as Transportation Network Companies, which provides both ride-hailing (as Uber/ Lyft) and ride-sharing (Uber Pool/ Lyft-share) opportunities (Shared Mobility Definition, 2013). The Birmingham metro area offered only the ride-hailing service during the time of the survey administration.

Inauguration and Growth of TNCs

The TNC services launched in 2009, when the first app-based company Uber (formerly named as UberCab) was introduced in San Francisco with an aim to provide ride-hailing services (Hartmans, A., & Leskin, P., 2018). With time, Uber has become the largest Transportation Network Company with 56.3% market share of ride-sharing drivers and having 25% of the U.S. population who uses Uber at least once a month (Mazareanu, E., 2019). Following Uber, Lyft, the second-largest Transportation Network Company in the United States, was also launched in San Francisco in 2012 (Timeline, 2019). Lyft was initially the product of the base company Zimride which used to provide ride-sharing options to students and businesspersons through private social networks in San Francisco, CA, from 2009 (Zimride, 2019). The literature review provides the following summary about the introduction of the TNCs as a travel mode in U.S (Table 1).

Table 1. Summary of the TNC growth with time

Year	Event
2007	Zimride (social media based)
2009	Launch of Uber
2012	Launch of Lyft
2014	Introduction of UberPool and Lyft Share
2015	Uber in Birmingham
2017	Lyft in Birmingham
2019	Via in Birmingham

In 2014, Uber and Lyft launched UberPool and LyftLine (presently LyftShare), respectively, with the purpose to match rides with close destinations and encourage riders to share rides with others at a lower cost (Moran, M., & Lasley, P., 2017). At present, in major cities, UberPool and LyftShare options are more popular to users than Uber and Lyft. A study in Chicago found out that UberPool and Lyft Share are respectively 7.5% and 1.9% more cost-effective options than automobile use (Schwieterma, J. P., 2019). On the contrary, Uber and Lyft. which are only ride hailing services, are found to be less than 1% cost-effective than personal automobile use. As several metro areas including Birmingham still do not offer the UberPool and LyftShare options, it would be interesting to find out if the residents of such areas think Transportation Network Companies are more cost-effective than their typical travel mode. Such information can also help the companies understand the market needs and opportunities better, and plan so that they can properly meet such needs.

TNCs in Birmingham Metro Area

At the time of survey administration, Birmingham metro area had only two Transportation Network Companies providing their services to this region. Uber was first launched in this region in January 2015 (Ganucheau, A., 2015) thus expanding the transportation mode options in the Birmingham market. Two years later in February 2017, Lyft was launched to provide service in this region (Harris, S., 2017). However, as mentioned above, both companies only offer the ride hailing service to the users whereas the most beneficial from the transportation perspective, ride sharing services are not yet introduced to this region. In December 2019, Via was also launched in Birmingham under a pilot project. Via is a leader in on-demand public mobility that provides on-demand ride sharing options at various. The Birmingham pilot program covers a small radius with the promise to provide ride sharing service only by $1.5. The objective of the Via shared ride services it to complement and expand public transportation options for select portions of the City of Birmingham (Birmingham City Council, 2019). The currently receives public funding through a partnership between the City of Birmingham and the Community Foundation of Greater Birmingham.

Demographic Studies of TNC users

Several earlier studies were identified that looked at the demographics of TNC users across United States (Table 2). A common characteristic of those users is that they mostly belong in 18-34 years old age group and most of them are highly educated. It should be noted that different studies used different class criteria and results came out according to the survey participants of those cities as reflected in Table 2.

Table 2. Demographic characteristics of TNC users acquired from surveys

Source of Research	Survey Area	Sample Size	Dominant Demographics	
			Item	Value
Lavieri, P. & Bhat, C. R. (2019)	Dallas-Fort Worth Metropolitan Area, TX	906	Age Education Gender Household Income	: 18-34 : Less than undergrad : Male : Less than $100,000
Rayle et. al. (2016)	California	380	Age Education: Gender Household Income	: 25-34 : Bachelor's Degree : Male : $100,000-$200,000
Circella et. al. (2018)	San Francisco, CA	1975	Age Education Gender Household Income	: 25-34 : Some college/ technical : Male : $20,001-$80,000
Clewlow, R. R. & Mishra, G. S. (2017)	Boston, Chicago, Los Angeles, New York, San Francisco, Seattle, Washington, D.C.	4094	Age Education Gender Household Income	: 18-29 : Advanced Degree : Female : $150,000-More
Chen Z. (2015)	Pittsburgh	89	Age Education	: 35-64 : Bachelor's Degree
Vinayak et al. (2018)	Puget, WA	2170	Age Education Household Income	: 35-44; 18-24 : Graduate Degree : Less than $24,999
Dias et al. (2017)	Puget, WA	2789	Age Education Household Income	: 18-34 : Bachelor or Higher : Above $100,000
Schaller Consulting (2018)		365 million	Age Gender Education Household Income	: 25-34 : Male : Graduate/ professional : Above $200,000
Sikder, S. (2019)	NHTS 2017, U.S.	17476	Age Gender Education	: 16-35 : Male : Bachelor or Higher

Though the common conception was initially that people with low income who might not own an automobile would be a significant proportion of users of TNCs, the data represented on Table 2 shows that is a misconception as the surveys show that TNC customers represent a variety of income levels. So, literature observed that TNC use is not directly related to income level but rather age, education as well as the traffic conditions of the region.

Users Perspective Studies of TNC users

The user perspective towards the transportation mode is a significant identifier of mode selection. The user perspective can dictate the transportation habit of the population. Chen, Z. (2015) conducted a survey on Pittsburg, PA, to understand the travel habits of the ride-sourcing users. His data set of 349 respondents shows that the percentage of the trip with Ride sourcing is higher than that reflected on National Household Travel Survey (NHTS) 2009, and that 82% of the total ride-sourcing trips in the Pittsburg area were conducted for "social/leisure" purpose.

The use of Transportation Network Companies for transportation relates to the perspective of travelers about the safety and value of TNCs. Wang et al. (2019) conducted an analysis of data from 378 non-TNC users in China, and the results showed that "perceived value" and "perceived risk" have respectively positive and negative impacts on the travelers' decision about choosing TNCs as their daily mode. If the "perceived value" is high, and "perceived risk" is low to the travelers, there is a higher chance of using TNCs in the future (Wang et al., 2019). So, the research suggested that, while observing the

perspective of TNC users, it is also important to take the frame of mind of the TNC non-uses into account.

A recent study focusing on older adults (65+ years) illustrates that not-for-profit ride-sharing companies which do not provide the door-to-door assistance to older adults are not popular among them (Freund et al. 2020). This study also shows that Alabama is one of the states with limited availability of non-for-profit ridesharing or door-to-door ride-sharing services. In this context, our study would be helpful to determine if the available Transportation Network Companies, which are for-profit ride-sharing services, are often used by older adults to serve their transportation needs.

Though Transportation Network Companies are top-rated among young users, Schwartzberg (2015) reported that the new type of ride-sharing offered by Via, which provides service accessibility like TNCs and user sharing like vanpool, has 27% riders of 55+ year's old age, where only 30% Via riders are from 25 to 34 years old.

A comprehensive study of transportation users from nine major metro areas in the US (Boston, Chicago, Los Angeles, Miami, New York, Philadelphia, San Francisco, Seattle and Washington DC) determined that the users of these metro areas are using TNCs to avoid driving after alcohol consumption and to get to places where parking is limited or expensive (Clewlow, R. R. & Mishra, G. S., 2011).

Other studies also discuss reasons behind choosing the TNCs as the travel mode. The literature suggests that TNCs are more popular to be used among young people mostly in the evening time for recreational trips rather than commuting trips for work and errands (Lavieri, P. & Bhat, C. R., 2019). A study in San Francisco reported that the inclination towards TNCs is presiding by the secure payment system along with short wait time (Rayle

et al., 2016). The same study determined that "technology-embracing, pro-environment, and variety-seeking" attitudes are significant factors towards selecting TNCs as a trip mode in greater California.

Role of TNC Trips in Trip Generation or Replacement

The growth of TNCs has been seen by many skeptics as contributing to traffic congestion as well as threatening the viability of taxi and public transit services. In New York, during peak hours about 7.5% of trips are performed by TNCs whereas only 4% are performed by taxis (Bialik, C., 2015). Also, the same study reported that in downtown New York City, Uber has a 27% market share where the taxi has only 20%.

The literature confirms that technology-enabled services can affect travel behavior in dynamic ways by providing more travel options, reducing travel uncertainty, and potentially replacing other modes (Alemi et al., 2018). TNC services introduce added convenience to the user and may impact auto ownership and driving licensure trends. Research by Sivak (2014) states that the percentage of zero-vehicle households may also increase as a result. Moreover, another study states that 40% of TNC users in San Francisco reported that they use their private vehicle less due to the adoption of on-demand mobility sharing services (Rayle et al., 2014). This is a great benefit, from the transportation perspective, as less automobile use is beneficial for congestion relief, reduction of environmental impacts, reduction of costs associated with road maintenance and parking, and support of sustainability.

However, low expense and high availability of TNCs often results in both an increase in the number of trips as well as increase in vehicle miles traveled (VMT). The latter is due to the fact that TNCs are hovering at specific locations waiting for service

calls. Jiao et al. (2020) analyzed the 2017 National Household Travel Survey data in an effort to determine the influence of “Car sharing”, “bike-sharing” and “Ride-hailing”. His results on both weekends and weekdays show that ride-hailing is substantially impacting the increase of trip generation.

In New York, NY, Schaller (2017) raised concerns about the effects of TNCs on traffic congestion, emissions, and their potential to undermine public transit and taxi services that are essential components of urban transportation networks. His concerns were based upon the fast-growing market share of TNCs. In 2016, TNCs transported 15 million passengers per month, and the ridership tripled between June 2015 and the fall of 2016. In addition, his analysis indicated that TNCs added 600 million miles of vehicular travel to the city. Furthermore, he proposed a type of road pricing scheme to counter the rapid growth of TNCs.

In Boston, MA, a recent report by the Boston Metropolitan Planning Organization (Gehrke et al., 2018) surveyed 1,000 travelers who frequently use Uber and/or Lyft. That survey concluded that introducing TNCs in Boston, MA resulted in transit substitution at a rate of 54% with 12% occurring during the morning or afternoon commute periods. In addition, the survey concluded that transit substitution was more frequent among riders with a weekly or monthly transit pass. Thus, those who ride the transit more often are more likely to drop it for TNC services.

In San Francisco, CA, the San Francisco County Transportation Authority partnered with researchers from Northeastern University who developed a methodology for collecting data through TNCs Application Programming Interfaces (APIs) with high

spatial and temporal resolution (Cooper et al., 2018). Despite not having an independent data source to validate against, they were able to quantify the market penetration rate of TNCs in the study area. They estimated that TNCs serve over 170,000 trips on a typical weekday compared to 40,000 passengers served by public transit. Furthermore, they concluded that TNC trips followed traditional time-of-day distributions and were mostly transit substitution trips.

Studies that reported on the purpose of the trips conducted by TNCs found that the majority of ride-sharing trips are for non-commuting trips like shopping, medical, welfare, or entertainment (Vanderschuren, M., & Baufeldt, J., 2018). A study that was conducted in San Francisco and Oakland documented that 37% of survey respondents prefer big companies for transportation rather than peer-to-peer car sharing. Reliability and reputation of the TNC service provider can significantly influence this result (Ballús-Armet, I. et al., 2014). In 2015 & 2019, TNC service provider Uber made some pilot test in NY, FL and TX. They found out that TNCs can be very effective as the first and last mile mode to complete a trip for the public transit users. (Shared-use Mobility Center, 2015 & 2019).

The literature review provided useful insights on TNC use and its impacts on mode choice and travel demand, however, it did not yield any studies in the Birmingham region documenting such impacts. Given the fact that case studies on TNC use and impacts are still limited and findings from earlier studies are localized and reflect that characteristics of users in the particular local, there is a need to conduct a study of travelers' perceptions and use of TNCs in Birmingham. The study would be used to document users' attitudes, choices, and behavioral trends and will help to quantify the influence of identified technologies on travel behavior and demand.

CHAPTER THREE

METHODOLOGY

This chapter discusses the methodology adapted for the survey questionnaire development and introduces the phases of survey development using the Qualtrics Research Core platform.

Survey Questionnaire Development

The survey of Birmingham travelers aimed at identifying awareness, usage, and attitudes towards TNCs among transportation system users in Birmingham, AL. With a purpose to capture such data, an online questionnaire survey was designed and used to collect travel preferences, typical trips, and demographic data in accordance with the ITE Manual on Transportation Engineering Studies (ITE, 2011).

First, approval was obtained from the Institutional Review Board (IRB) for Human Use to proceed with the survey. The Qualtrics Research Core tool was used to prepare the questionnaire as it provided a user-friendly platform. The questionnaire was modified at various stages and was pretested and fine-tuned prior to use to ensure that it was easy for responders to understand the question and provide answers.

The questionnaire asked transportation users about their preferences towards using TNCs, frequency of use, the reason for selection along with demographic information such as gender, age, annual income, education level, and vehicle ownership. The criteria for collecting the demographic data were adopted from the Census criteria. Moreover, the

questionnaire solicited detailed 24-hr trip information of the respondents on a typical day. In the determination of the exact locations of origin and destination of the trips on a 24-hr travel diary, we used Google maps Application Programming Interface (API) key application. This allowed respondents to insert the location of their origins and destinations easily.

The survey was administered in the Birmingham, AL region between December 2018 and January 2019. Given a population of 1,141,309 capita in the Birmingham Metro Area as per the 2016 Census data, a sample of 400 responses was deemed sufficient according to the formula shown in the Equation 1 for calculating the standard population sample size.

$$n = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)} \quad \text{..... (1)}$$

Where n is the sample size, z is the z-score for the corresponding confidence interval, e is the margin of error, N is the population size as per latest Census reports, and p is the standard deviation (assumed to be equal to 0.5).

We went through a detailed data verification process to check the responses received using ArcGIS software, built-in tests, and through close manual observation. We removed several responses from the database that were incomplete or failed validation tests and collected new responses to replace those that did not pass validation tests or showed mismatch of reported data. A final database of 451 responses from the Birmingham Metro Area was used in the analysis.

Survey Development Tool

The Birmingham transportation users survey was developed and conducted using the Qualtrics Research Core platform. Qualtrics LLC partnered with UAB to collect the required responses for arranging the proper sample data for the survey area. While developing the survey, the questionnaire was segregated into eight blocks, each with the purpose of collecting a distinct type of information. The developed eight blocks and the tools used to shape them are discussed next whereas a copy of the survey questionnaire is available in Appendix-A.

Block One: Informed Consent

This block included a cover page starting with the invitation to the survey respondents to be a part of the research project that studies technology influence on travel demand and behavior. It also included a statement of the participants' requirements and rights and welcomed feedback from the participants. It ended up giving the participants the option of providing consent and continue or not participate in the study. They were also informed on this block that they could move out of the survey at any certain point if they wish to. The cover page of the Birmingham survey is shown in Figure 1.

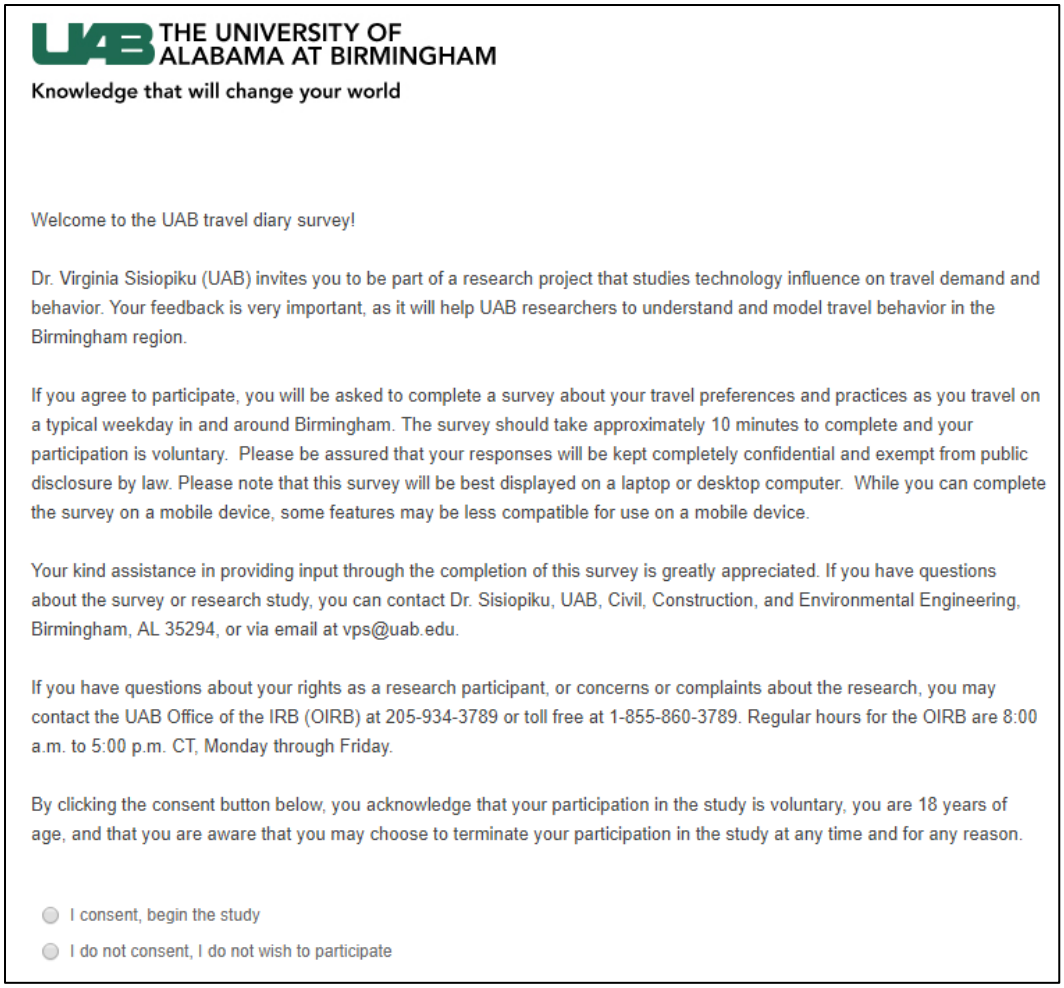


Figure 1. Block 1 of the Birmingham Travel Diary Survey.

Block Two: ZIP Code Validation

This block was used for the validation of the Zip Code. This block asked participants to insert their Home Zip Code. Twenty nine zip codes were identified as located within the study area of interest. If the code was in the list of survey area Zip Codes, participants were directed to the next block. If the Zip code was out of the survey area, then the participant was redirected to the end of the survey with a thank you message. We used "Matches Regex" function from the "Skip logic" of the Qualtrics tool. We had to use

"inverse" logic of Java in the "Matches Regex" to choose the marked Zip Code for continuing the survey.

Block Three: Travel Preferences

This block was divided into two sets of questions. Both sets started with a question related to travel modes that the participant used during the past year from the survey responding date. If they choose TNCs as one of their travel modes, the survey displayed three questions about TNC use, which captured information about their last TNC use, the reason for choosing TNCs, and trip purpose for the trips that they performed using TNCs. On the other hand, if the participants did not use TNCs over the past year, the survey displayed the second set of questions which solicited input about the indifference towards the TNC uses. In both sets, survey participants were provided some common reasons in addition to an option stated as 'Other' that gave them the chance to write in other reasons within a text box provided.

Block Four: Travel Diary Consent

This block was inserted after the first pilot test, which will be discussed later. The purpose of this part of the survey was to remind the participants about the importance of providing precise and truthful responses to the survey questions, including trips performed.

Block Five: Initial Location

Block five was organized to collect the participants' initial location at 12:00 am on a typical day along with information regarding the type of location or land use (e.g., home, school, work, nightlife/bar etc.). We wanted to make it as easy as possible to the respondent to provide proper information about their locations, thus the location information was

collected using Google Map API (Application Program Interface) key as the Figure 2. The question prompted the participants to find their address by typing part of their address and/or keywords from the map provided below the box (Figure 3). Using Google Map API also helped us to get actual latitude and longitude for all locations entered which, in turn, helped us to determine origins and destinations of reported trips and calculate the proper travel distance.

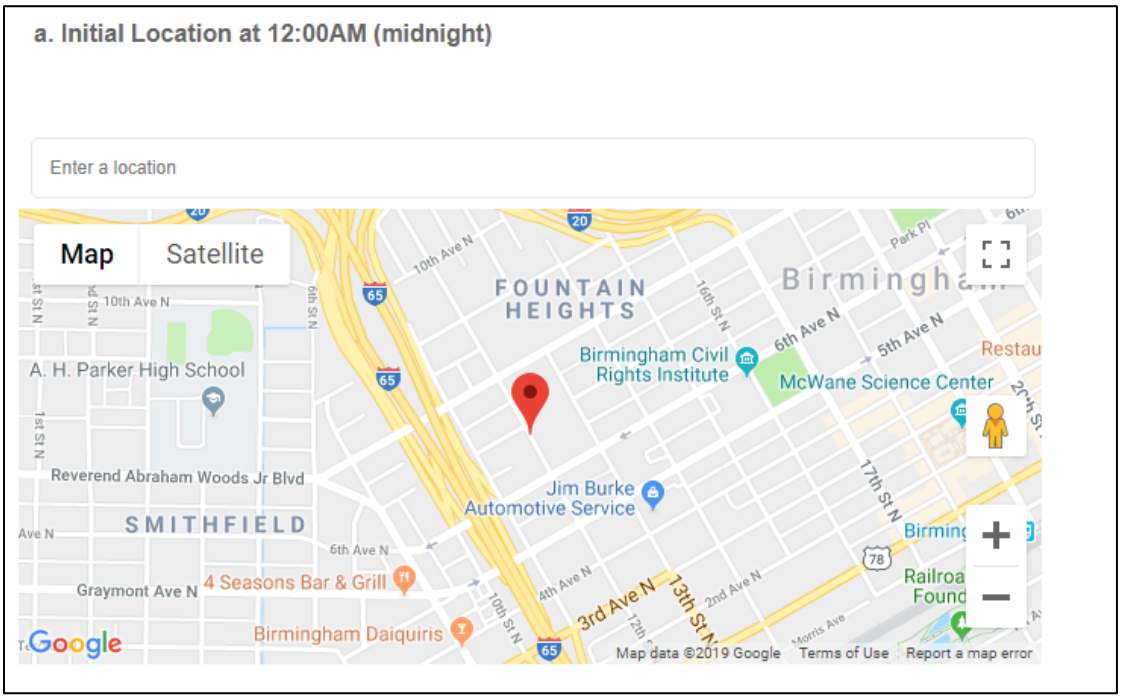


Figure 2. Application of Google API to Record the Proper Location.

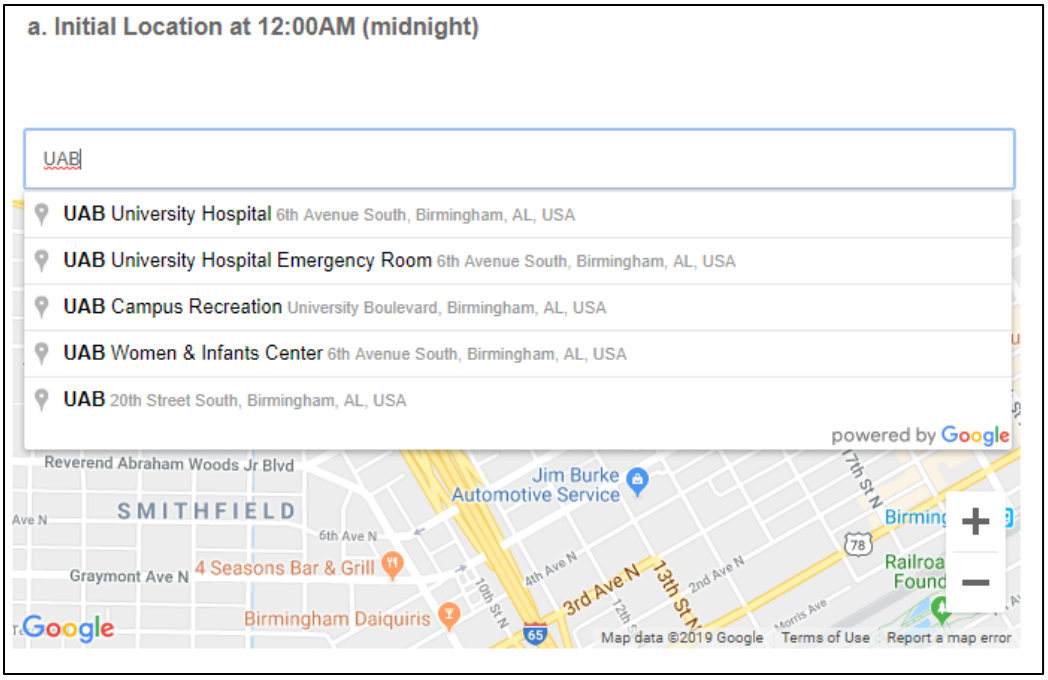


Figure 3. Using Key Words to Find the Exact Location.

Block Six: 24-hr Trip Details

This block requested to collect information for each and every trip that the survey participant conducted on a typical day (24-hr period). The block asked about the location, departure time, arrival time, trip purpose, and the mode of the first trip on a typical day originated by the participant. If the 'mode' was selected as "Uber/Lyft," the participant was displayed a new box to provide the information about TNCs such as waiting minutes, preferred company, and vehicle availability.

After the information about the first trip was entered, the survey participant was asked if this was his/her last trip of the day. A “no” response triggered a request to record information about his/her second trip of the day. The process continued until the responded reported that a trip was his/her last trip for the day.

To automate the process, this block used the "Loop and merge" tool of Qualtrics through the last question as shown in Figure 4. If "yes" was selected as the answer, the survey continued to the next block. If "No" was selected as the answer, the survey returned to the start of the block, thus allowing the participants to report details about their next trip. This way the participants could provide all of their trip information for the 24-hr period.

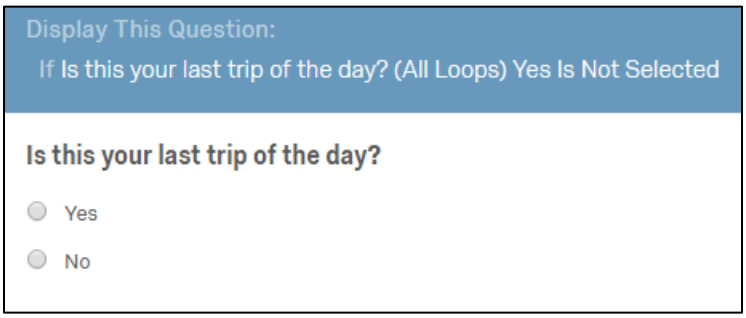


Figure 4. Question for "Loop and Merge" Function.

Block Seven: Facility Preferences

This block asked survey participants if they wished to see expansion of services related to Public Transit (bus, light rail), TNCs, Bicycle Lane, Sidewalks, Parking Lots in their area.

Block Eight: General Information

This block includes the collection of demographic information of the participants, which are gender, age limit, employment status, occupation, industry type, annual household income, highest degree, auto ownership. Most of the questions were created using the "Multiple Choice" and "Drop Down List" tool from Qualtrics tools. The answer options were provided according to the CENSUS category to validate the types of

participants. This block also asked the home location or the nearest intersection to allow for validation of the Home Zip Code provided in block two of the survey of Birmingham transportation system users.

Selection of Participants: Survey Area and Data Sample

Our testbed was the metropolitan area of the greater Birmingham located in northcentral Alabama. The region comprises of the cities of Birmingham, Homewood, Vestavia Hills, Mountain Brook, and Hoover. We have selected 29 residential ZIP code areas as our survey zone (Figure 5). Details about the survey area are given in Table 3.

As discussed in the Survey Questionnaire Development section and given that the area is populated by 1,141,309 capita as per the 2016 Census, data collection of 400 valid survey responses were deemed appropriate to represent the proper travel behavior of the Birmingham population. We decided to increase the number to 450 participants to account for imputed records, if any. UAB has partnered with Qualtrics LLC to recruit and administer the survey on the Birmingham, AL metropolitan area through Qualtrics Research Core.

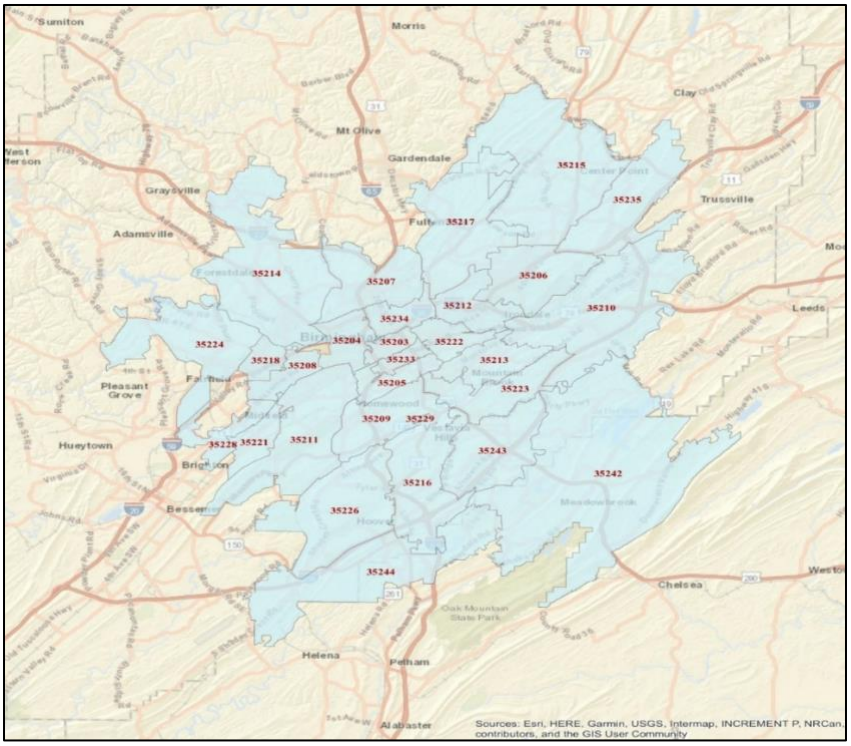


Figure 5. Survey Area

Table 3. Information about survey area

Item		Details
Location	:	Birmingham, AL metropolitan area
Cities	:	Birmingham, Homewood, Vestavia Hills, Mountain Brook and Hoover
Zip Code	:	35203, 35204, 35205, 35206, 35207, 35208, 35209, 35210, 35211, 35212, 35213, 35214, 35215, 35216, 35217, 35218, 35221, 35222, 35223, 35224, 35226, 35228, 35233, 35234, 35235, 35242, 35243, 35244
Population	:	1,141,309 capita (2016 Census)
Available Travel Modes	:	Private vehicle, bus, taxi, TNCs, bikes, carpool, vanpool
Major Employer (>300 employee)	:	140

CHAPTER FOUR

SURVEY PRETESTING AND DATA VALIDATION

The data collection process through the Birmingham Travel Diary survey had to go through several pretesting phases. Data validation was also essential to ensure that we get the proper data to make a real-time travel diary for the Birmingham Metro Area. In total, among the five phases, first two phases were for the survey pretesting and the later three phases are for data validation. The survey pretesting and data validation process are described in this chapter.

Survey Pretesting

Phase-I: Beta testing

In this first phase, we provided the survey to about 15 people around UAB. In this phase, we wanted to know if the general public could understand the survey questions and how much time, on average, they need to complete the survey. From the responses, we updated some questions to improve clarity and flow. For example, some people are confusing on the last question of block 5. The question was initially worded as, “Did you take another trip?” and the options were given “Yes” or “No” but then rephrased for clarification as shown in Figure 6.

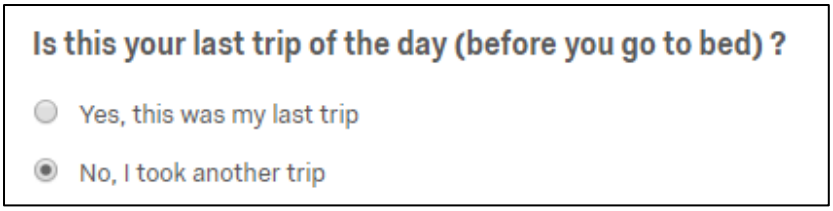


Figure 6. Rephrased Question of Block 5

Phase-II: Test Launch by Qualtrics LLC

On phase-II of survey pretesting, Qualtrics tested the survey among the 10% of the required sample. They run a soft launch and collected 10% responses, prior to fully launching this survey to ensure that the instrument is functioning correctly. After this phase, we decided to input another block (which is Block Four of Chapter Three), which help make participants aware that they need to input several details about their every trip of a typical day. The block was created as shown in Figure 7.

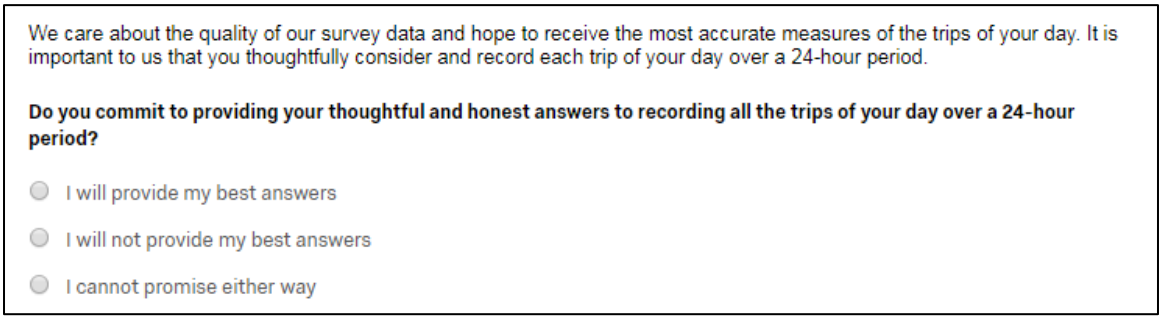


Figure 7. New Block to Collect the Proper Trip Record

Data Validation

Phase-III: Home Location Verification

At this phase, Qualtrics provided 473 responses as the final survey responses after cleaning up the incomplete responses from their side in January 2019. Among the 473 surveys, we kept 448 responses from participants residing in our survey area. The rest of the 25 responses were not in our survey area and had to be eliminated. Though they provided a ZIP Code included in the Birmingham Metro Area, while giving their home address, they had provided some different locations in the Block Eight of the survey. We verified those addresses using ArcGIS and decided not to take those responses as we could not trust the information provided. Among the 448 respondents, 104 respondents have given two different home addresses in trip data of Block Five and the home location question of Block Eight. Home address is a significant piece of information for the survey, and a quality check metric omitting these records left us with 344 usable responses.

Phase-IV: Home Location Verification

During this phase of data verification, Qualtrics provided 111 new responses to supplement the previously accepted 344 responses. After checking the details about the trips and matching the home addresses provided in the trips, we eliminated 12 responses and kept 443 responses for our data analysis.

Phase-V:

During the final phase of data collection and quality control, Qualtrics LLC again ran the survey and collected around ten more responses. So finally, after cleaning up and matching the home addresses provided in the demographic data on Block Eight and trip

data on Block Five, we accepted 451 responses as our final data set which we used to perform the data analysis in our study. Figure 8 represents the distribution of responses within the survey area, which also shows greater representation from the densely populated areas, thus adding confidence that our database was a proper data set for the analysis.

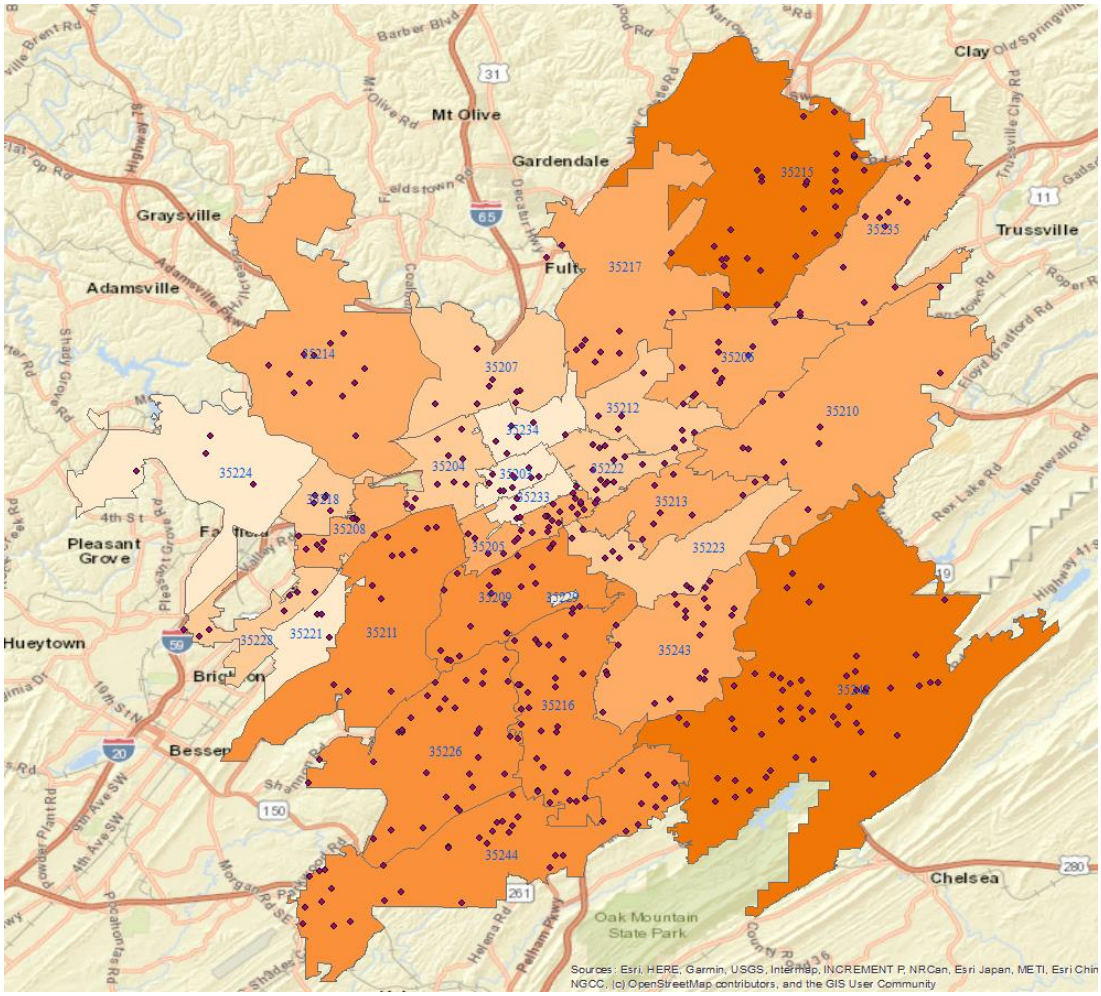


Figure 8. Survey Respons Distribution vs Population Density

A brief about the data set is given on the following Table 4.

Table 4. Summary of survey responses data

Item	: Details
Data Collection Period	: Nov 2018- Jan 2019
Total Responses	: 451
Total Numbers of Trips	: 1,023
Number of TNC Trips	: 69
Average Travel Time per Trip	: 25.64 minutes

CHAPTER FIVE

DATA ANALYSIS AND RESULTS

This chapter discusses the demographics of the survey participants, their stated preferences towards TNCs and other available transportation modes, and present information about TNC trips in the Birmingham areas and transportation users' preferences and needs.

Demographic Data

Among the 451 responders considered in the analysis, 342 were women, and the remaining were men. The overrepresentation of women in the survey was noted, but it is not alarming as many surveys report higher numbers of survey participants as being female. The responders provided details for 1,023 trips performed over a 24-hr period. Analysis of the data showed that TNCs were involved in approximately 6.37% of the reported trips, with 73% of TNC trips performed by female responders. When taking exposure into consideration, the finding indicates that TNCs are used almost at the same rate among female and male transportation users in the Birmingham region.

The survey participants represented age groups across the lifespan with a peak (25%) at between 25 to 34 years of age. The age distribution of the Birmingham survey sample is relatable to the actual scenario of Birmingham Metro Area, based on analysis of CENSUS records. (Figure 9).

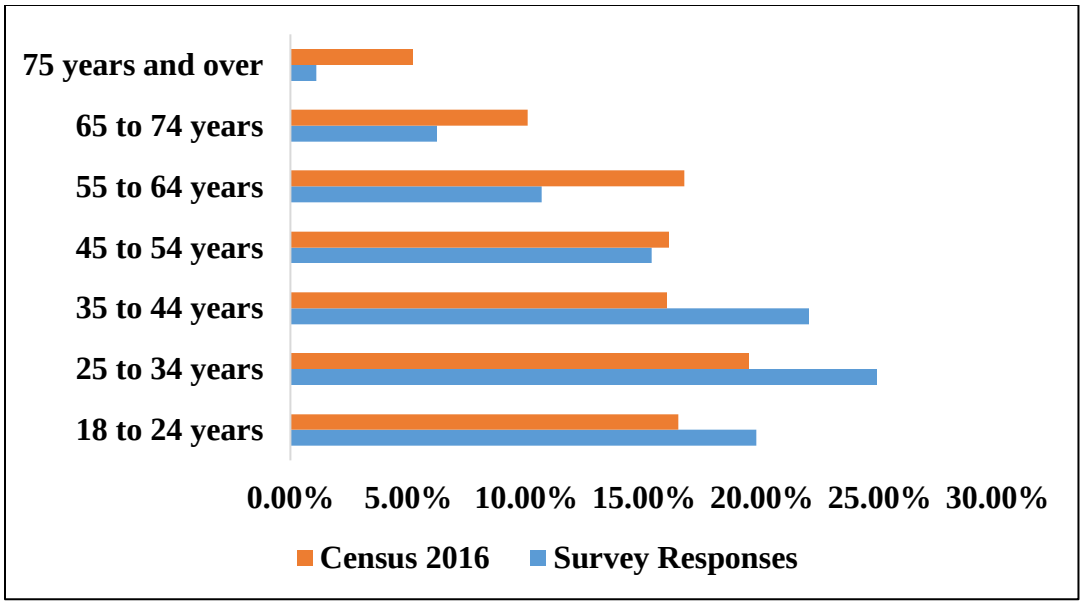


Figure 9. Age Distribution of Census 2016 Population and Survey Participants

Figure 10 displays information related to survey participants' employment status and occupation. It can be seen that over 55% among the survey participants are full time employees and the remaining 44% represents part-time employees, retirees, self-employed people, stay-at-home parents, students, unemployed and others.

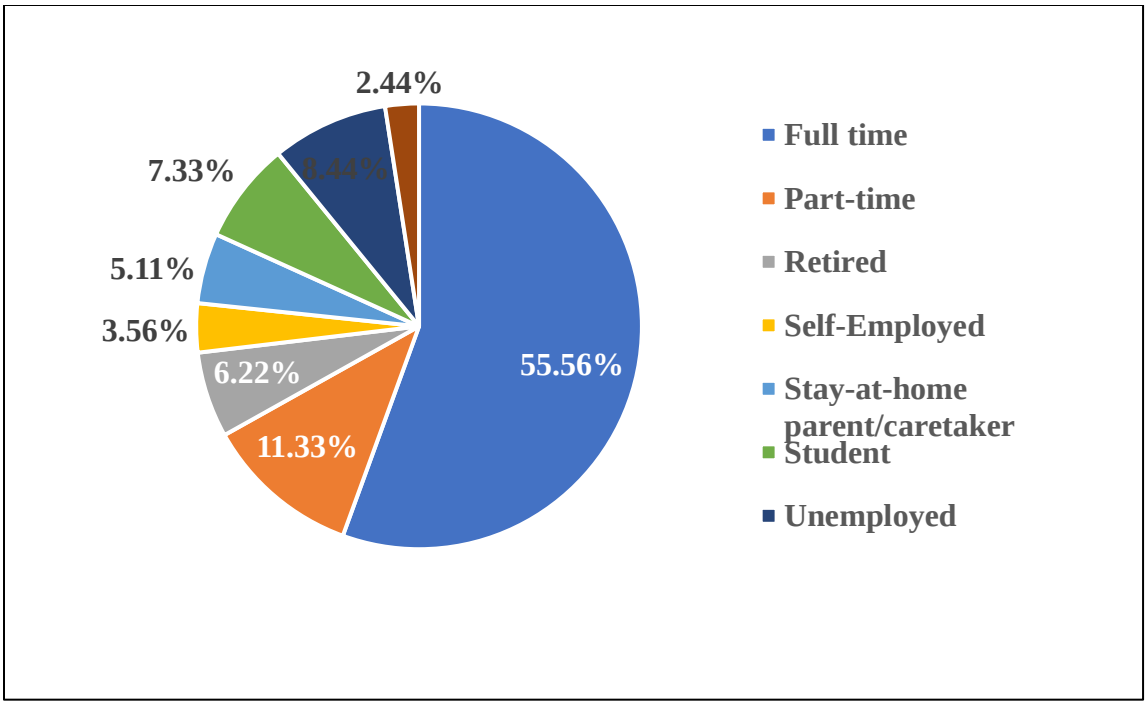


Figure 10. Employment Status of Survey Participants

The following two pie charts (Figure 11 and Figure 12) show the occupation and the type of industry the respondents serve, respectively. Figure 11 shows that a large percentage of survey participants (41%) are employed in the Management, Business & Art occupation sector. Figure 12 shows responses from a variety of distinct industries which provides some additional confidence about having a representative sample of the Birmingham metro population participating in the survey.

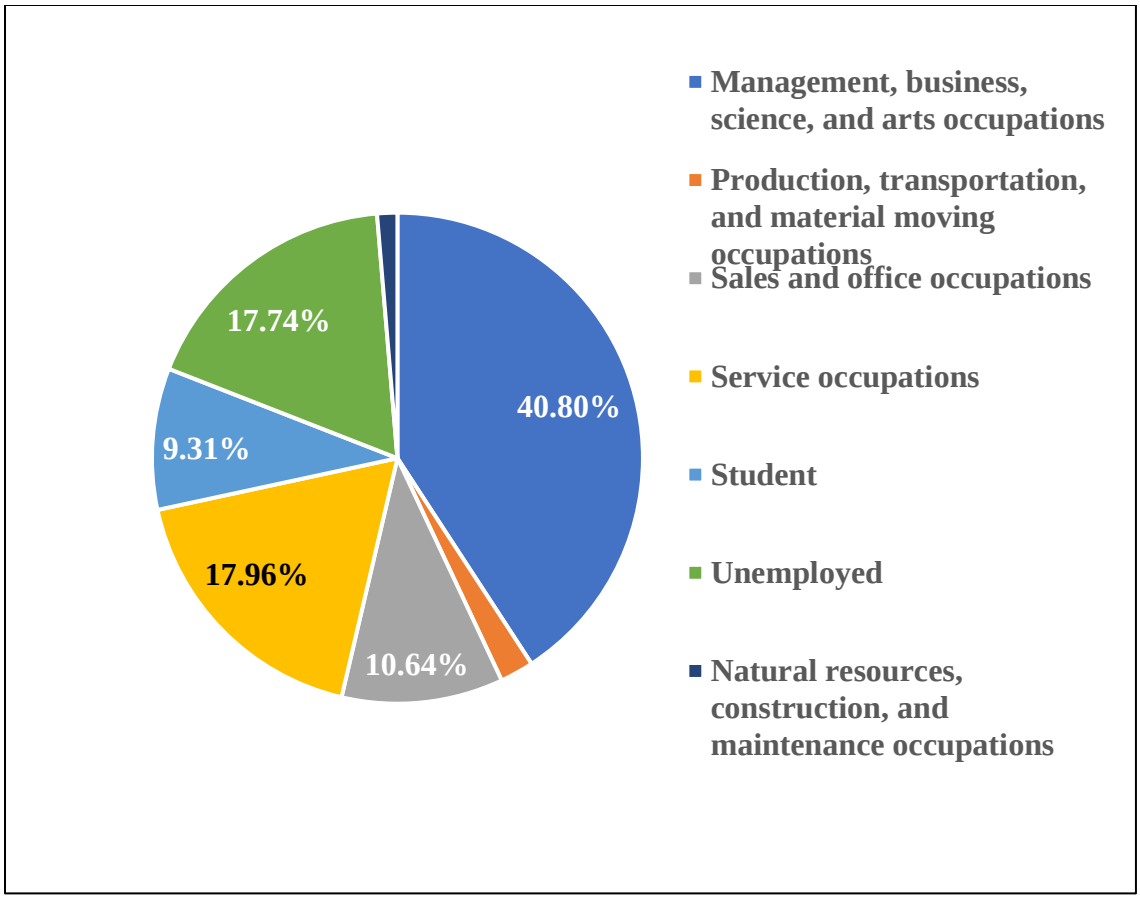


Figure 11. Occupation of Survey Participants

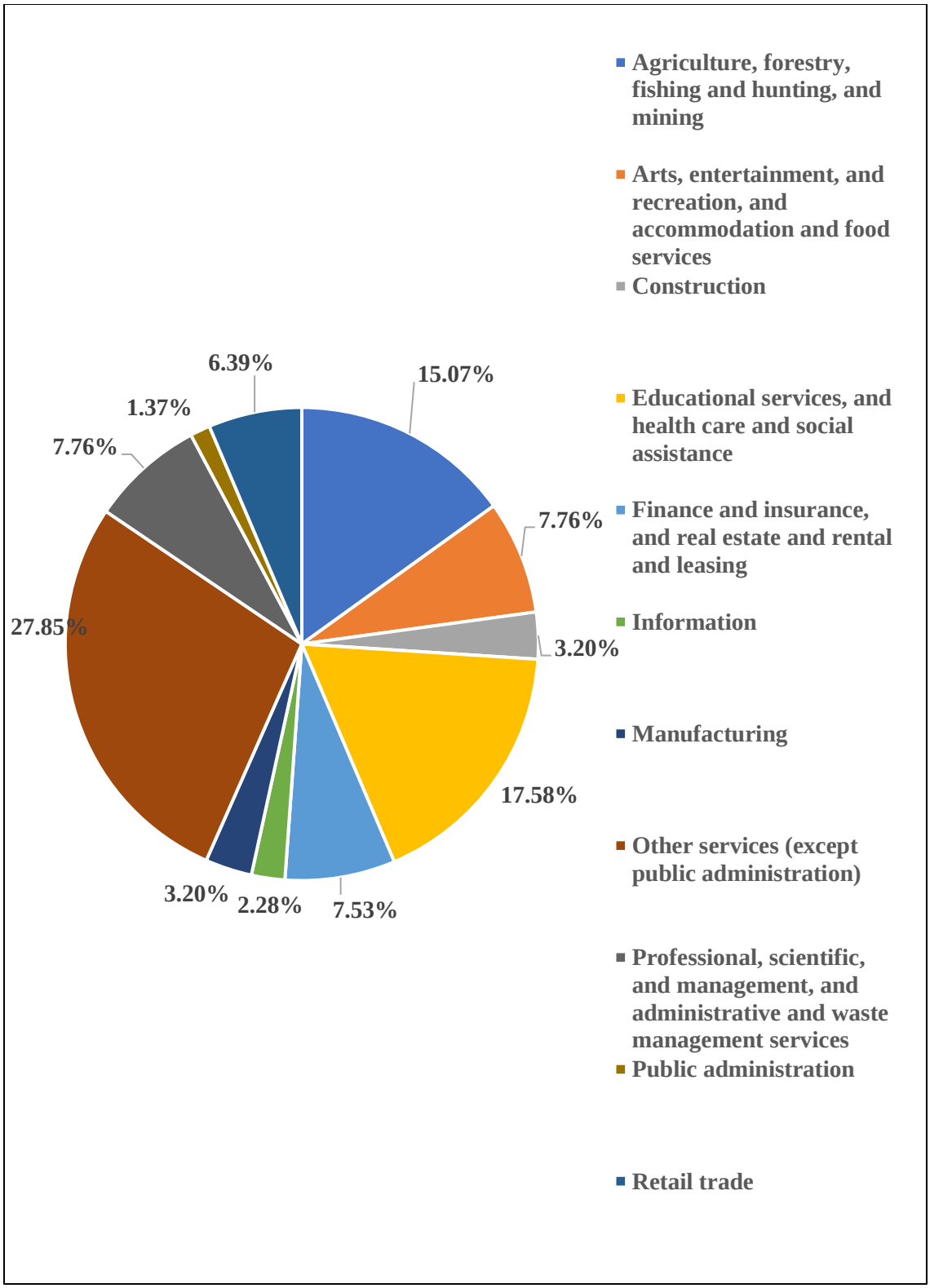


Figure 12. Working Industry of Survey Participants

Figure 13 shows that survey participants are drawn from different education levels. Based on their self-reported data, around 43% of them have a high school degree, 24.6% have Bachelor degree, and 15.3% have a Master's degree. These are higher than state averages, given the proximity of the study area to the University of Alabama at Birmingham which is also the largest employer in the state of Alabama.

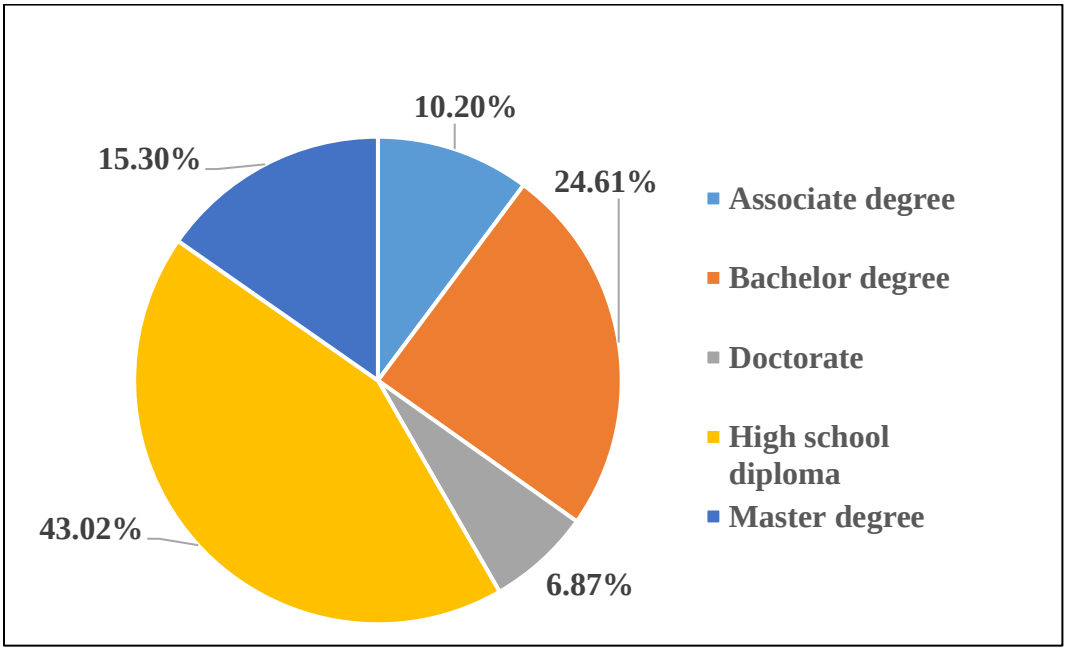


Figure 13. Education Level of Survey Participants

The following two figures (Figure 14 and Figure 15) represent the demographic characteristics of the TNC users, a subsection of the survey respondents. The details presented related to age, income, education level and car availability (Figure 14) and employment status, occupation and industries (Figure 15).

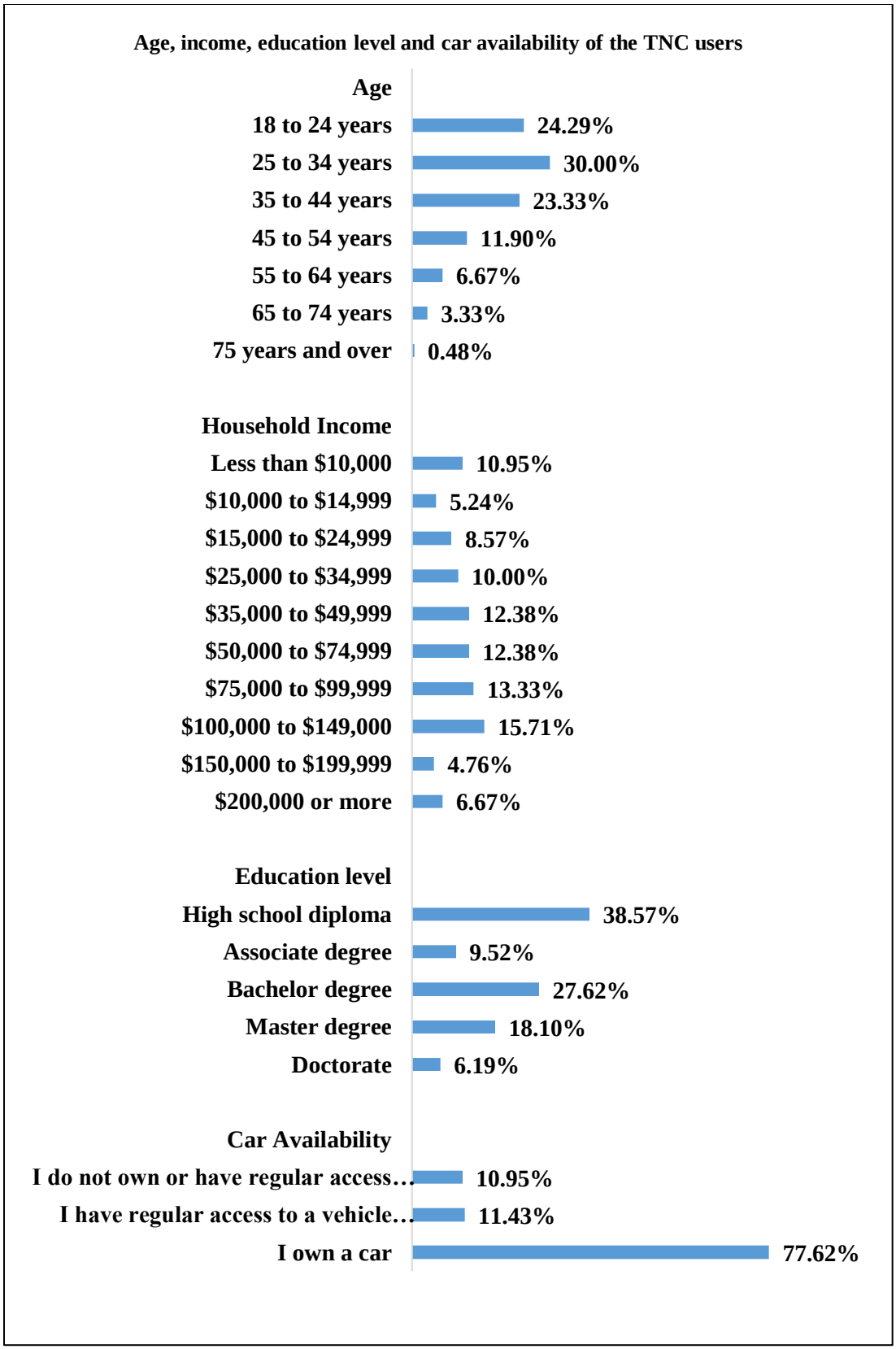


Figure 14. Age, Income, Education Level and Car Availability of TNC Users

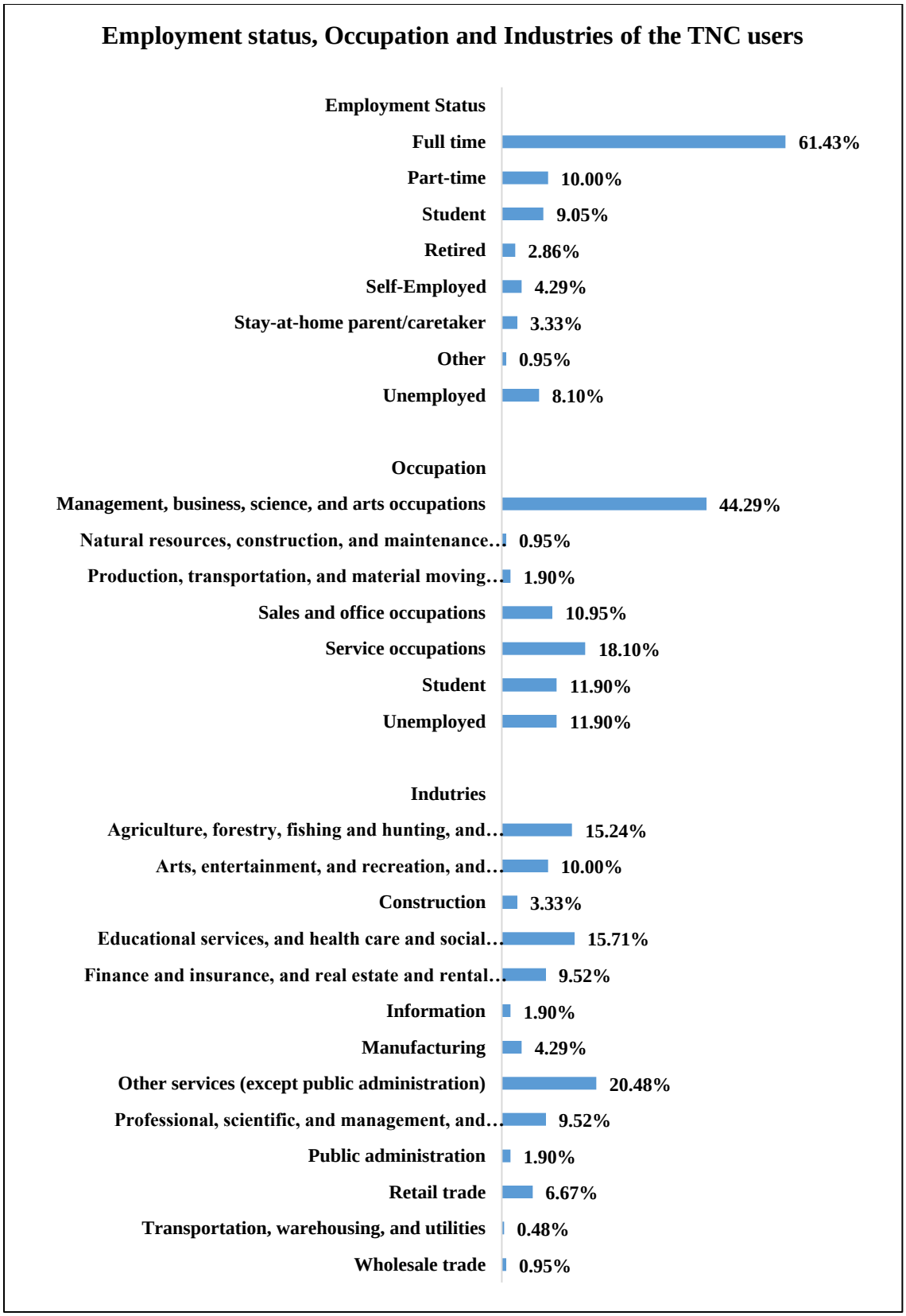


Figure 15. Employment Status, Occupation and Industries of TNC Users

The figures show that the majority of TNC users that replied to the Birmingham survey are from 25 to 44 years old (over 53% total), about two thirds of them work full time, and nearly 78% own an automobile. This finding further confirms that the vast majority of TNC users in the region travel with TNCs by choice rather than necessity, a finding that is in line with similar reported findings from surveys across the nation.

Preferences towards TNCs

To understand the survey participants' mode choices and their exposure to modes of transportation other than automobiles, we asked them whether or not they have used TNCs, public transit, bicycle, ride-sharing program, etc. in the past year. As shown in Figure 16, approximately 45% of survey participants indicated that they had used TNCs in the past year. This is an important finding given that only 21% reported the use of public transit during the same period and 12.6% of the bicycle.

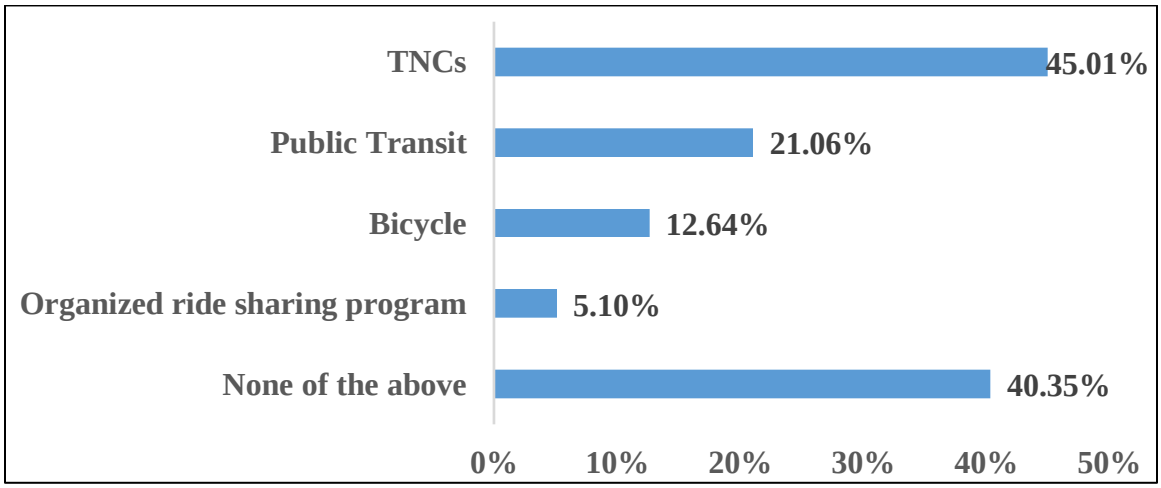


Figure 16. Modes Used in the Past Year by the Survey Participants

With a purpose to understand the frequency of TNC use, the respondents were also asked when was the last time that they used TNCs in the Birmingham region. Analysis of survey responses who marked themselves as TNC users revealed that 50% of them used TNCs within the past month, and half of those (about 24.3%) reported using TNCs at least once within the seven days preceding the survey.

Additional analysis was performed to determine the potential impact of age on TNCs selection. Table 5 provides a cross-tabulation of survey results indicating the frequency of TNC use by age bracket. We observed that 25 to 34 years old survey participants use the TNCs the most (about 27.14%) followed by 18 to 25 years old responders (19.5%). The data from middle-aged and elderly users also clearly shows that the use of TNC drops steadily as age increases.

Table 5. Frequency of TNC among TNC users according to different age level

Age versus TNC Use Frequency	Within the past 7 days	Within the past 30 days	Within the past two months	Within the past six months	Within the past year	Total
18 to 24 years	6.67%	3.81%	0.95%	6.19%	1.90%	19.52%
25 to 34 years	4.76%	8.57%	5.71%	5.24%	2.86%	27.14%
35 to 44 years	3.33%	3.81%	1.43%	5.24%	3.81%	17.62%
45 to 54 years	5.24%	4.29%	1.43%	1.43%	3.81%	16.19%
55 to 64 years	1.90%	4.29%	0.00%	2.86%	1.43%	10.48%
65 to 74 years	2.38%	2.38%	0.48%	1.43%	1.43%	8.10%
75 years and over	0.00%	0.00%	0.00%	0.48%	0.00%	0.48%

Responders were also asked to note the reason(s) for using TNCs in the past. To identify the most influential reason for selecting TNC services as a mode of transportation, we factorized each reason to take a value of 1 if selected, and 0 if not selected. Table 6 documents the mean and standard deviation selection according to the survey responses. The results clearly show that respondents reported convenience as the main driving force for the selection of TNCs as a mode of transportation. Safety/avoiding driving when intoxicated and lack of automobile availability was cited as the second and third most important reasons for the use of TNCs in the survey of Birmingham users.

Survey respondents who had chosen the "other reason" option from the list had stated the following reasons for their preference towards TNCs:

- *To the airport and back*
- *Restaurant with low parking spaces*
- *Car was towed to dealership for repair*
- *Tourists in another city*
- *Transportation from hospital*
- *Sightseeing tour*
- *Was involved in a car accident and needed a ride to home*
- *Going to work*
- *To get to train station*
- *Dropped car at auto shop and took Uber for home*
- *Rental car pickup*

Table 6. Mean (Standard Deviation) of the factors affecting the TNC preference

Reasons	Within the past 7 days	Within the past 30 days	Within the past two months	Within the past 6 months	Within the past year	Total
Convenience	0.13 (0.33)	0.15 (0.36)	0.07 (0.25)	0.14 (0.35)	0.07 (0.26)	**0.56 (0.5)**
Safety/to avoid driving under the influence	0.07 (0.26)	0.09 (0.29)	0.03 (0.17)	0.06 (0.23)	0.05 (0.22)	**0.30 (0.46)**
Car is not available	0.07 (0.26)	0.06 (0.24)	0.05 (0.22)	0.06 (0.24)	0.02 (0.15)	**0.27 (0.44)**
Destination has little or no parking availability	0.06 (0.23)	0.08 (0.27)	0.02 (0.14)	0.06 (0.23)	0.03 (0.18)	**0.24 (0.43)**
Cheaper than other alternatives	0.05 (0.22)	0.05 (0.22)	0.01 (0.12)	0.07 (0.25)	0.02 (0.15)	**0.21(0.41)**
Parking at destination is expensive	0.06 (0.24)	0.05 (0.21)	0.01 (0.12)	0.05 (0.21)	0.01 (0.12)	**0.19 (0.39)**
Transit is not accessible	0.02 (0.14)	0.01 (0.12)	0.01 (0.10)	0.01 (0.10)	0.00 (0.07)	**0.06 (0.23)**
Transit is not reliable	0.02 (0.14)	0.01(0.10)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	**0.03 (0.17)**
Other reason	0.01 (0.10)	0.01 (0.10)	0.00 (0.07)	0.00 (0.07)	0.00 (0.07)	**0.03 (0.18)**
Other modes are not available	0.00 (0.00)	0.01 (0.10)	0.00 (0.07)	0.00 (0.07)	0.00 (0.07)	**0.02 (0.15)**

There were 242 survey respondents that had not used TNCs within the past year who were asked to mark their reason for not considering TNCs as a viable mode choice. It was found that almost as shown in Figure 17, nearly 30% survey respondents reported that the use of TNCs was not convenient for them while another 20% noted that they do not use TNCs due to associated cost. Other reasons for not using TNCs cited by the respondents include the following:

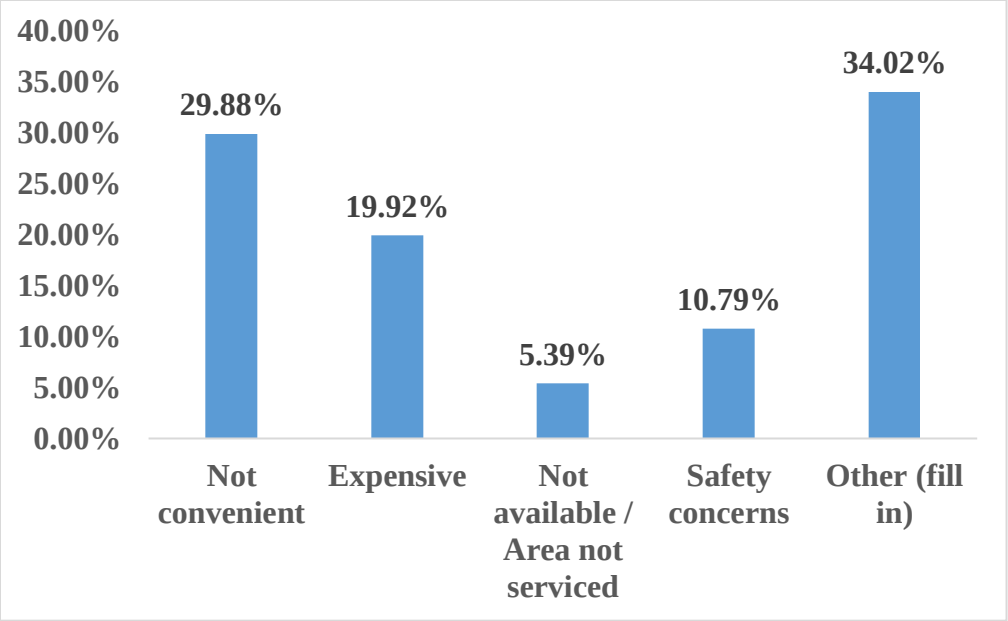


Figure 17. Reasons for not Using TNCs

- *I have my own personal vehicle*
- *Have not had the opportunity*
- *I prefer public transportation because it brings diverse people together. If I desperately needed transportation, I would use a taxicab.*
- *I drive or ride with friends*
- *Live where i work so there is not a need for it*
- *Wheelchair user*
- *Too far from home*
- *Not interested*
- *It feels weird to ride in another persons' car*
- *It's quicker to hop in my own car and drive.*
- *I have a car on my household*

Birmingham Area TNC Trip Characteristics

The documentation of trips undertaken during a typical day 24-hour travel diary by the 451 Birmingham questionnaire survey respondents provide trip details for 1023 trips. As shown in Figure 18 over 85% of these trips were conducted by private automobile and 6.3% by TNCs (i.e., Uber and Lyft). The data are consistent with earlier large-scale surveys

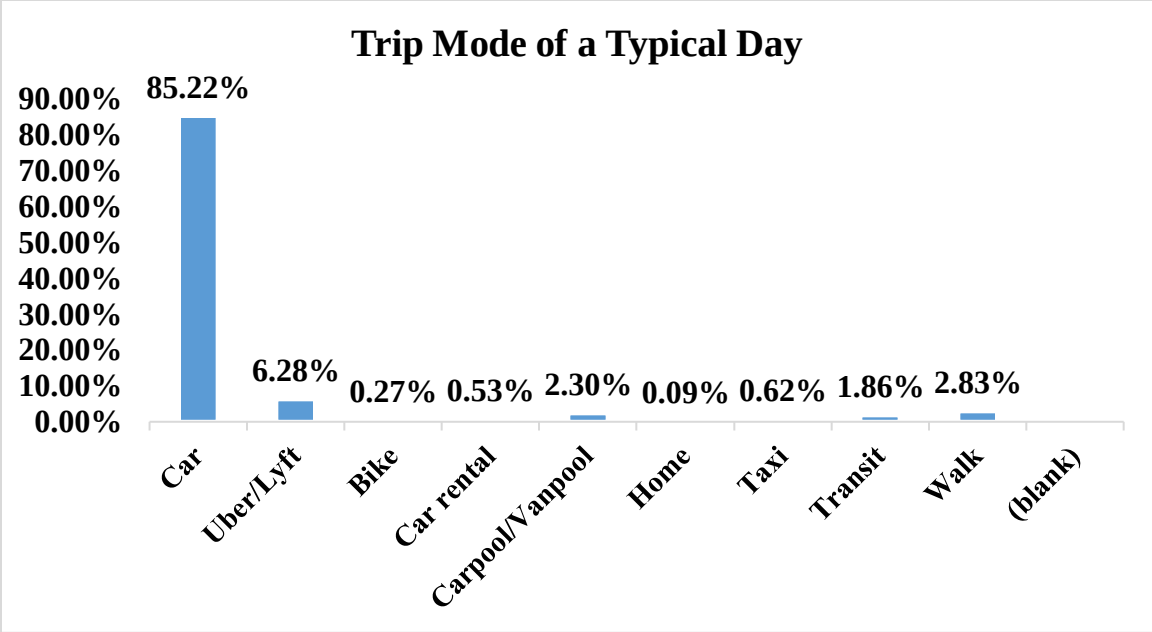


Figure 18. Typical Day Trip Mode Percentages

in the Birmingham region by Sisiopiku (Sisiopiku, 2018; Sisiopiku and Ramadan, 2017) which reported that over 88% of UAB employees and 82% of UAB students commute to UAB by private automobile.

We also broke down the results according to the percentage of TNC users and non-users. We observed that though 10.95% of TNC users do not own or have regular access to automobile while this number is only 5.81% for non-users of TNC services. Furthermore, nearly 78% of TNC users own a vehicle, just 3% less that the 81% of non-TNC users that report vehicle ownership. Table 7 shows the details based on the Birmingham survey responses.

Table 7. Car Availability vs TNC use

Car Availability	TNC User	TNC Non-user
I do not own or have regular access to a car	10.95%	5.81%
I have regular access to a vehicle that someone else in my household owns	11.43%	13.28%
I own a car	77.62%	80.91%

Cross-tabulation of trip purpose by trip mode in Table 8 shows that the majority of the trips conducted by TNCs are trips to work or to home. This result is consistent across the other available modes, including the automobile. The results also indicate that responders use TNC services often for dining out and late-night entertainment. When accounting for the number of trips performed by each mode, the percentage of trips made for eating out/take out/nightlife with TNCs was found to be 22%, which is far higher than the same reported for automobile trips (11% of total). This behavior shows a more definite preference for the use of TNCs over automobiles for dining out and entertainment trips among the Birmingham survey responders. This attitude is consistent with findings in the literature suggesting that the most significant levels of TNC use are on Friday and Saturday evenings, and the busiest time in most cities is between 7:00 pm and midnight (Feigon and Murphy, 2018).

Figure 19 presents the distribution of TNC trips by purpose and available TNC options. Two TNC companies operate in Birmingham, namely Uber and Lyft. TNC users in the Birmingham Metro Area reported using Uber for more than 80% of TNC trips.

Table 8. Trip purpose vs trip mode

Trip Purpose to Trip Mode	Car	TNCs	Carpool/ Vanpool	Car Rental	Taxi	Transit	Bike	Walk
Home	27.2%	**1.6%**	0.5%	0.3%	0.4%	0.5%	0.1%	0.4%
Work	18.4%	**2.4%**	0.4%	0.0%	0.2%	0.7%	0.1%	0.4%
School	2.8%	**0.3%**	0.1%	0.0%	0.0%	0.4%	0.1%	0.6%
Eat/Take-out	6.7%	**0.5%**	0.4%	0.1%	0.0%	0.0%	0.1%	0.4%
Nightlife/ Bar	1.2%	**0.4%**	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%
Shopping-Grocery	8.8%	**0.3%**	0.2%	0.0%	0.0%	0.1%	0.0%	0.8%
Shopping-Retail	6.9%	**0.3%**	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%
Services (e.g. bank, post office)	7.1%	**0.2%**	0.4%	0.0%	0.1%	0.3%	0.0%	0.2%
Pick-up passenger	3.4%	**0.0%**	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Drop-off passenger	2.8%	**0.4%**	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	**85.3%**	**6.3%**	**2.3%**	**0.5%**	**0.6%**	**1.9%**	**0.3%**	**2.8%**

This choice is not surprising, given that Uber services have been available for a longer time in the Birmingham region than Lyft, and thus users are more familiar with the Uber provider. The finding is also consistent with national data reporting that Uber has largely dominated the market since its 2009 inception, accounting for over 80% of the market share, though recently, this proportion has dropped below 75% (Cortright, 2017).

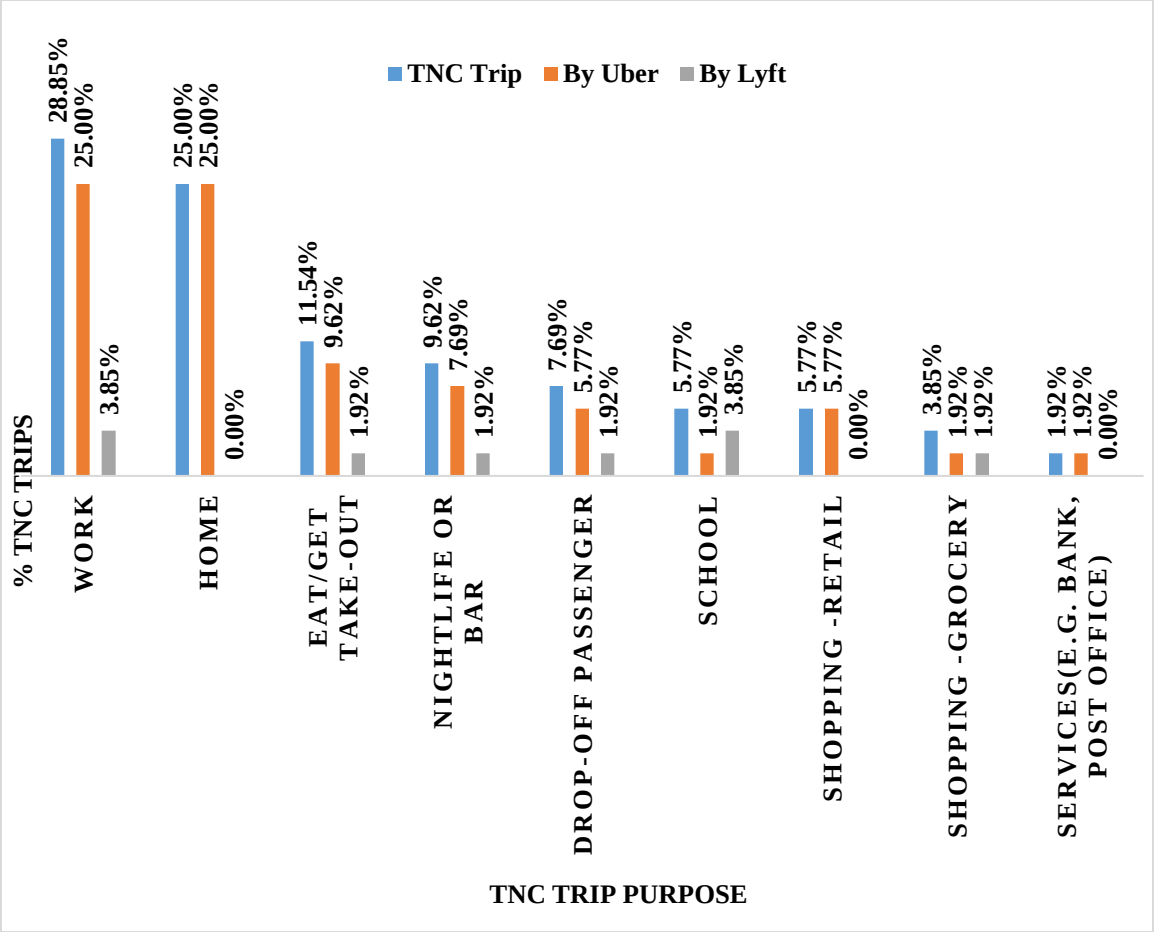


Figure 19. Trip Purpose of TNC Trips and Preferred Provider

As mentioned earlier, TNC availability in a transportation market is believed to have a potential adverse impact on public transportation use. A study of approximately 9,500 participants across North America saw a slight shift away from public transit ridership as a result of TNC market availability (Martin & Shaheen, 2010).

To understand the connection between auto ownership, transit users, and TNC use in Birmingham case study we classified the TNC trips reported in the Birmingham survey by vehicle ownership/availability and trip purpose. The figure represents the results. We can observe from Figure 20 that 25% of TNC users that completed the Birmingham survey

own a vehicle and still use TNCs for select trip purposes. Another 52% reported that they do not own an automobile, but one is available in their household, while the remaining 23% of TNC users reported no vehicle ownership or access. The majority of the 23% TNC users were public transit dependent users before the introduction of TNCs in the Birmingham Metro Area. While the information summarized in the Table is useful, the low transit availability and the relatively low use of TNCs in the Birmingham region do not allow for drawing definitive conclusions regarding the impact of TNC use on transit ridership at present.

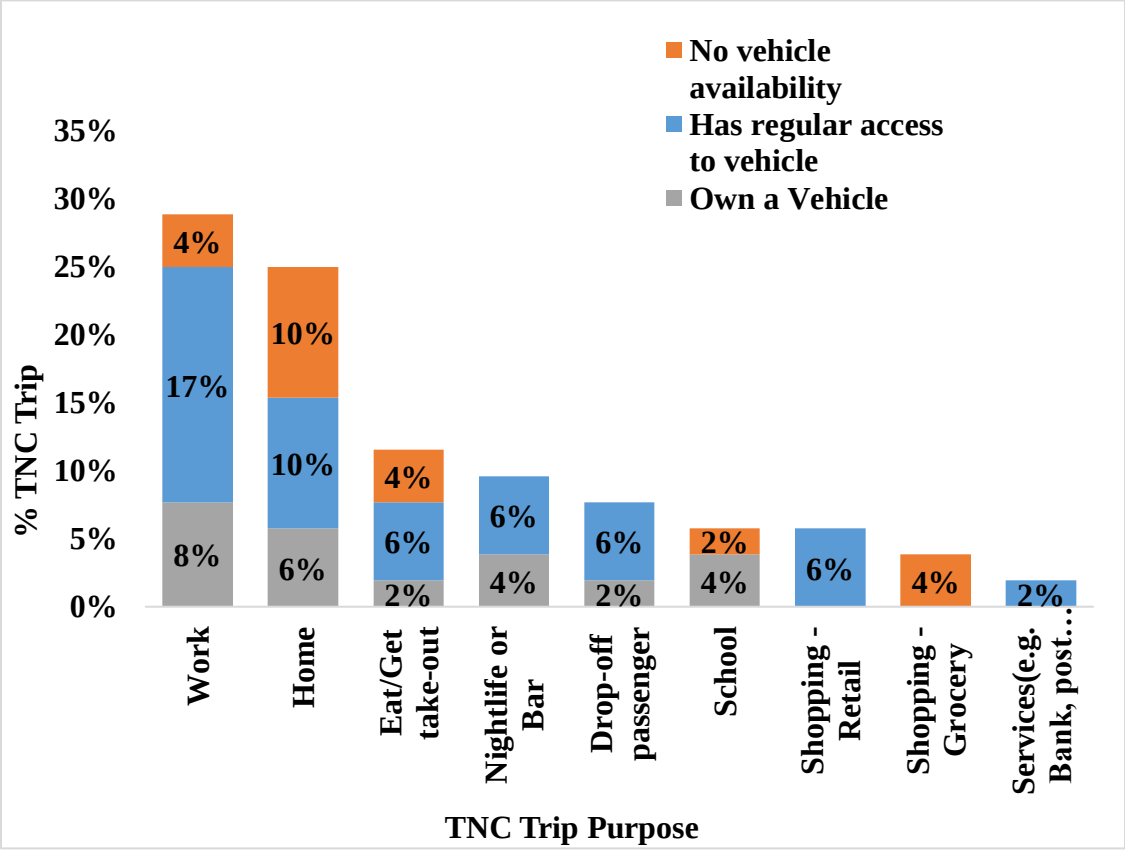


Figure 20. Car Availability of TNC Users

A factor that was considered as a potential determinant of TNC use was the trip distance. According to the characteristics of the TNC trips reported in our study, TNC users use TNC services for trips under 10 miles. A comparison between TNC and non-TNC trips revealed that the average trip length performed by TNC was 5.19 miles, far lower than the average trip length of automobile trips (9.28 miles) in the region. Further analysis indicated that the longest TNC trips involved drop-off of a passenger or trips to work or home. The average trip length per trip purpose for TNC trips is showcased in Figure 21.

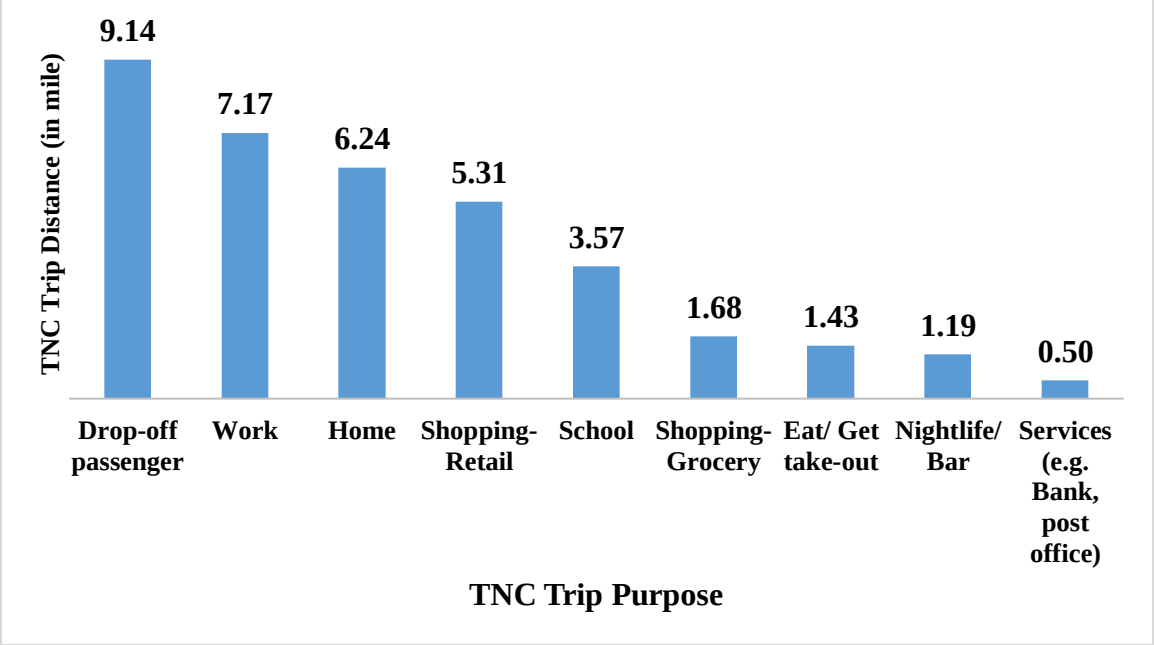
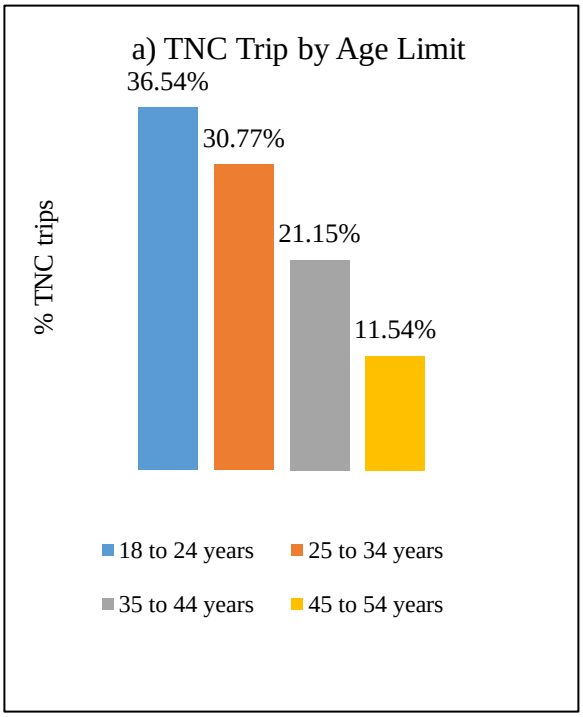


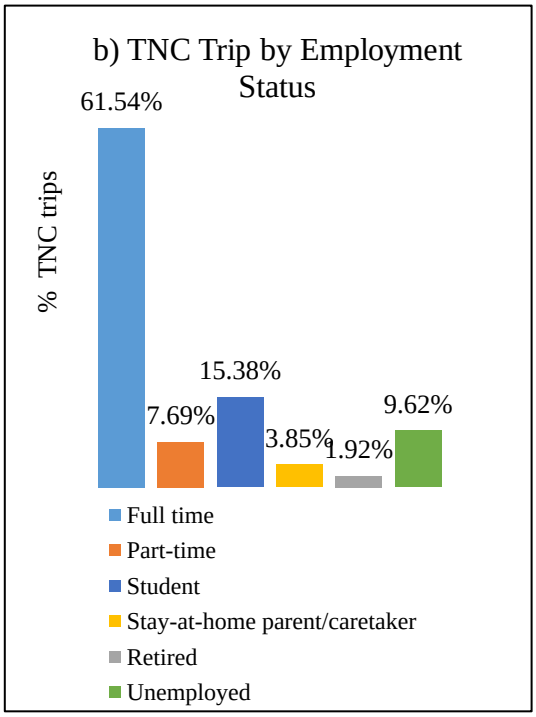
Figure 21. TNC Trip Distance (in miles) for Various Trip Purposes

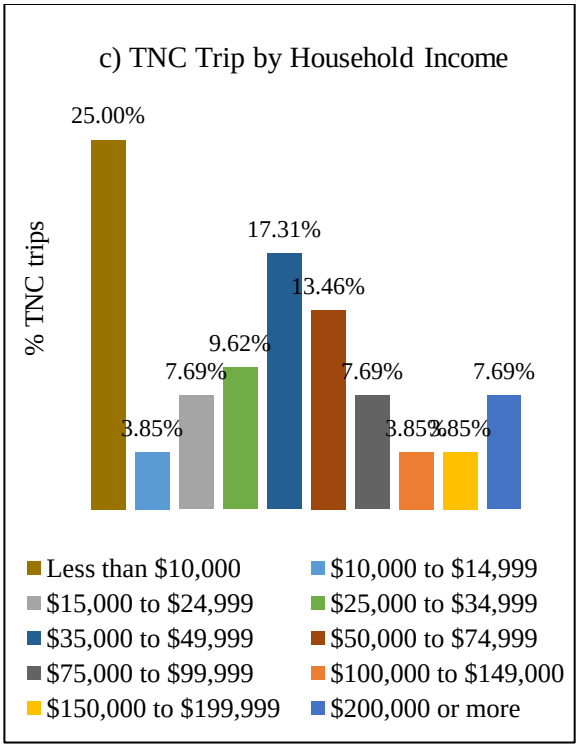
Similarly, analysis of travel times reported in the survey of the Birmingham transportation system users indicated that the average trip by TNC was 25.64 minutes long, whereas automobile trips averaged 28.38 minutes. This is consistent with findings of the

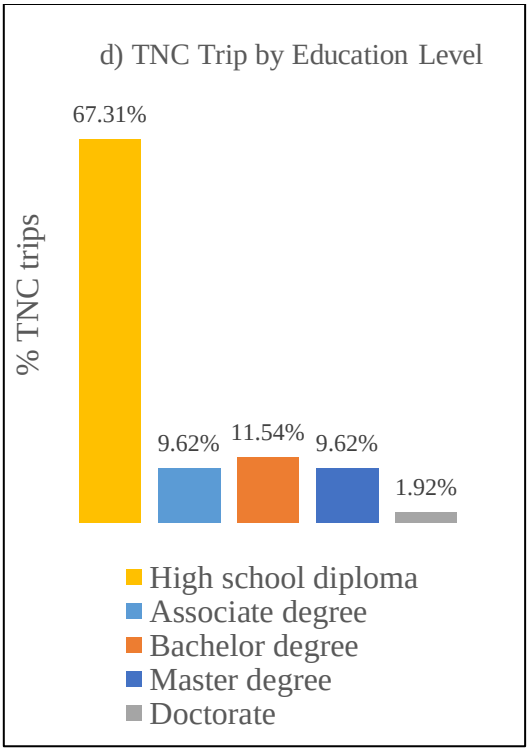
2013 American Community Survey commuter data for the Birmingham-Hoover Metro Area, which reported average commute in the Birmingham metro of 25.7 minutes.

Figure 22 presents details about the documented 6.3% TNC trips based on the 24-hr trip diary that study participants entered into the Birmingham survey. The findings summarized in Figure 22 helped us to define the profile of the typical TNC user in the Birmingham region as a 25-34 years old who likely owns an automobile and is using the service for commuting trips or for entertainment purposes for short to medium range distances (or average of 5 miles).


a) TNC Trip by Age Limit
% TNC trips
36.54%
30.77%
21.15%
11.54%
18 to 24 years
25 to 34 years
35 to 44 years
45 to 54 years


b) TNC Trip by Employment Status
% TNC trips
61.54%
7.69%
15.38%
3.85%
1.92%
9.62%
Full time
Part-time
Student
Stay-at-home parent/caretaker
Retired
Unemployed


c) TNC Trip by Household Income
% TNC trips
25.00%
3.85%
7.69%
9.62%
17.31%
13.46%
7.69%
3.85%
3.85%
7.69%
Less than $10,000
$10,000 to $14,999
$15,000 to $24,999
$25,000 to $34,999
$35,000 to $49,999
$50,000 to $74,999
$75,000 to $99,999
$100,000 to $149,000
$150,000 to $199,999
$200,000 or more


d) TNC Trip by Education Level
% TNC trips
67.31%
9.62%
11.54%
9.62%
1.92%
High school diploma
Associate degree
Bachelor degree
Master degree
Doctorate

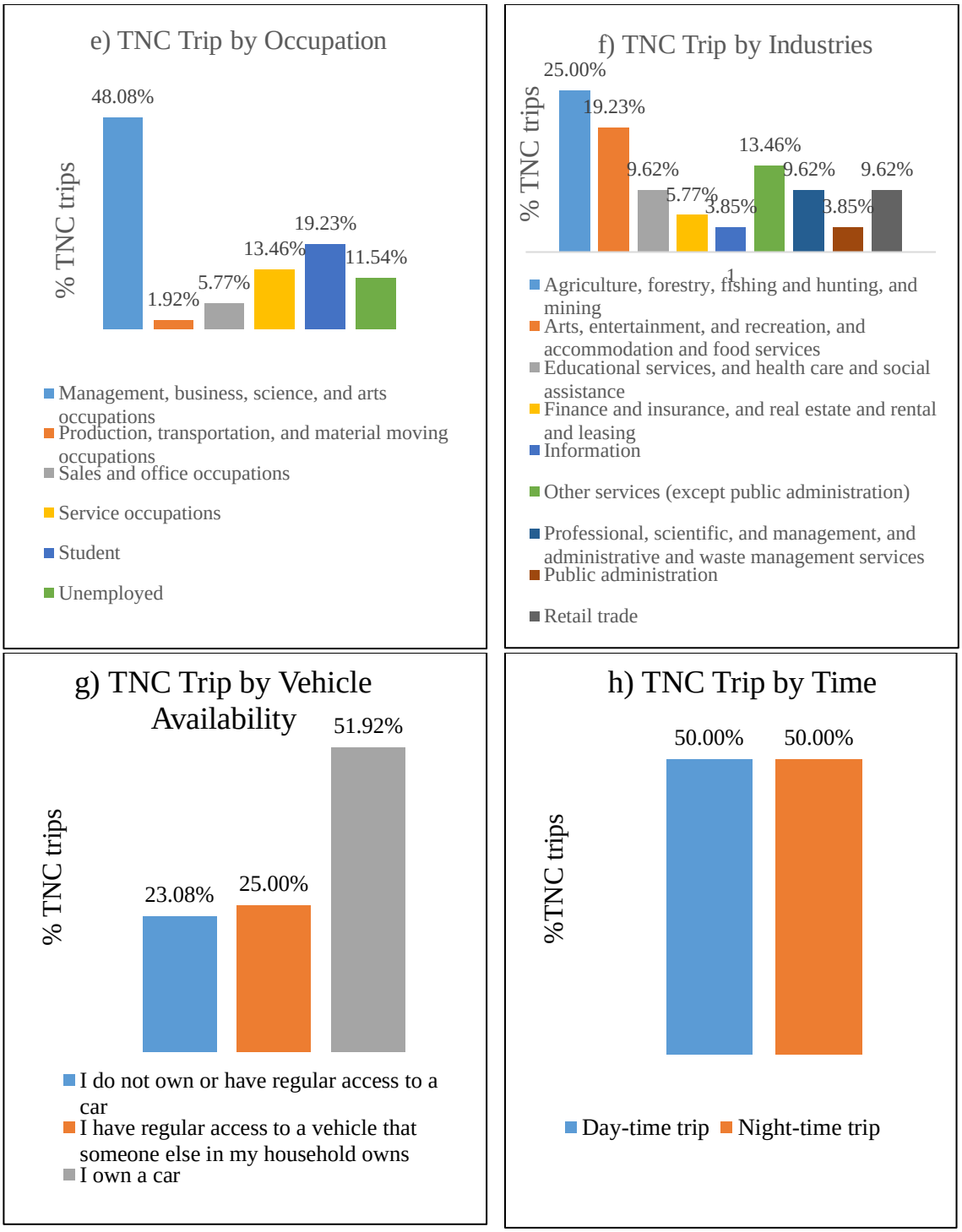


Figure 22. TNC Trip by a) Age Limit, b) Employment Status, c) Household Income, d) Education Level, e) Occupation, f) industries, g) Vehicle Availability, and h) Time

If we further breakdown the day-time trips and night-time trips into waiting time and available vehicle showing on the app, the responses received show that 88.46% of TNC users that responded to our survey noted that only 1-2 vehicles were available (Table 9). This indicates the limitation of TNC service on Birmingham metro area, which differentiates TNC use in the region compared to large metropolitan areas that performed similar studies such as San Francisco, Boston, and New York to name a few. When we consider waiting time, most of the TNC Birmingham riders noted that they had to wait 0-5 minute for a vehicle to arrive but one third of all TNC riders reported waits of 6-10 minutes.

Table 9. Correlation of TNC trip time with waiting minute and vehicle availability on app

Available vehicle on App	**1-2**	**3-5**	**Total**
Day-time trip	**38.46%**	**11.54%**	**50.00%**
0-5 minute	19.23%	5.77%	25.00%
11-15 minutes	3.85%	3.85%	7.69%
6-10 minutes	15.38%	1.92%	17.31%
Night-time trip	**50.00%**	**0.00%**	**50.00%**
0-5 minute	32.69%	0.00%	32.69%
6-10 minutes	17.31%	0.00%	17.31%
Total	**88.46%**	**11.54%**	**100.00%**

Personal Preferences for Future Improvements

When Birmingham survey participants were asked about their preferences with respect to future improvements related to transportation infrastructure and services, 26% recommended an expansion of TNC services in the Birmingham region (Figure 23).

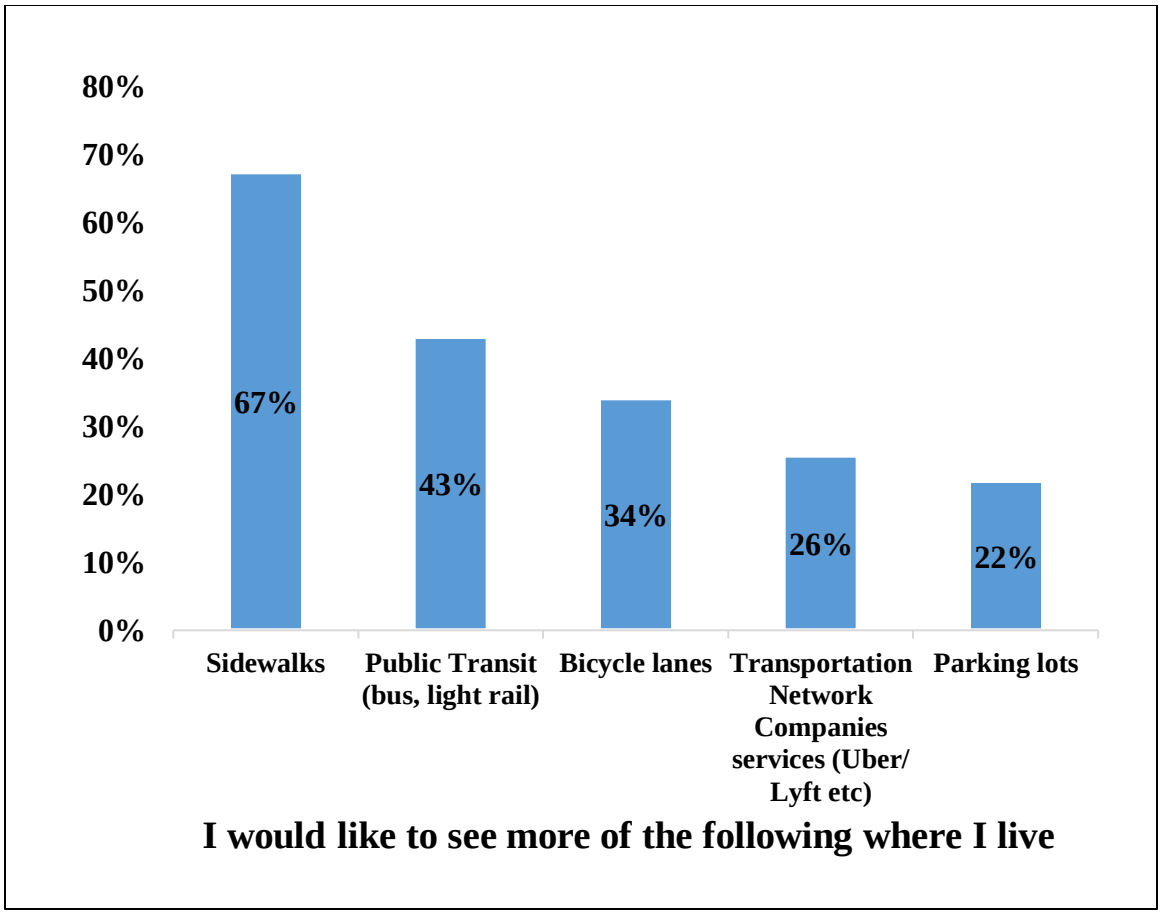


Figure 23. Preferences for Future Improvements

The current level of use of TNCs in the Birmingham Metropolitan area, coupled with transportation users' expressed interest in expansion of TNC services, highlight the importance of understanding the potential impacts of such services on traffic operations and traffic congestion in the region.

CHAPTER SIX

CONCLUSIONS, APPLICATIONS AND RECOMMENDATIONS

Conclusions of the Study

The analysis of 451 questionnaire surveys of Birmingham transportation system users shed light on users' awareness and use of TNC services in the region. Examination of over 1,000 reported trips indicated that approximately 6.3% of those trips were performed using TNCs, with Uber having 80% of the TNC market share. Determinants that make TNCs a preferable mode to travelers include convenience of use, and reduction of concerns for traffic safety (especially for late night trips to bars and eating establishments). Lack of parking availability at destination was also listed as a reason for selecting TNCs as a mode of travel.

Examination of respondents' demographics and cross tabulation analyses provided evidence that TNC users cover a wide range of age groups, with younger users being overrepresented compared to elderly. Lack of vehicle availability was associated with a quarter of all reported TNCs, thus indicating that the majority of TNC users select TNC services as a mode of choice for certain trips.

The analysis also confirmed that the market share of TNC trips in the Birmingham region is currently small (6.3% of trips reported). This is consistent with expectations, given that Uber and Lyft were recently introduced in the region and that transportation users in the Birmingham Metro still largely embrace the automobile-dependent commuting

culture. Still, 45% of the survey responders reportedly have used TNC in the past year, an indication of awareness of TNC service availability. This population segment can be further targeted with marketing plans and incentives to encourage mode switching to shared modes, including TNCs.

Application of the study

This survey is an attempt to document the preferences, attitudes, and choices of transportation users in the Birmingham area in the presence of TNC services. The study highlights links between TNC service availability and travel choices among adults in the region, where the auto-dependent built environment likely influences these links. This study is also significant for providing transportation agencies the means to better-plan mobility as a service (MaaS) where car/ridesharing platforms are active. Moreover, the study findings can inform TNC- and other shared-mode services about the needs and opportunities of the local market and enable them to better understand how the travel behavior, mode-choice, and travel demand might affect the use of TNCs in the future. The results reported in this work are also expected to help transit agencies, and TNC companies to coordinate their efforts towards achieving integrated system operations that could attract new customers and benefit both types of transportation services in the future.

Recommendation for Future Study

Ridership data logs from Uber, Lyft and similar services for the Birmingham market area can provide very valuable information about current practices, future opportunities, and impacts from TNC use in the Birmingham region, as they relate to trip generation, mode choice, and congestion impacts. Thus a future study is recommended to

identify and document such impact when TNC data for the Birmingham area become publicly available.

Future studies can also expand the survey sample size and include new and emerging modes like UberPool and LyftShare. In particular some attention should be given to "Via", a new TNC option for dynamic ride sharing that was introduced to Birmingham as a pilot program after the completion of this survey. "Via" covers a small radius of service in the Birmingham region and is an app-based vanpool program that operates on a small fee. Analysis of "Via" service information and comparison of Uber and Lyft ridership data before and after the introduction of "Via" could provide valuable information about the interest of Birmingham transportation users for a service like "Via" and its substitution effect on TNC trips in the region.

Moreover, future local surveys should seek the perspectives of Uber/Lyft drivers can be collected and compare those to the users' perspective to determine ways of encouraging and facilitating TNC use and improving both user and driver experience with the service.

The results presented in this report establish links between TNC availability and mode choices among transportation users in the Birmingham region. The robustness of the results will benefit from expanding the scope of the data collection to include users from other regions. More analysis and research needs to be undertaken to see how findings from this study compares to those from other regions in the Southeast and across the nation.

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APPENDIX A

Birmingham Region Travel Diary Survey

Start of Block: Informed Consent

Q1 Welcome to the UAB travel diary survey!

Dr. Virginia Sisiopiku (UAB) invites you to be part of a research project that studies technology influence on travel demand and behavior. Your feedback is very important, as it will help UAB researchers to understand and model travel behavior in the Birmingham region.

If you agree to participate, you will be asked to complete a survey about your travel preferences and practices as you travel on a typical weekday in and around Birmingham. The survey should take approximately 10 minutes to complete and your participation is voluntary. Please be assured that your responses will be kept completely confidential and exempt from public disclosure by law. Please note that this survey will be best displayed on a laptop or desktop computer. While you can complete the survey on a mobile device, some features may be less compatible for use on a mobile device.

Your kind assistance in providing input through the completion of this survey is greatly appreciated. If you have questions about the survey or research study, you can contact Dr.

Sisiopiku, UAB, Civil, Construction, and Environmental Engineering, Birmingham, AL 35294, or via email at vps@uab.edu.

If you have questions about your rights as a research participant, or concerns or complaints about the research, you may contact the UAB Office of the IRB (OIRB) at 205-934-3789 or toll free at 1-855-860-3789. Regular hours for the OIRB are 8:00 a.m. to 5:00 p.m. CT, Monday through Friday.

By clicking the consent button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.

○ I consent, begin the study

○ I do not consent, I do not wish to participate

End of Block: Informed Consent

Start of Block: ZIP Code Validation

Q2 **Home ZIP Code**

_____

End of Block: ZIP Code Validation

Start of Block: Travel Preferences

Q3 I have used the following in the Birmingham region at least once in the past year:

Check all that apply

- ○ Transportation Network Companies (Uber, Lyft, etc.)
- ○ Public Transit
- ○ Organized ride sharing program
- ○ Bicycle
- ○ ⊗None of the above

Q4 Last trip with Transportation Network Companies (Uber, Lyft, etc.)

- ○ Within the past 7 days
- ○ Within the past 30 days
- ○ Within the past two months
- ○ Within the past 6 months
- ○ Within the past year

Q5 Reason(s) for using Transportation Network Companies (Uber, Lyft, etc.)

Check all that apply

- ○ Convenience
- ○ Cheaper than other alternatives

- ○ Destination has little or no parking availability
- ○ Parking at destination is expensive
- ○ Safety/to avoid driving under the influence
- ○ Car is not available
- ○ Transit is not accessible
- ○ Transit is not reliable
- ○ Other modes are not available
- ○ Other reason (fill in) _____

Q6 Trip purpose(s) for using Transportation Network Companies (Uber, Lyft, etc.)

Check all that apply

- ○ Commute to school/work
- ○ Run an errand (e.g. shopping, medical/dental appointment, etc.)
- ○ Special events where parking is an issue
- ○ Nightlife (or any other activity impairing driving)
- ○ Shopping
- ○ Other (fill in) _____

Q7 Reason(s) for not using Transportation Network Companies (Uber, Lyft, etc.)

Check all that apply

○ Not convenient

○ Expensive

○ Not available / Area not serviced

○ Safety concerns

○ Other (fill in) _____

End of Block: Travel Preferences

Start of Block: Travel Diary Consent

Q8 We care about the quality of our survey data and hope to receive the most accurate measures of the trips of your day. It is important to us that you thoughtfully consider and record each trip of your day over a 24-hour period. Do you commit to providing your thoughtful and honest answers to recording all the trips of your day over a 24-hour period?

○ I will provide my best answers

○ I will not provide my best answers

○ I cannot promise either way

End of Block: Travel Diary Consent

Start of Block: Initial Location

Q9a Please tell us about your trips during a typical weekday

Considering your trips yesterday or on a typical weekday, indicate every place you visited from the beginning of the day and for a 24-hour period. For the purpose of this survey, the day starts at 12:00 AM (midnight). Please also list walk trips that are 10 minutes or longer.

a. Please provide address (or closest intersection) to your initial location at 12:00AM (midnight)

_____

(Google Map was inserted on the survey)

Q9b Location Type

- ○ Home
- ○ Work
- ○ School
- ○ Ear/ Get take-out
- ○ Nightlife/ Bar
- ○ Shopping- Grocery
- ○ Shopping- Retail
- ○ Services (e.g. Bank, post office)
- ○ Pick-up passenger
- ○ Drop-off passenger

End of Block: Initial Location

Start of Block: 24hr Trip Details

Q10 Please tell us about your trips during a typical weekday.

Considering your trips yesterday or on a typical weekday, indicate every place you visited from the beginning of the day and for a 24-hour period. For the purpose of this survey, the day starts at 12:00 AM (midnight). Please also list walk trips that are 10 minutes or longer.

b. Trip/Place Visited (address or closest intersection)

_____

(Google Map was inserted on the survey)

Q11a Trip Start Time

	hh	mm	AM/PM
Trip Start Time	00 ▼	00 ▼	AM ▼

Q11b Trip End Time

	hh	mm	AM/PM
Trip End Time	00 ▼	00 ▼	AM ▼

Q12 Trip Purpose

○ Home

○ Work

○ School

○ Eat/ Get take-out

○ Nightlife/ Bar

○ Shopping- Grocery

○ Shopping- Retail

○ Services (e.g. Bank, post office)

○ Pick-up passenger

○ Drop-off passenger

Q13 Mode

○ Car

○ Carpool/Vanpool

○ Car rental

○ Taxi

○ Uber/Lyft

○ Transit

○ Bike

○ Walk

Q14 Please share your experience with Transportation Network Companies (Uber, Lyft, etc.)

For each location you normally Uber/ Lyft or similar rides, indicate the typical wait time and car availability. Car availability means the number of Uber/ Lyft cars you typically see swarming your location when using the mobile app.

	Wait Time in minutes	Company	Uber/ Lyft Car Availability
	0 - 5 minutes ▾	Uber ▾	1-2 ▾

Q15 Is this your last trip of the day (before you go to bed)?

○ Yes, this was my last trip

○ No, I took another trip

End of Block: 24hr Trip Details

Start of Block: Facility Preferences

Q16 I would like to see more of the following where I live.

Check all that apply

- ○ Public Transit (bus, light rail)
- ○ Transportation Network Companies services (Uber/ Lyft, etc.)
- ○ Bicycle lanes
- ○ Sidewalks
- ○ Parking lots

End of Block: Facility Preferences

Start of Block: General Information

Q17 Gender at birth

○ Male

○ Female

Q18 Age

○ 18 to 24 years

○ 25 to 34 years

○ 35 to 44 years

○ 45 to 54 years

○ 55 to 64 years

○ 65 to 74 years

○ 75 years and over

Q19 Current employment status

- ○ Full time
- ○ Part-time
- ○ Student
- ○ Stay-at-home parent/caretaker
- ○ Self-Employed
- ○ Retired
- ○ Unemployed
- ○ Other

Q20 Occupation

- ○ Management, business, science, and arts occupations
- ○ Service occupations

○ Sales and office occupations

○ Natural resources, construction, and maintenance occupations

○ Production, transportation, and material moving occupations

○ Student

○ Unemployed

Q21 Industry

○ Agriculture, forestry, fishing and hunting, and mining

○ Construction

○ Manufacturing

○ Wholesale trade

○ Retail trade

○ Transportation, warehousing, and utilities

○ Information

○ Finance and insurance, and real estate and rental and leasing

○ Professional, scientific, and management, and administrative and waste management services

○ Educational services, and health care and social assistance

○ Arts, entertainment, and recreation, and accommodation and food services

○ Public administration

○ Other services (except public administration)

Q22 Annual Household Income

○ Less than $10,000

○ $10,000 to $14,999

○ $15,000 to $24,999

○ $25,000 to $34,999

○ $35,000 to $49,999

○ $50,000 to $74,999

○ $75,000 to $99,999

○ $100,000 to $149,000

○ $150,000 to $199,999

○ $200,000 or more

Q23 Highest Degree

○ High school diploma

○ Associate degree

○ Bachelor’s degree

○ Master’s degree

○ Doctorate

Q24 Auto Ownership

○ I own a car

○ I have regular access to a vehicle that someone else in my household owns

○ I do not own or have regular access to a car

Q25 Please provide home address or closest intersection

_____

End of Block: General Information

APPENDIX B

ZIP Code List

- 35203
- 35204
- 35205
- 35206
- 35207
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- 35209
- 35210
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