IndyGo On-Board Transit Survey Final Report

May 15, 2017

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IndyGo

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2016 IndyGo On-Board Survey

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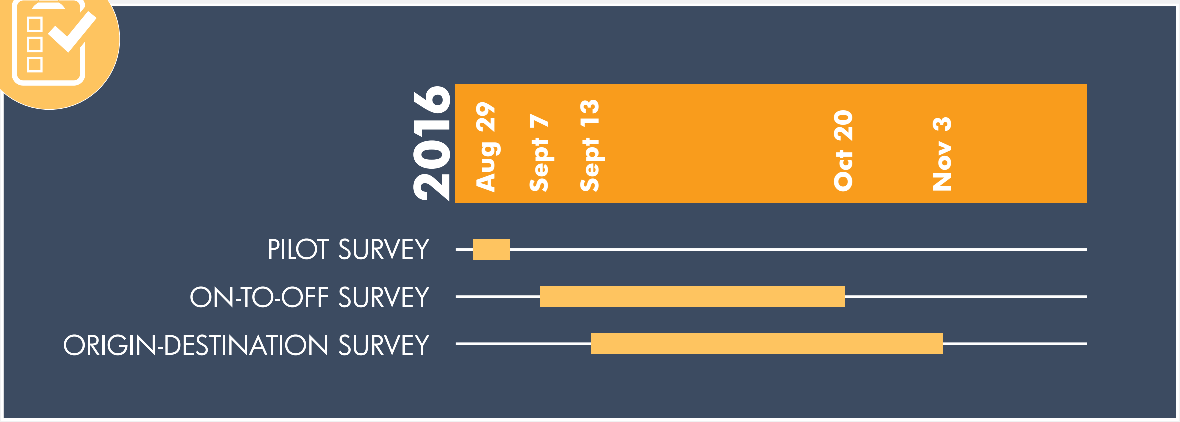
CHAPTER 1 EXECUTIVE SUMMARY

BACKGROUND

ETC Institute and Lochmueller Group conducted a system-wide on board survey of ridership for the Indianapolis Public Transportation Corporation (IndyGo). The following two surveys were conducted for all IndyGo routes:

1. Origin-Destination Survey and
2. On-to-Off Survey



In total, **4,189** usable surveys were collected. Key elements of the study include:

- Developing a survey instrument
- Developing sampling goals for each bus route
- Collecting and processing the surveys
- Weighting and expanding the data
- Analyzing survey results and reporting the results

The objective of the survey is to analyze travel patterns, transit use and determine the makeup of IndyGo's ridership. A comparison with demographic data for Marion County was also included where appropriate.

KEY FINDINGS

The analysis conducted was two-fold:

- Examine the **travel behavior characteristics** of IndyGo riders.
- Examine **demographic characteristics** of IndyGo riders.

The survey data used for this analysis were weighted and expanded to be representative of IndyGo's ridership.

48% Most of IndyGo's riders can be considered "frequent riders." Nearly half use the service 3-5 days per week.

49% Nearly half of IndyGo riders reported that there is no vehicle available to their household, while about 20% reported having two or more vehicles available to their household.

90% of single vehicle households have more than one member.

71% of riders are employed, including 20% that work part-time.

76% of IndyGo riders are from households that earn less than $35,000 annually. About 1% come from households that earn more than $100,000 annually.

93% Walking is the dominant access and egress mode for all riders. 93% walk to the bus stop while 95% walk to their final destination.

- Biking is the second most popular access and egress method at about 3%, reflecting trips made daily.

Demographic Profile of
2009 & 2016 RIDERS

2009

- 27% RIDERS BEGAN THEIR TRIP FROM WORK
- 28% RIDERS USED INDYGO TO GO TO WORK
- 49% MALE RIDERS
- 51% FEMALE RIDERS

2016

- 24% RIDERS BEGAN THEIR TRIP FROM WORK
- 26% RIDERS USED INDYGO TO GO TO WORK
- 54% MALE RIDERS
- 46% FEMALE RIDERS

Destination for
TRIPS STARTING AT HOME

- 48% GO TO A WORK RELATED DESTINATION
- 25% GO TO A SOCIAL/ RELIGIOUS/PERSONAL BUSINESS DESTINATION
- 11% GO TO A SHOPPING DESTINATION
- 7% GO TO AN EDUCATION RELATED DESTINATION
- 5% GO TO A DOCTOR/ CLINIC/HOSPITAL

BUS TRANSFERS

- 72% USED ONLY ONE BUS TO COMPLETE A ONE WAY TRIP
- 27% USED TWO OR MORE BUSES
- <1% USED THREE OR MORE BUSES

TYPICAL INDYGO RIDER

AFRICAN AMERICAN MALE

AGE 35-49

HE WORKS FULL-TIME BUT LIKELY HAS A HOUSEHOLD INCOME OF LESS THAN $24,999 PER YEAR.

THERE IS NO VEHICLE AVAILABLE TO HIM.

HE HAS A MONTHLY BUS PASS AND WALKS TO AND FROM THE BUS STOP.

HE ONLY TAKES ONE BUS TO ARRIVE AT HIS DESTINATION.

HE USES THE BUS 3 TO 5 DAYS A WEEK TO TRAVEL BETWEEN HOME AND WORK.

DOWNTOWN TRANSIT CENTER

The Julia M. Carson Transit Center opened on June 26, 2016 and is located on the corner of Washington and Delaware Streets. It was built for IndyGo riders to have a central "hub," making it more convenient to make transfers. It also provided shelter from weather for passengers waiting for buses. The opening of the transit center triggered system-wide route changes. This on board survey was conducted by IndyGo in order to determine new ridership origin and destination travel patterns resulting from the opening of the transit center.

INDYGO OPPORTUNITIES

One area of opportunity for IndyGo to grow its ridership is by increasing bus service. This would include increased bus frequency on all routes leading to decreased waiting time, longer service hours for early morning/late night trips and improved weekend service. Having an enhanced bus network with more direct routes would lead to quicker travel times and attract additional ridership as well. Providing rapid transit lines along high ridership corridors would also allow for much shorter travel times and improved rider experience.

CHAPTER 2
DATA ANALYSIS

2.1 DATA ANALYSIS

This section of the report focuses on the results of the On-Board Survey and presenting them based on various parameters. For the purposes of this analysis, ridership estimates used linked weightage factors. Generally, the results using linked and unlinked weightage factors are comparable. However, the unlinked weightage factors overestimate the number of transfers/buses used and skew the results for that survey question. The total estimated ridership based on the linked weightage factor is about 27,600.

A Microsoft Excel tool that includes data sets listed in this report was provided to IndyGo. It allows the user to run a query for single or cross-tabulated questions asked in the survey. The tool reports results for either linked or unlinked trip weights. The Excel tool allows IndyGo to filter and sort the data electronically for various survey questions.

Typical IndyGo Rider

IndyGo's typical passenger is an African American male between the age of 35 and 49. He uses the bus 3 to 5 times a week to travel between home and work. The typical rider works full-time but likely has a household income of less than $25,000 per year. He does not have a vehicle available to use. Most riders walk to and from the bus stop and only require one bus to reach their destination.

Travel Characteristics

Of the trips that originate from home, about 48% go to a work related location, followed by 28% going to a social/religious/personal business destination. About 11% go to a shopping location, 5% to the doctors/clinic/hospital and 7% go to school (including university). IndyGo riders use the public transit service to go to a wide variety of destinations.

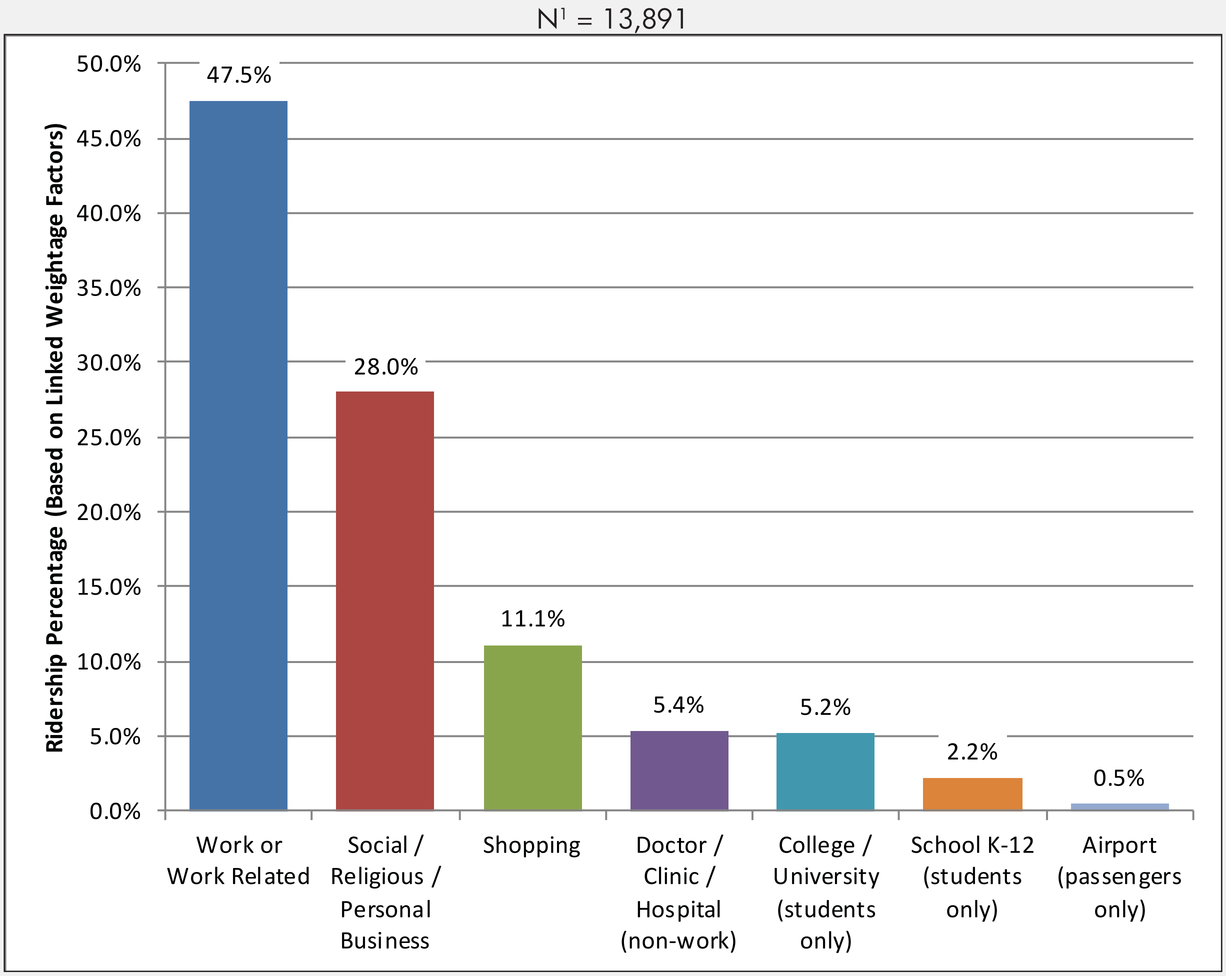


Figure 2-1: Destination Locations for Home originated trips

1 The variable N refers to the total average weekday ridership based on the linked weightage factors used for the graph.

QUESTION 1

Question 1: What type of place are you coming from now?

About half of IndyGo riders begin their trips from home. Nearly 24% of passengers start from work or a work related location. Although the majority of riders begin their trips from home or work, a substantial portion (about 26%) of passengers start from other locations such as the doctor's office, school or shopping. This shows that IndyGo serves a variety of trip origins.

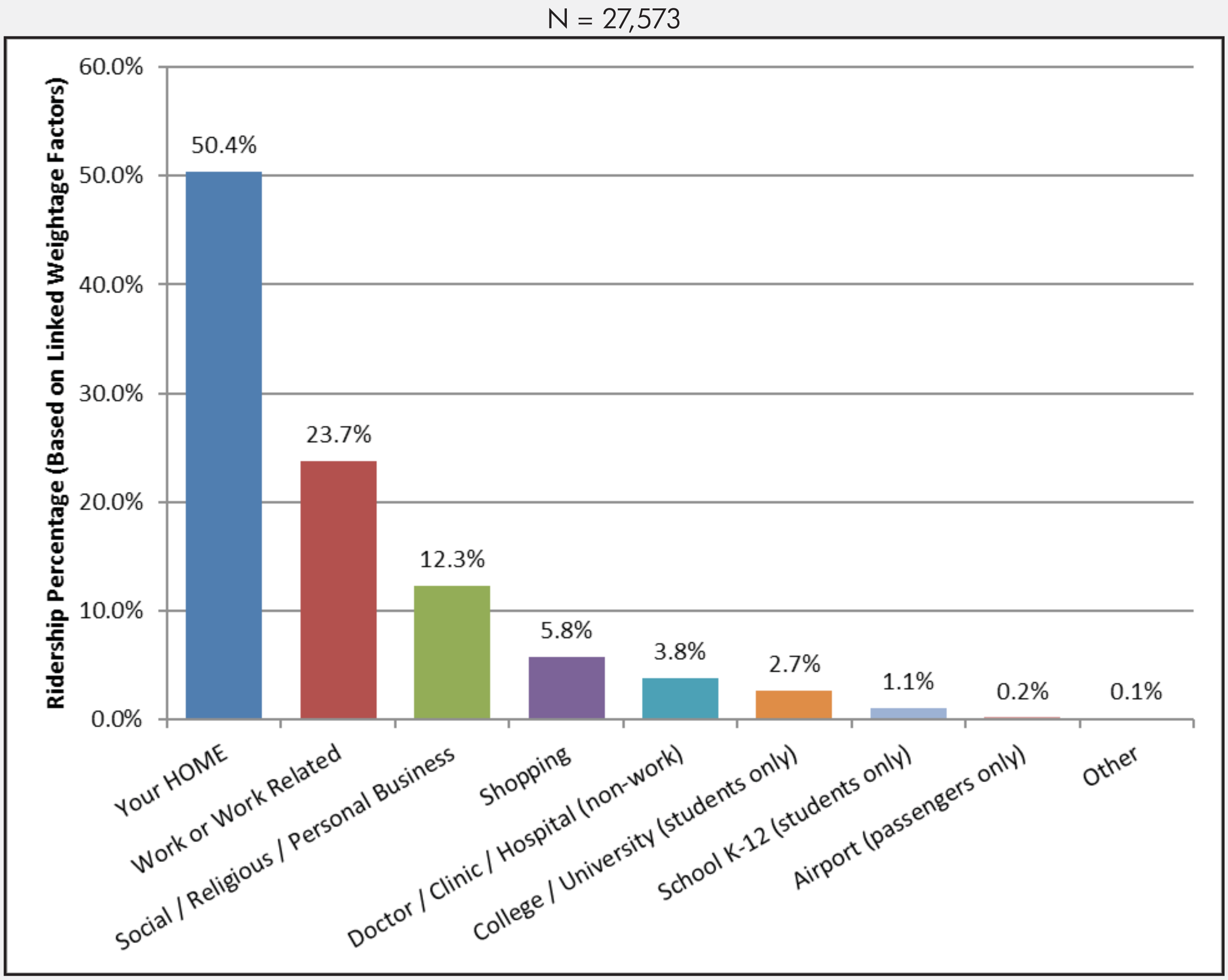


Figure 2-2: What type of places do IndyGo riders begin their trip?

QUESTION 1

The percentage of riders originating from school or college/university is more prevalent among the younger age categories while the older age categories tend to have more trips originating at a doctor/clinic/hospital. The percentage of riders originating at work increases with the age but then dips for seniors.

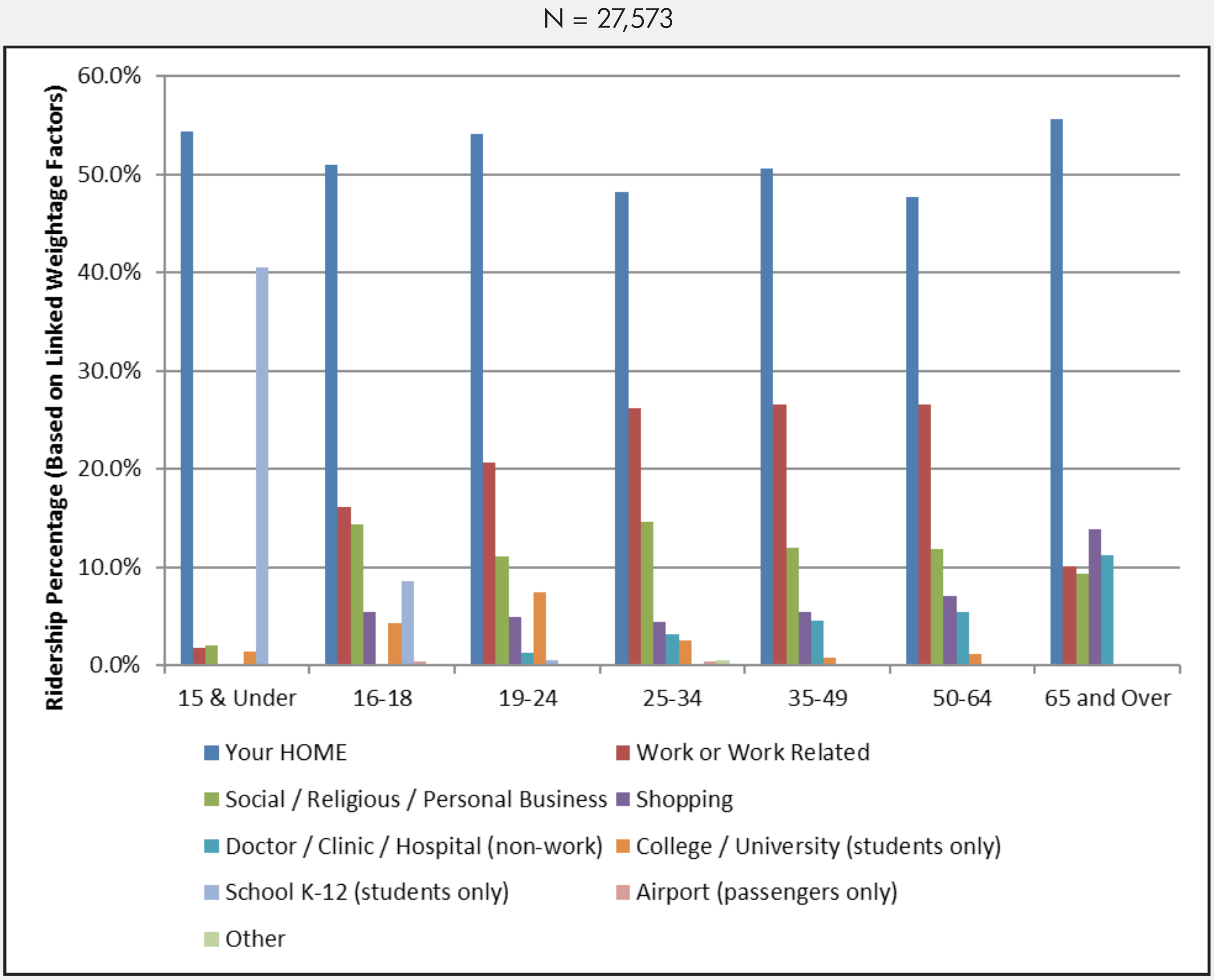


Figure 2-3: What type of places do IndyGo riders begin their trip based on age?

AGE GROUP	YOUR HOME	WORK OR WORK RELATED	SOCIAL/ RELIGIOUS/ PERSONAL BUSINESS	SHOPPING	DOCTOR/ CLINIC/ HOSPITAL	COLLEGE/ UNIVERSITY	SCHOOL K-12	AIRPORT	OTHER
15 & Under	54.3%	1.7%	2.0%	0.0%	0.0%	1.4%	40.5%	0.0%	0.0%
16-18	50.9%	16.1%	14.3%	5.4%	0.0%	4.3%	8.6%	0.4%	0.0%
19-24	54.1%	20.6%	11.1%	4.9%	1.3%	7.4%	0.5%	0.1%	0.0%
25-34	48.2%	26.1%	14.6%	4.5%	3.1%	2.5%	0.2%	0.3%	0.5%
35-49	50.6%	26.5%	12.0%	5.4%	4.5%	0.7%	0.1%	0.2%	0.0%
50-64	47.6%	26.6%	11.8%	7.1%	5.5%	1.1%	0.1%	0.2%	0.0%
65+	55.6%	10.0%	9.3%	13.8%	11.2%	0.1%	0.0%	0.0%	0.0%

Table 2-1: What type of place do IndyGo riders begin their trip based on age?

QUESTION 1

The origin/destination places for senior riders show that, compared to all riders, seniors make fewer trips to/from work and more trips to/from other locations. Seniors use IndyGo to go to a variety of locations, ranging from shopping to their doctor's office. Without IndyGo service, 43% of seniors would not have made these trips.

N = 1,265

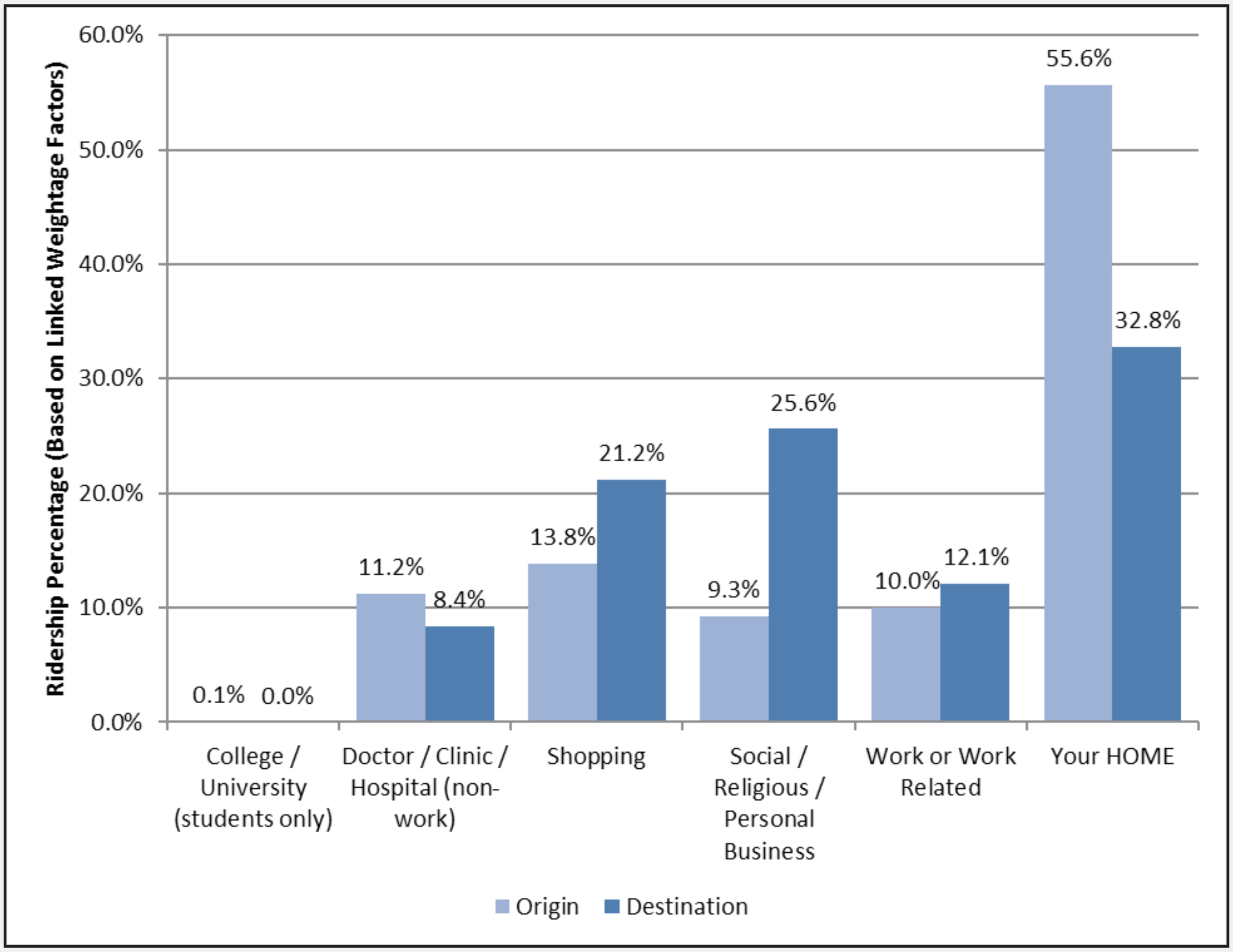


Figure 2-4: What type of places do seniors begin and end their trips?

QUESTION 1

N = 1,265

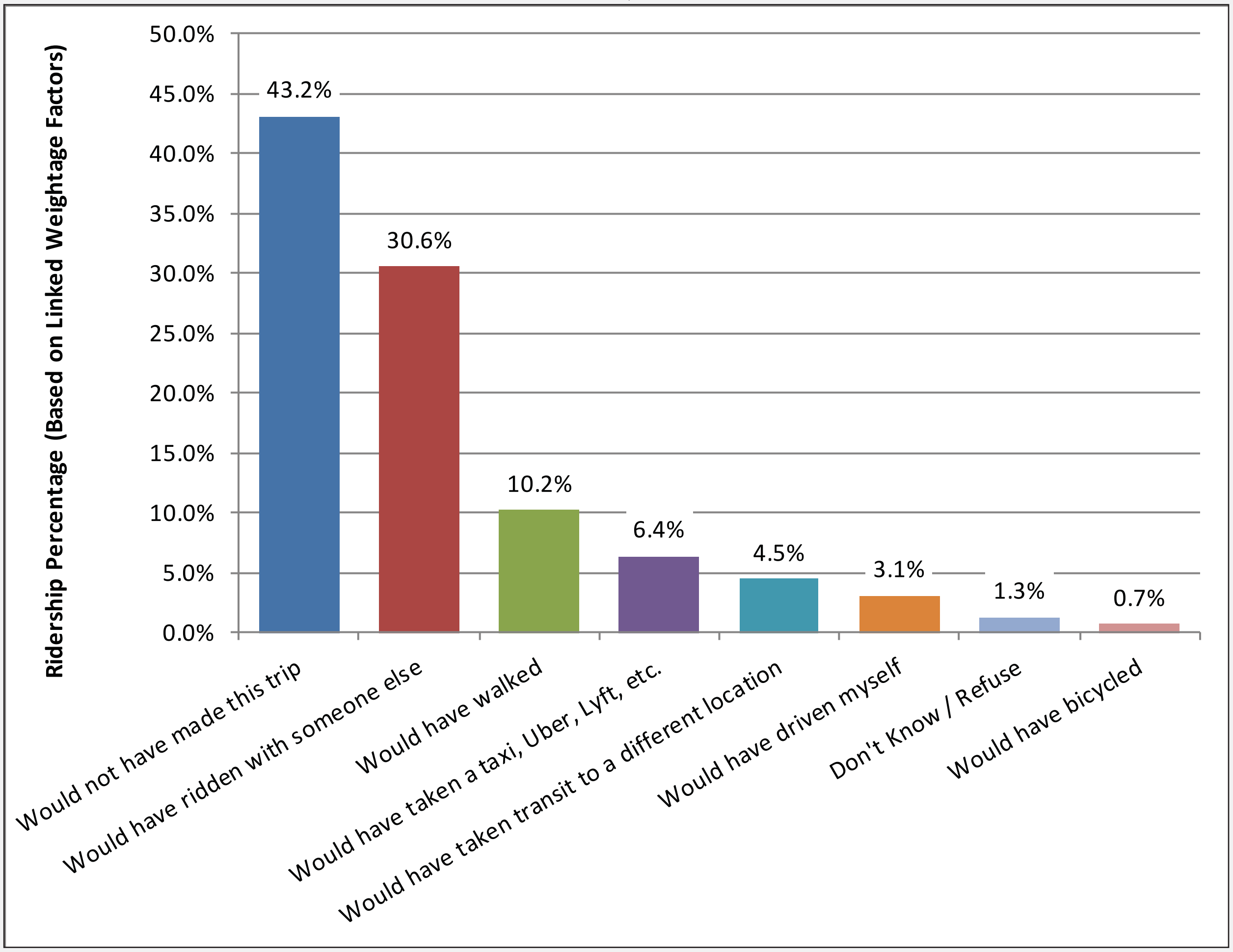


Figure 2-5: How would seniors make a trip if IndyGo service wasn't available?

QUESTIONS 2 & 3

Questions 2 and 3 ask riders to identify the name of the place they are coming from and the address of that place, respectively.

A heat map of the home origin locations is shown below. It can be seen that IndyGo riders begin their trips from a large service area, with the highest concentration being the downtown area.

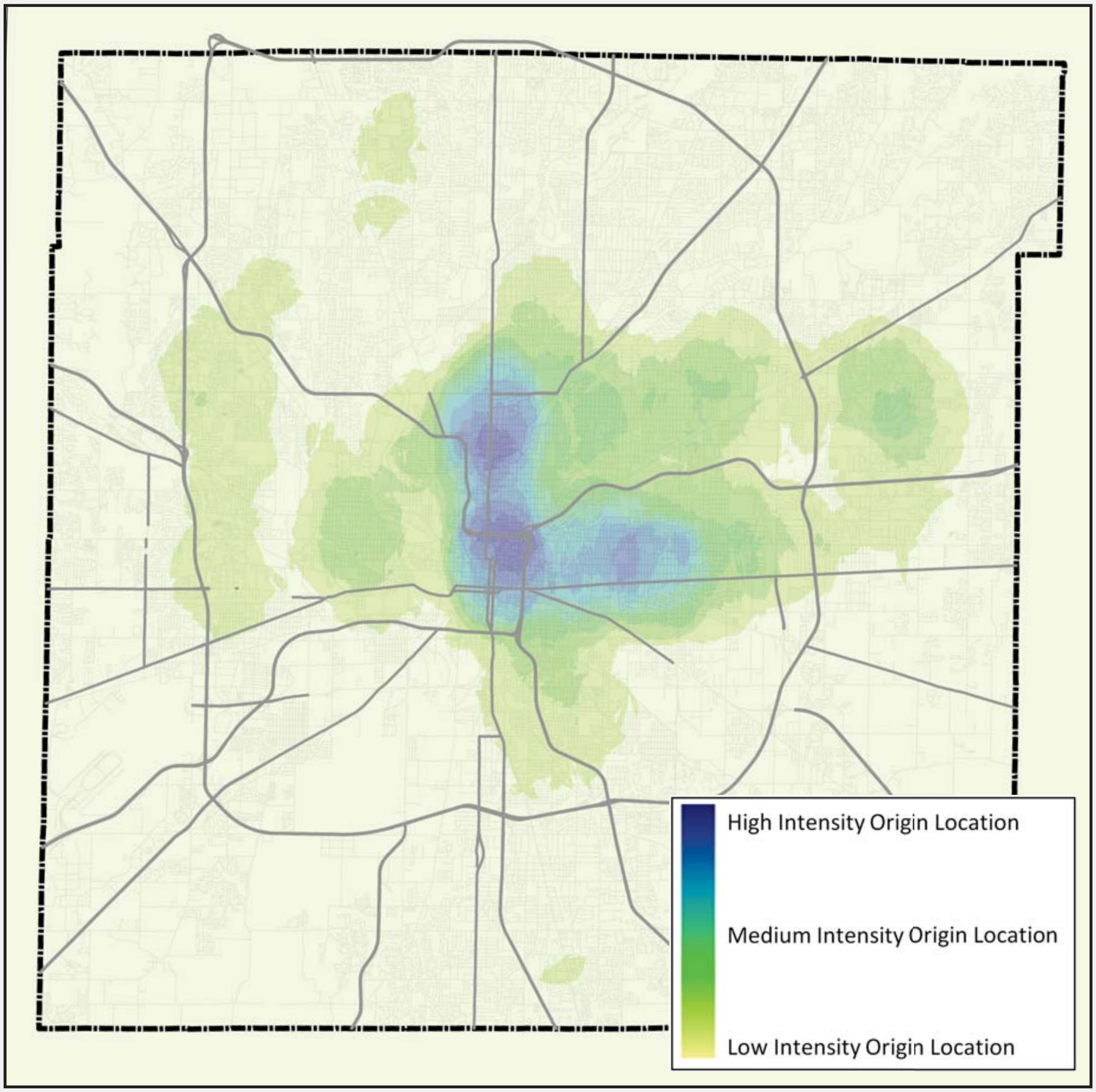


Figure 2-6: Home Origin Locations Heat Map

QUESTION 4

Question 4: How did you get from your origin (the place in Question #1) to the very first bus you used for this one-way trip?

The majority of riders walk or use a wheelchair to get to the appropriate bus stop. It's also important to note the number of riders that bike to the bus stop. Although it's a relatively low percentage at 2.9%, it corresponds to 800 one-way trips daily[2].

The riders that use a bike to arrive at their bus stop are typically travelling more distance from their origin or destination location than riders that walk to the bus stop. In fact, every IndyGo bus does have a bike rack that can store two or three bikes[3]. This is satisfying a real passenger need as can be seen by the estimated 800 riders daily that use bikes to arrive at their bus stops.

N = 27,573

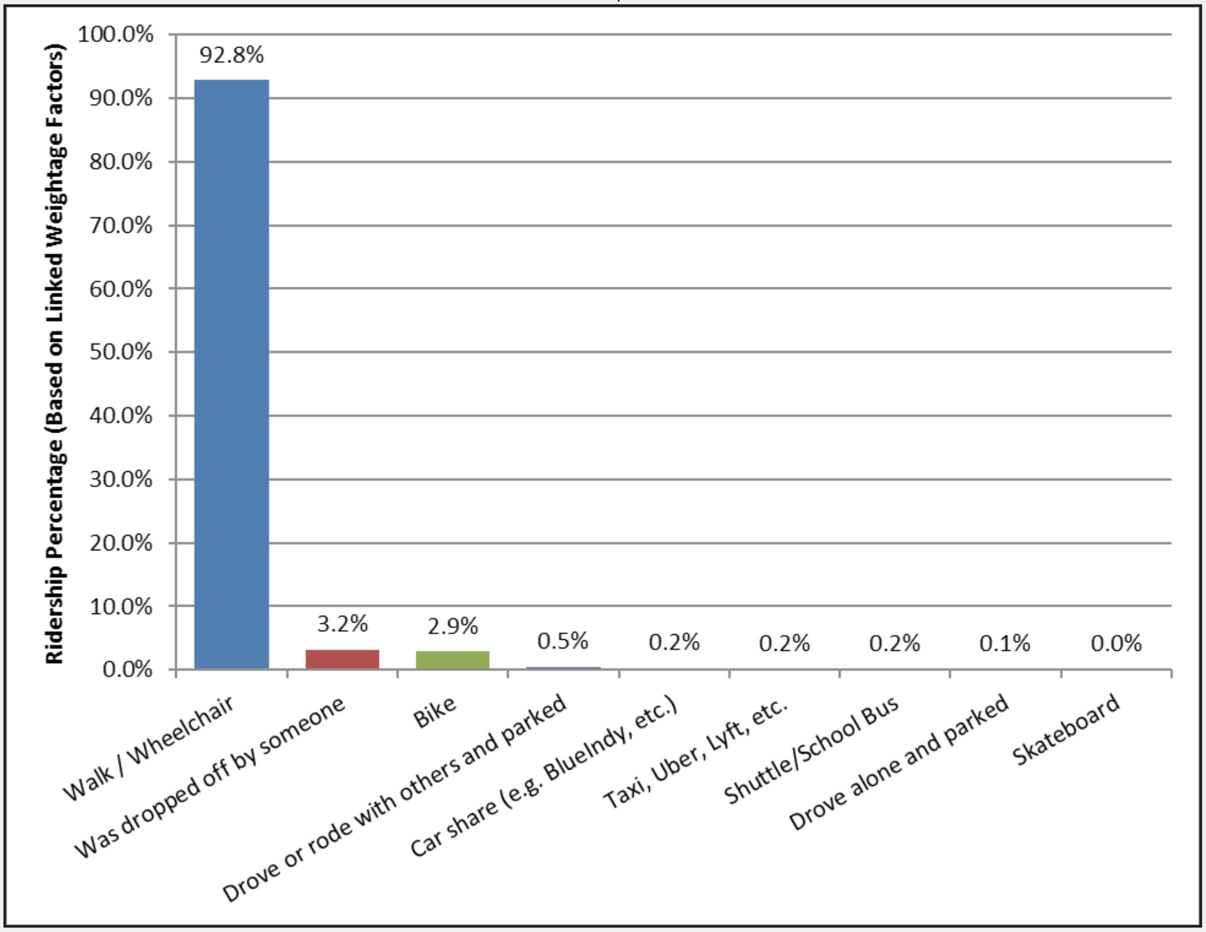


Figure 2-7: How do IndyGo riders get to their final destination once off the bus?

2 This survey was conducted during the fall. Actual daily bicycle usage may vary by weather and season.
3 Information provided on the IndyGo website: https://www.indygo.net/how-to-ride/bike-n-bus/

QUESTION 5

Question 5 asked respondents where they got on the bus to make this trip.

The distance that riders travel from their trip origin to their first bus stop was estimated based on survey responses for this question as well as questions 2 and 3. It can be seen that nearly 48% of passengers travel less than a quarter mile to reach their bus stop with about 25% traveling less than a tenth of a mile. Twenty-two percent of riders travel more than 1 mile to their bus stop.

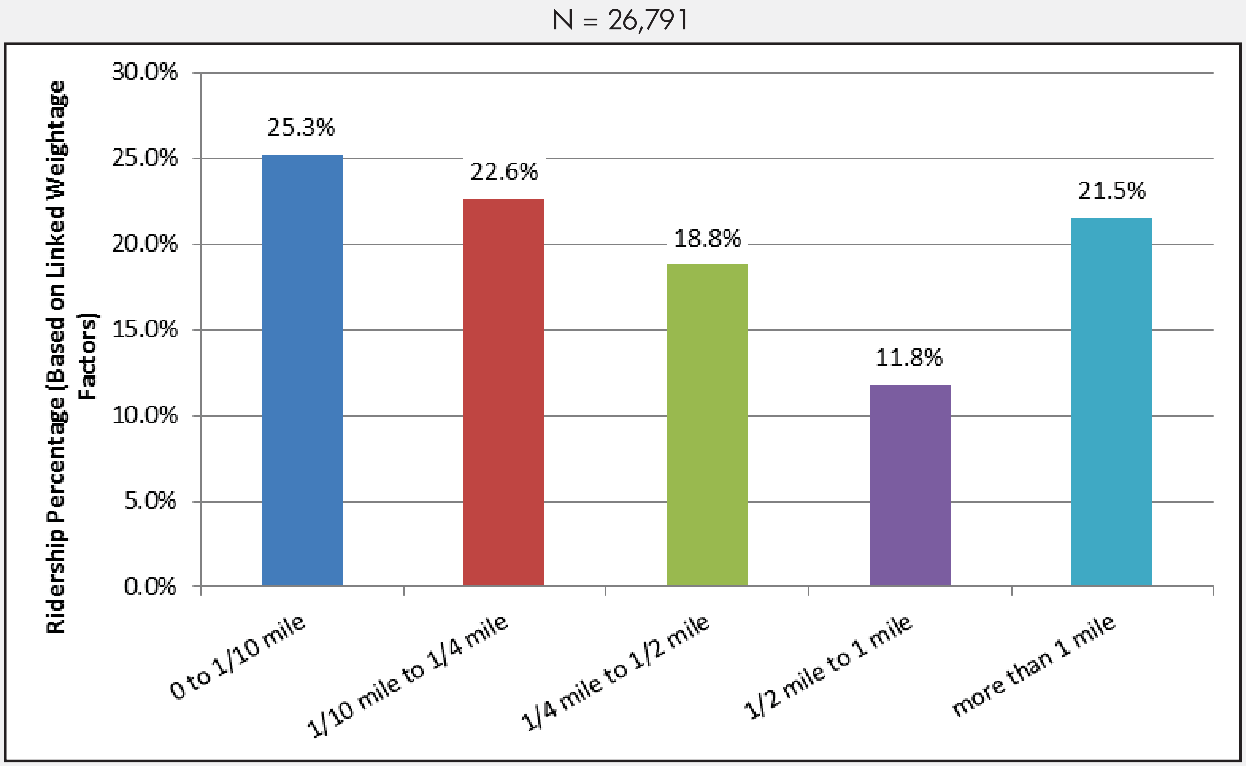


Figure 2-8: Distance IndyGo Riders Travel from Their Origin to Their First Bus Stop

QUESTION 6

Question 6: What type of place are you going to now?

About 38% of passengers end their trips at home, while 26% of riders have work or a work related location as their transit destination place. Even though most riders end their trips at work or home, over a third of passengers end their trips at other locations including religious places, shopping or to obtain medical care. This shows that IndyGo serves a variety of trip destinations.

N = 27,573

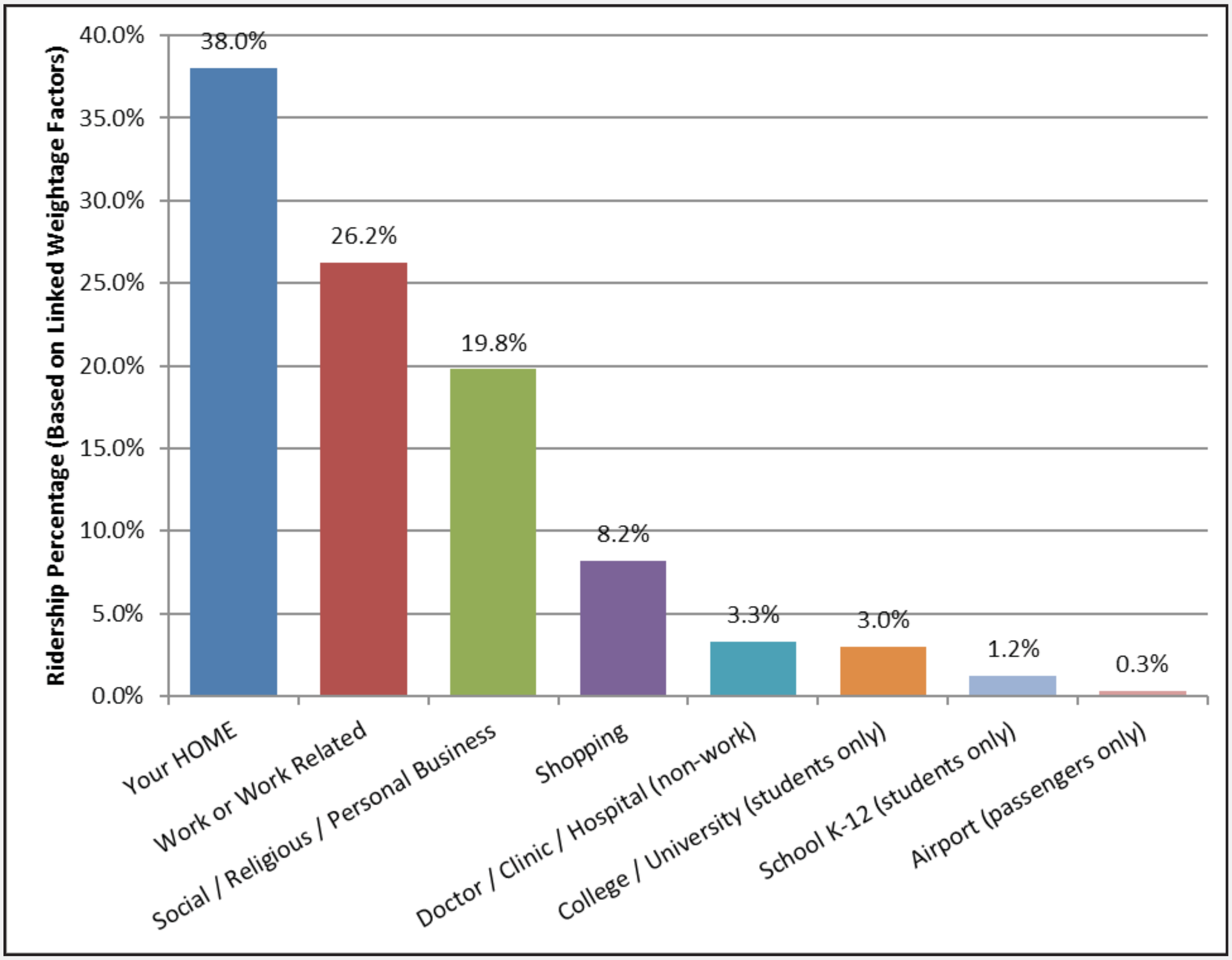


Figure 2-9: What type of places are destinations for IndyGo riders?

QUESTION 6

The survey revealed that the destination location for nearly 10% of 19-24 year olds is college/university. This corresponds to about 500 trips daily. IndyGo's services provide transportation to students, which is an important component of having access to higher education. A few of the larger schools within the IndyGo service area include:

- Indiana University Purdue University Indianapolis (IUPUI)
- University of Indianapolis
- Butler University
- Ivy Tech Community College

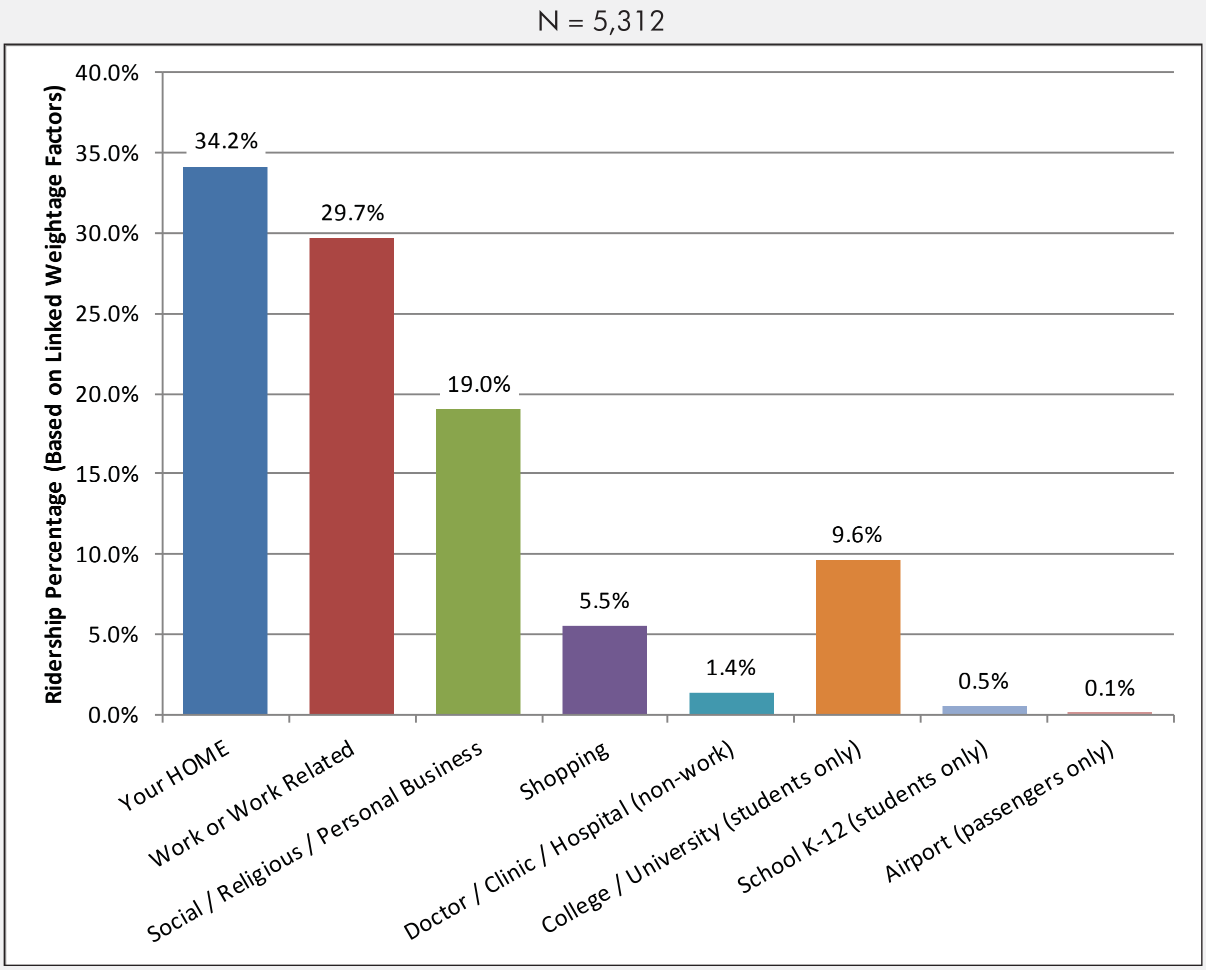


Figure 2-10: What type of places are destinations for 19-24 year old IndyGo riders?

QUESTIONS 7 & 8

Questions 7 and 8 ask riders to identify the name of the place they are going to and the address of that place, respectively.

A heat map of the non-home destination locations is shown below. It can be seen that a high concentration of IndyGo riders end their trips in the downtown area.

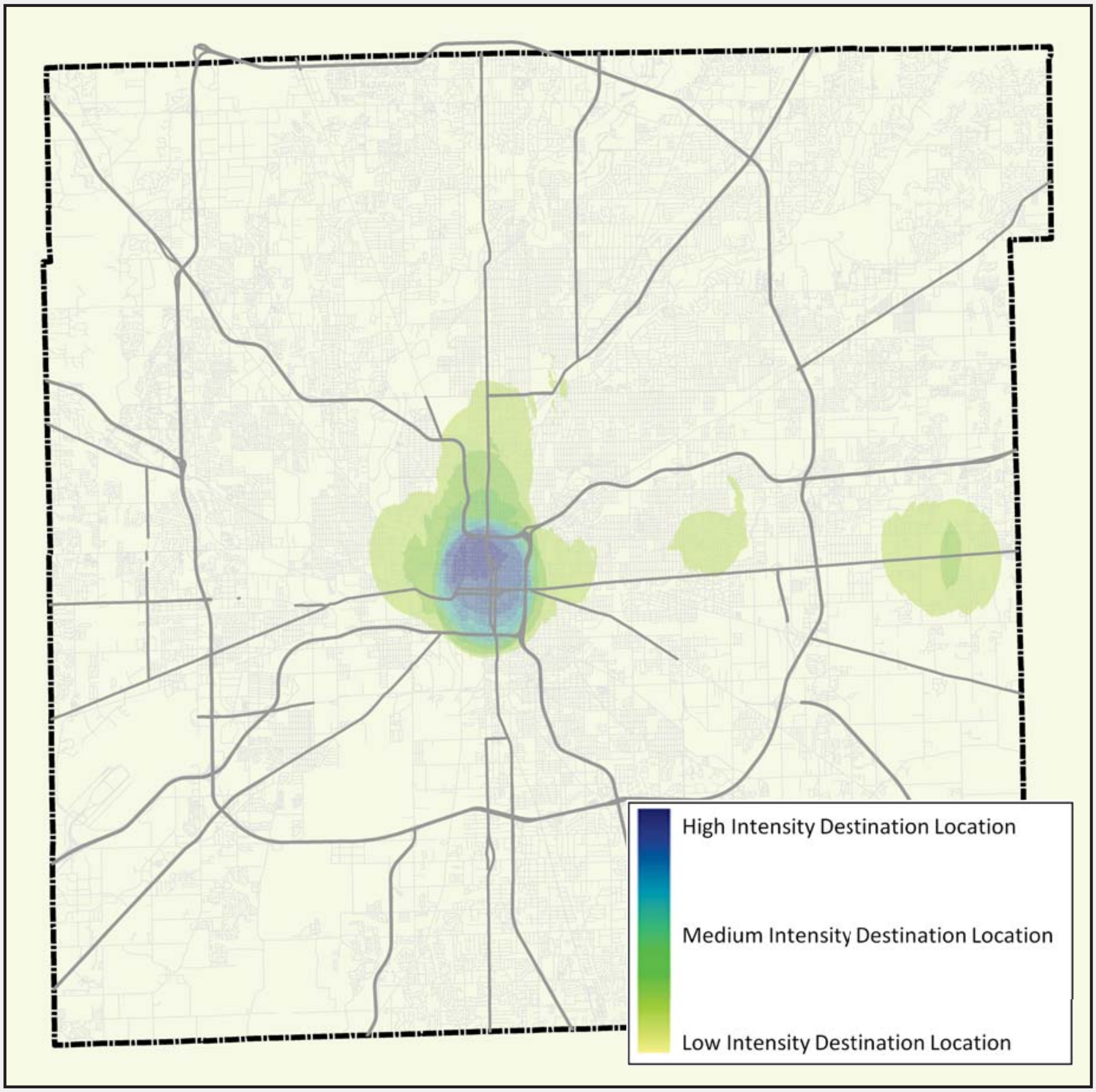


Figure 2-11: Non-Home Destination Locations Heat Map

QUESTION 9

Question 9: How will you get to your destination (listed in question #6) after you get off the last bus you will use for this one-way trip?

Similar to the Access Mode statistics, the majority of riders walk or use a wheelchair to get to their final destination from the bus stop. The percent of passengers that arrive at their final destination location using a bike is very close to the percent of passenger that use a bike to arrive at their bus stop. This indicates that most of the riders using bikes utilize the bike racks on the bus to take their bike with them. This further highlights the importance of bike racks on IndyGo buses.

N = 27,573

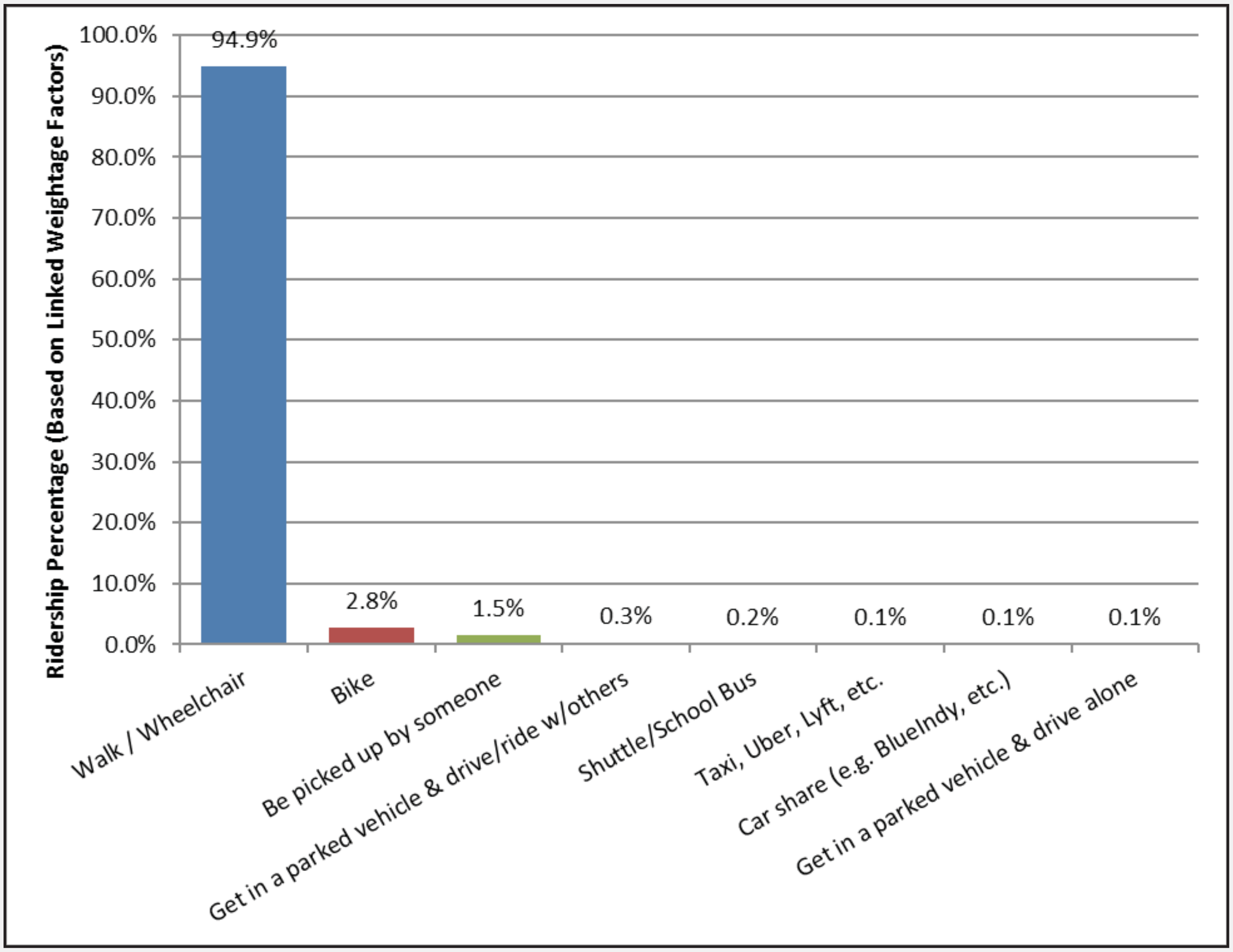


Figure 2-12: How riders get to their final destination after exiting the bus?

QUESTION 10

Question 10 asks for the nearest intersection location where the rider will exit the bus.

The distance IndyGo riders travel from their last bus stop to their trip destination was estimated based on survey responses for this question as well as Questions 7 and 8. More than half (51%) of the passengers travel less than a quarter mile to their bus stop, while about 29% travel less than a tenth of a mile. Nineteen percent of passengers travel more than 1 mile to their bus stop.

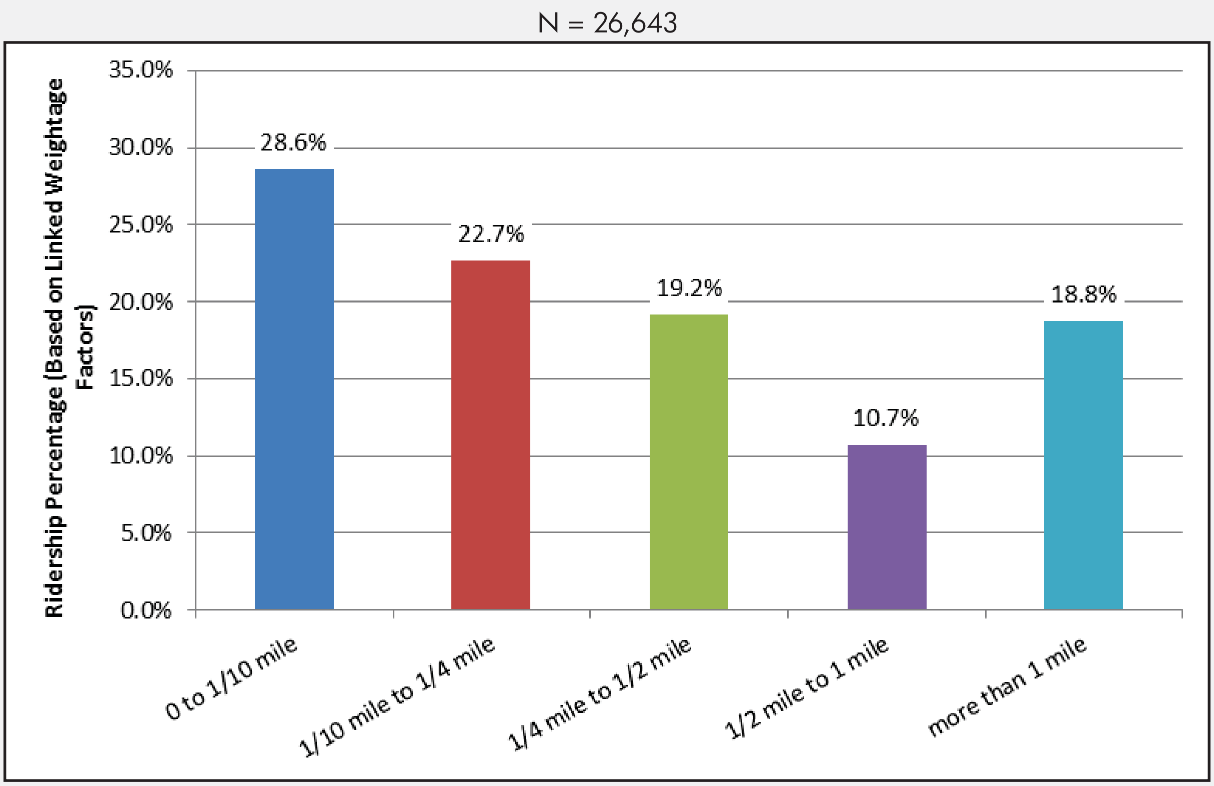


Figure 2-13: Distance IndyGo Riders Travel from Their Last Bus Stop to Their Destination

QUESTION 11

Question 11 has three parts and pertains to how many buses a riders uses to make their one-way trip:

Question 11a: Did you transfer from another bus before getting on this bus?
Question 11b: Will you transfer to another bus after getting off this bus?
Question 11c: Please list the bus routes in the exact order you use them for this one-way trip.

The majority of riders (about 72%) only use one bus to make their one-way trip. Slightly more than a quarter of passengers use two buses, and only about 1% use three or more buses.

N = 27,573

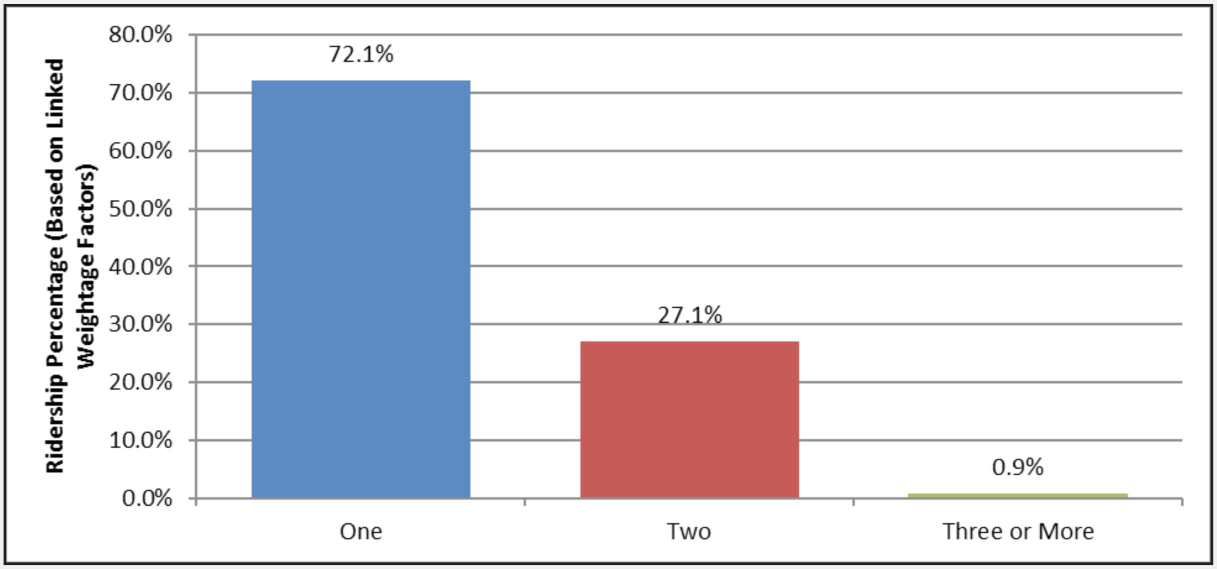


Figure 2-14: How many buses do riders use to make a one-way trip?

QUESTION 12

Question 12 asks what time riders boarded their bus. It was asked to ensure data was collected for different times of day.

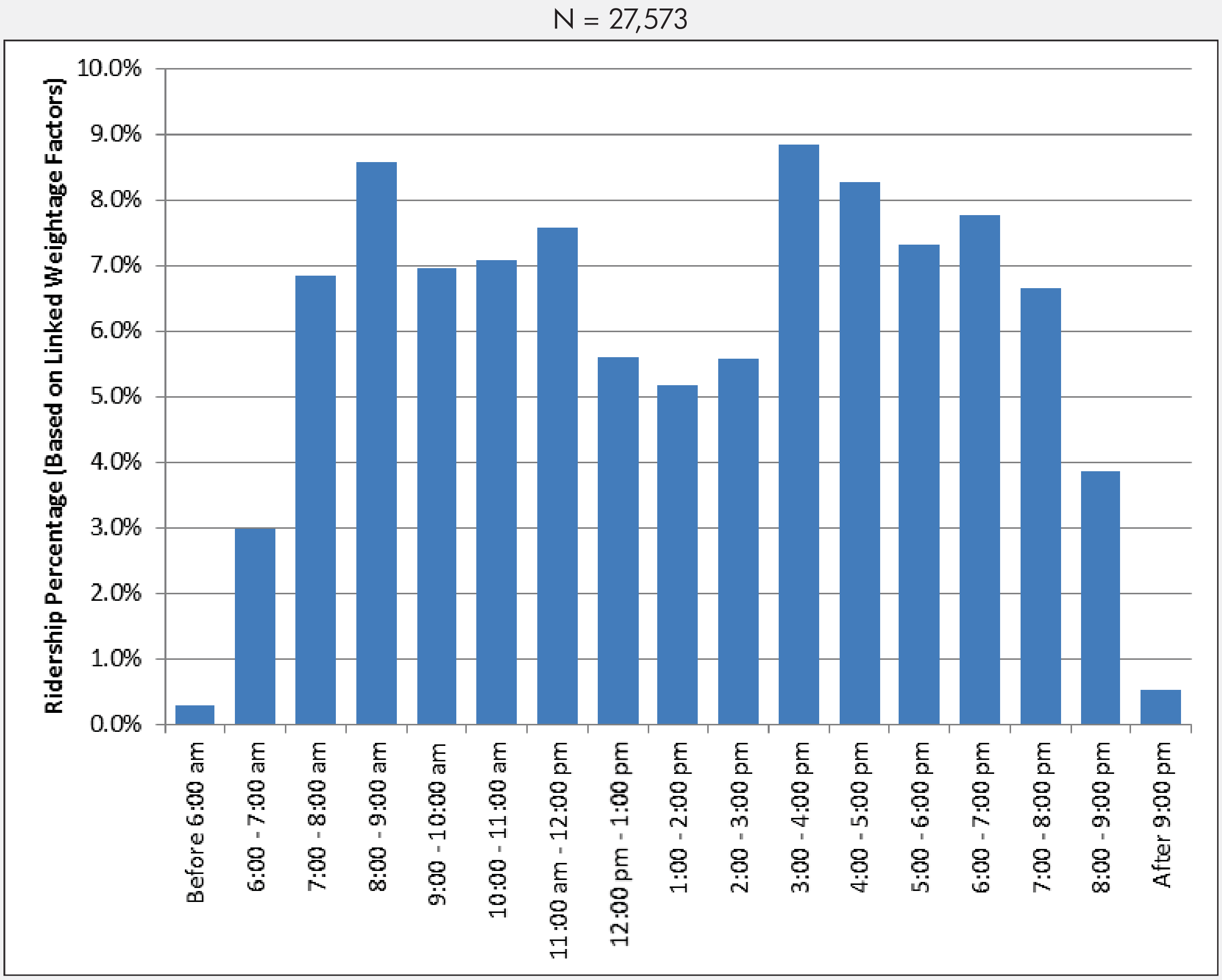


Figure 2-15: What time do riders board their bus?

QUESTION 13

Question 13: Will you (or did you) make this same trip in exactly the opposite direction today?

Nearly 51% of riders reported that they would make an identical trip in the opposite direction the same day. About 49% stated they would not make the same exact trip in the opposite direction on the same day. Many people make different trips in the “from home” and “to home” orientation (e.g., they may travel directly from home to work, but make a stop on the way home to shop, attend a night class, etc.)

N = 27,573

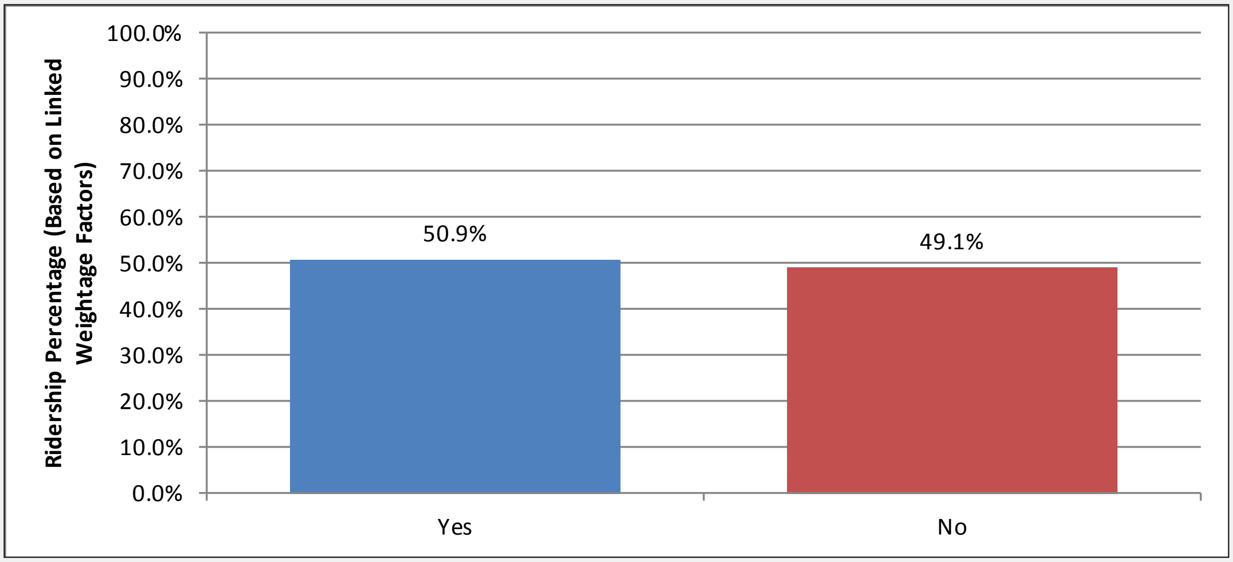


Figure 2-16: Do IndyGo riders make round-trips?

QUESTION 13

The percentage of riders that make round trips based on their out-of-home activity types are shown below[4].

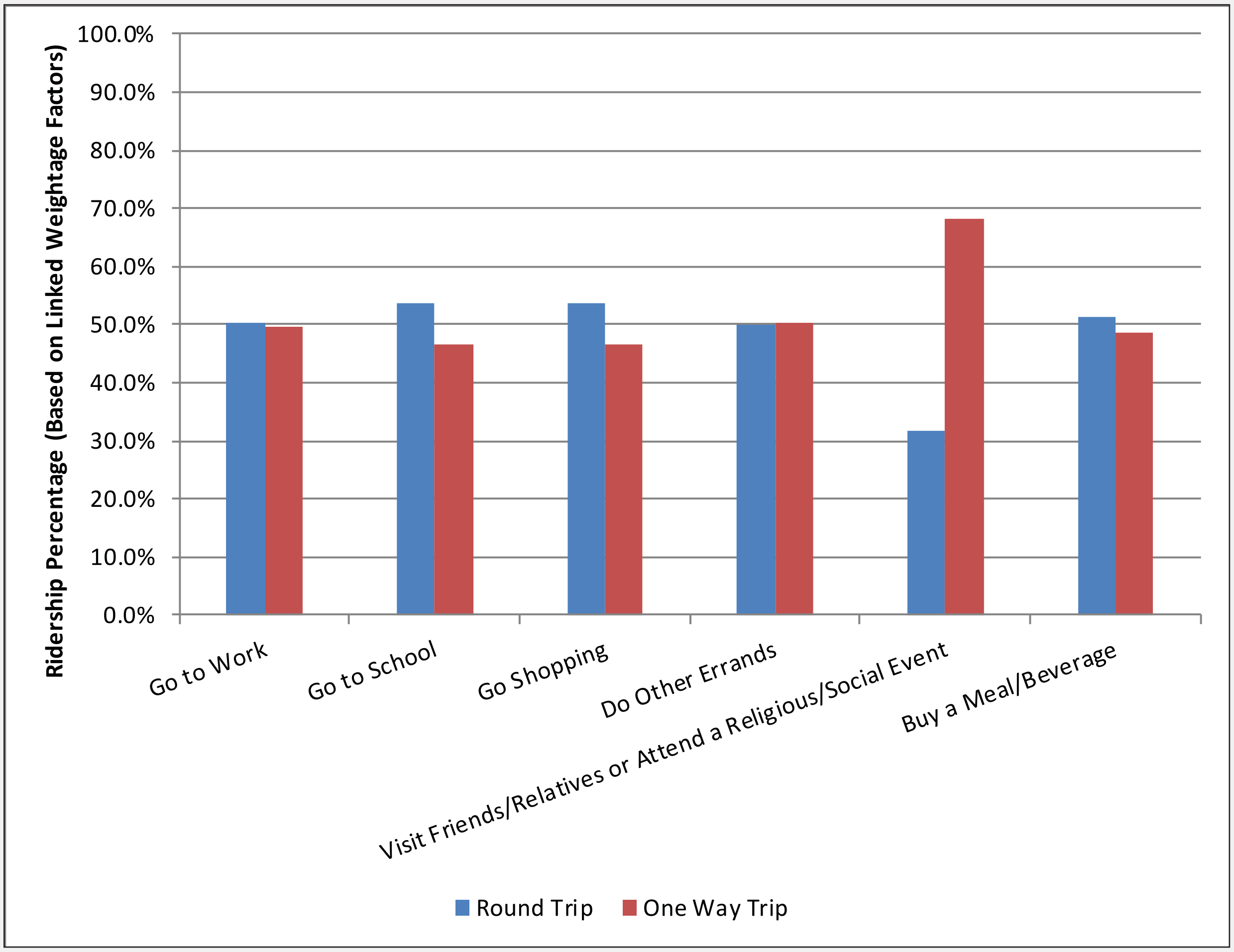


Figure 2-17: Do IndyGo riders make round-trips based on out-of-home activity types?

ACTIVITY TYPE	ROUND TRIP	ONE WAY TRIP
Go to Work	50.3%	49.7%
Go to School	53.6%	46.4%
Go Shopping	53.5%	46.5%
Do Other Errands	49.8%	50.2%
Visit Friends/Relatives or Attend a Religious/Social Event	31.7%	68.3%
Buy a Meal/Beverage	51.4%	48.6%

Table 2-2: Do IndyGo riders make round-trips based on out-of-home activity types?

4 Please refer to Question 16 for more details regarding out-of-home activity types.

QUESTION 14

Question 14: What fare payment methods were used for this one-way trip?

Nearly a third of IndyGo passengers use cash while the remaining two-thirds use various types of passes and other pre-pay options. The 1-Day pass and 31-Day pass are the most utilized pre-pay alternatives at 25% and 22% of the ridership, respectively.

N = 27,573

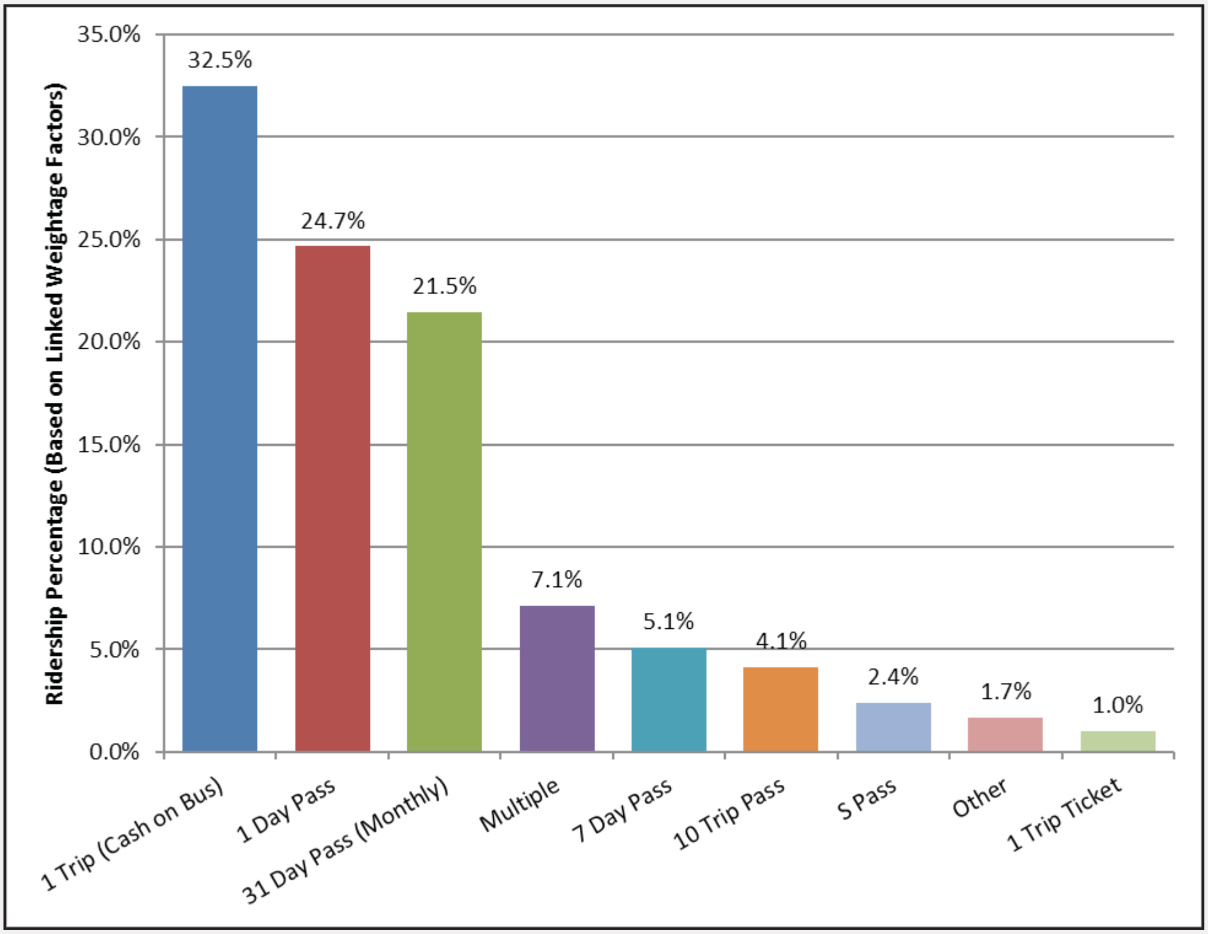


Figure 2-18: How do IndyGo riders pay their fare?

QUESTION 14

As income level increases, the percent of riders paying the cash fare also increases while the percent of riders using the 1-Day pass decreases. The percent of riders using the 31-Day pass remains relatively constant with income level.

N = 23,509

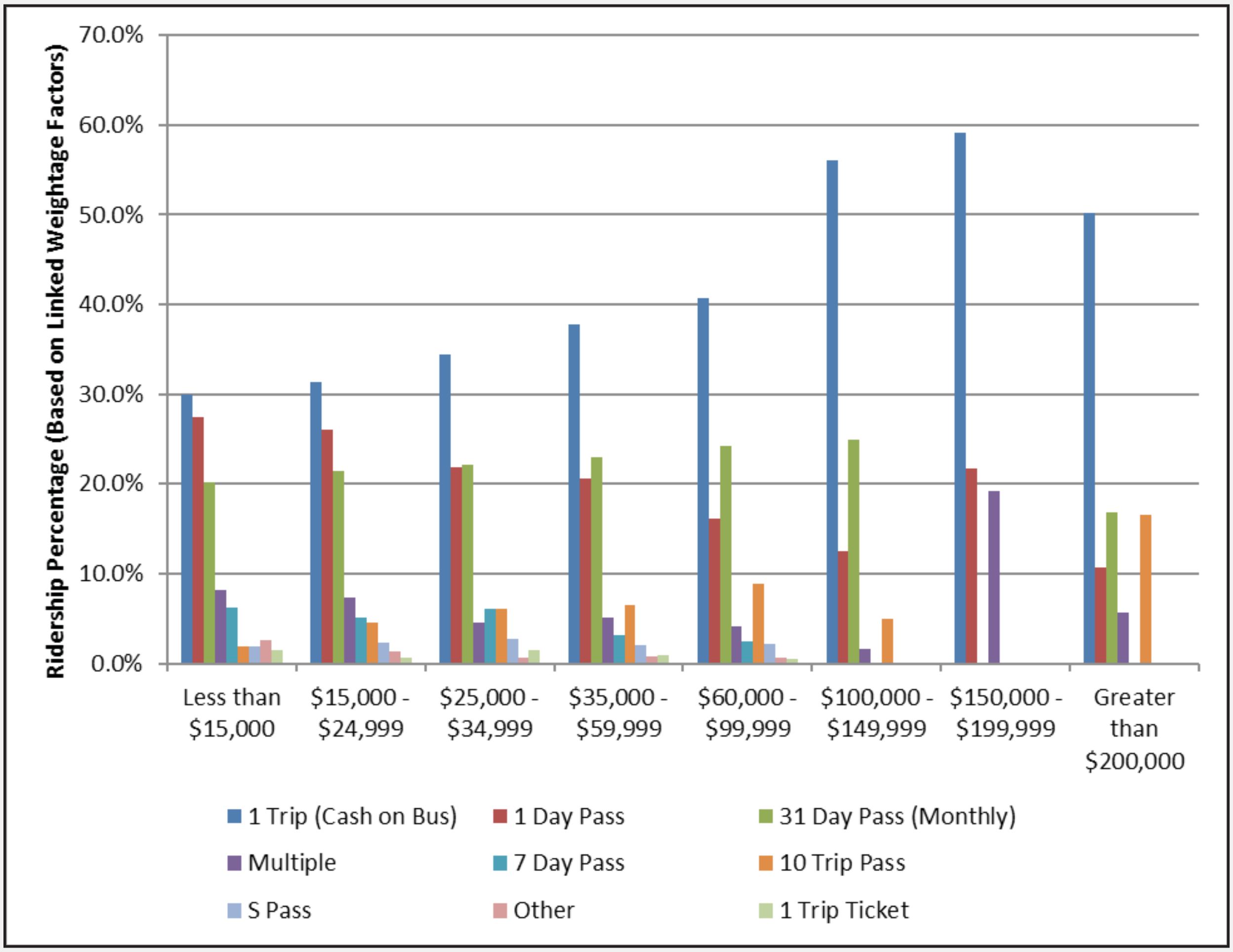


Figure 2-19: How do IndyGo riders pay their fare based on income?

QUESTION 15

Question 15: What type of fare was this?

Most IndyGo passengers are regular fare riders (about 81%). Fourteen percent of riders pay the half fare. Very few passengers use the student fare option.

N = 27,573

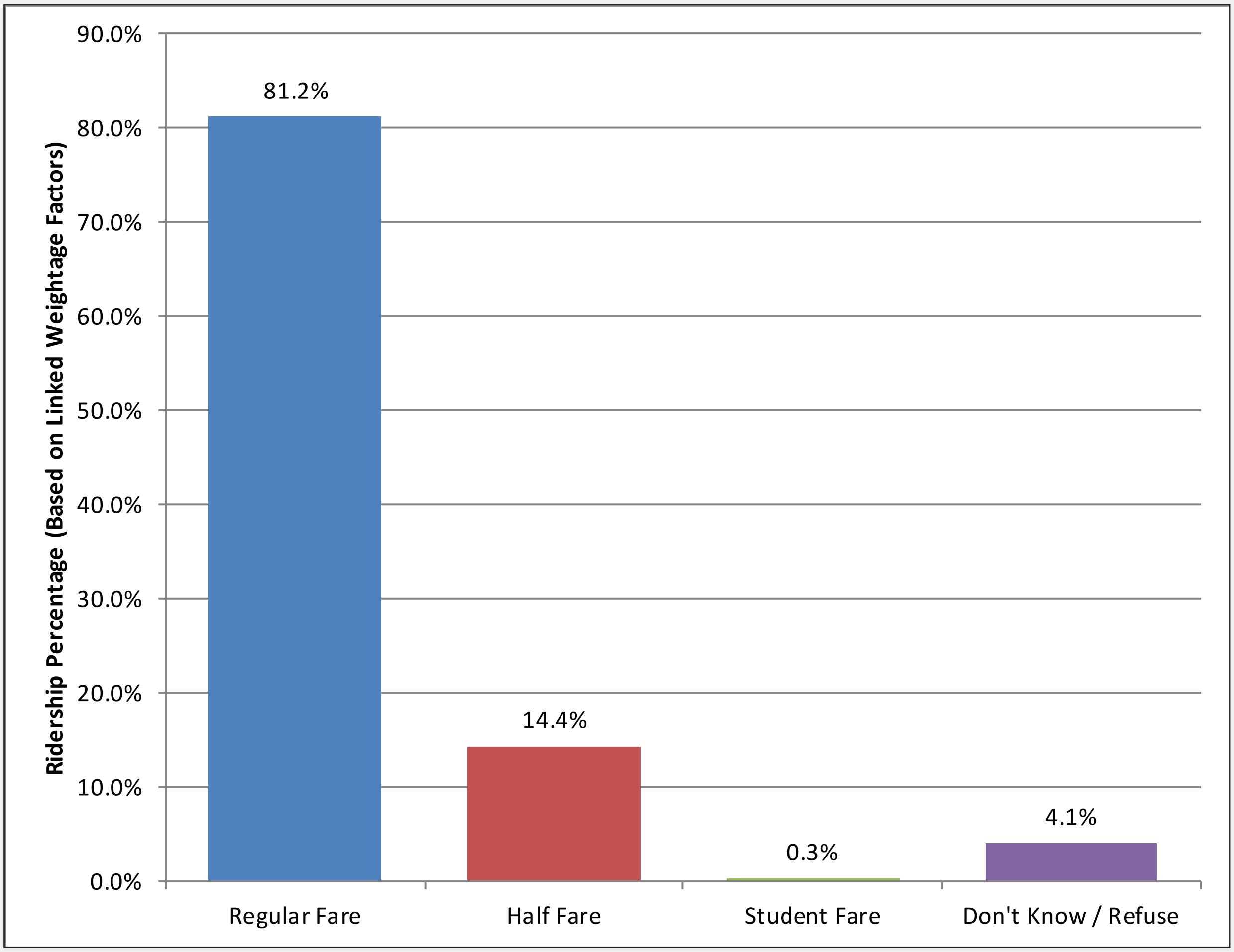


Figure 2-20: What type of fare do IndyGo riders pay?

QUESTION 16

Question 16: On this round trip (between the time you left and will return home) will you or did you (check all that apply)

The advent of tour[5]- or activity-based forecasting methods has created the need to be able to identify the tour purpose as well as the purpose of transit riders' individual point-to-point trips. Traditional on-board ridership surveys asked riders to identify their trip purpose, or activities at their origin and destination. As part of IndyGo's 2009 on-board survey, a new single question was designed to gather information on riders' tours while minimizing respondent burden. The approach was very successful, yielding considerable information on broader travel patterns and contributing to a peer-reviewed journal article, while yielding very low item non-response and negligible impact on overall survey response. The question was repeated in the 2016 survey. Question #16 asked the respondent: "On this round trip (between the time you left home and will return home) will you or did you: (check all that apply) - No other trip - Go to work - Go to school - Go shopping - Buy a meal/beverage - Visit friend/relative or attend a religious/social event - Other errands - Other (please specify)_______." Since multiple responses are possible, these responses add up to more than 100%.

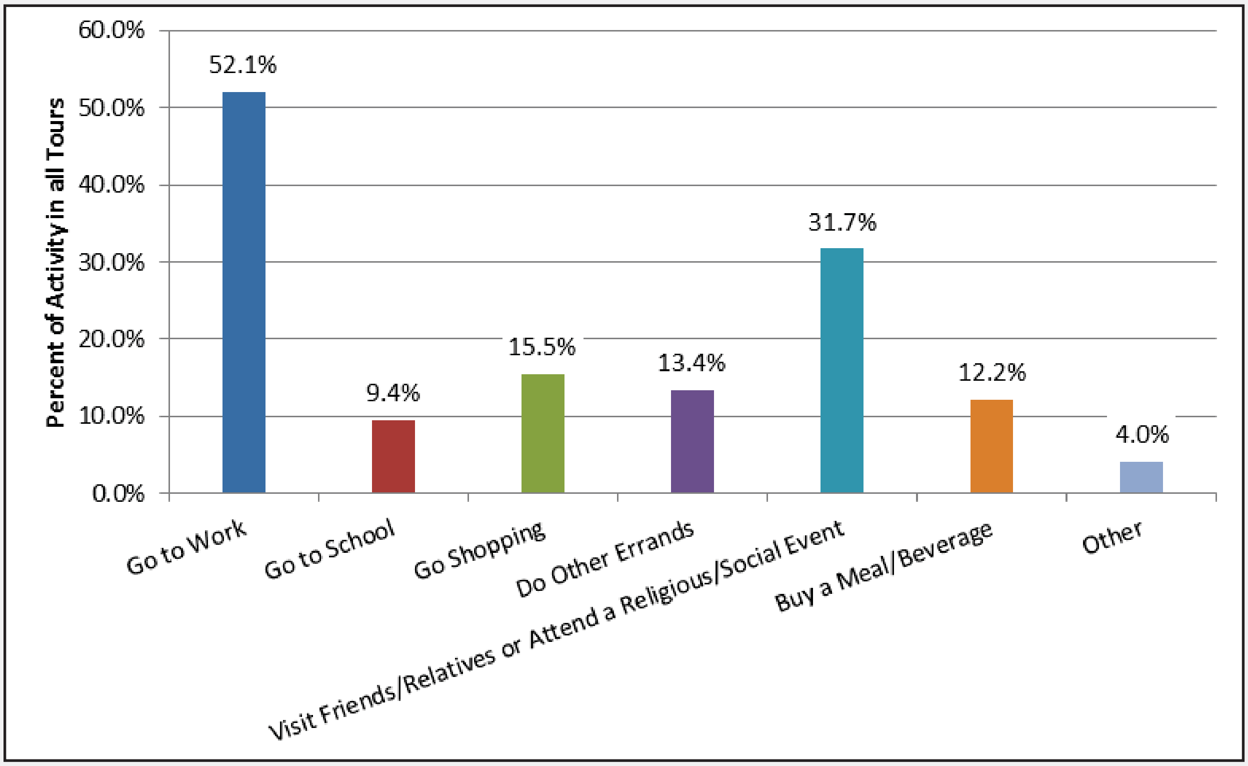


Figure 2-21: Percent of 2016 tours with each out-of-home activity type

The 2016 responses show a generally similar distribution of activities, but slightly fewer activities per transit tour compared to 2009. Two more distinct differences were a higher prevalence of other errands in 2009 and more riders visiting friends/attending a religious or social event in 2016. Although the 2009 results indicate that the question itself does not pose particular respondent burden, the 2016 results may indicate

5 A "tour" is the sequence of trips during the day from the time a person leaves home until returning home. A tour with one primary purpose may include trips not directly related to that purpose; for example, someone absent from home for full-time employment may make leave the workplace to eat lunch, go to the post office, and then return to the workplace. The trip between the restaurant and the post office is part of a "work tour," even though neither its origin nor destination is either the home or workplace.

some respondent fatigue perhaps related to the overall survey length. Alternatively, there may have been an actual change in rider behavior with riders engaging in fewer activities per transit tour.

The activity-based question allows the identification of not only the purpose of the trip observed in the survey, but the traveler's broader purpose for their tour from and to home. Comparing the riders responses to the activity-based question to their responses regarding the origin and destination purposes, there are both similarities and differences. While work was the most common out-of-home activity according to either question, only 46.9% of the observed trips had an origin or destination at work, while the activity-based question revealed that 52.1% of riders actually went to work while on their tour. Using the origin/destination questions only without the activity-based question would understate the number of transit trips on work tours. Similarly, only 7.4% of the observed non-home origins and destinations were at school, but the activity-based question revealed that 9.4% of riders went to school while on their tour. Further, while only 11.3% of non-home origins and destinations were visited for shopping, the activity-based question reveals that 15.5% of IndyGo riders went shopping while on their tour. These differences are modest, but still meaningful and helpful for travel model development.

From the information contained in the responses to the origin and destination purpose questions alone, it would be easy to underestimate the amount of activities being served by IndyGo's service or misrepresent their relative importance. For example, as the previous paragraph states, the activity-based question reveals that 16% of IndyGo riders need to make a shopping stop on their tour, even though only 11% of riders use "shopping" to describe the origin or destination of the trip on which they received the survey. Basing the purpose of travel only on the origin/destination could underestimate the amount of shopping served by transit by 50%.

In general, it has sometimes been hypothesized that transit riders may make fewer out-of-home stops on their tours than travelers in general. However, the information from IndyGo's survey calls this assumption into question. The activity-based question reveals that IndyGo riders make at least 1.47 stops on average between leaving home and returning. (Note: this estimate of stops per tour represents a lower bound, since multiple stops with the same purpose, such as shopping, would only be reported once, given the question's wording.) This level of tour complexity is less than that reported in the 2009 on-board survey (which showed 1.74 activities/tour), but a comparable level of complexity to non-transit tours. The most recent household travel survey for the region, the 2009 Central Indiana Travel Survey, showed that non-transit tours averaged 1.56 stops per tour (also calculated using activity-types for consistency). While this is marginally higher than the 2016 IndyGo survey results, it is a relatively small difference, suggesting that transit use is not correlated with significantly lower activity-participation rates. Moreover, it is also important to acknowledge that the seven years intervening between the household survey and current on-board survey probably has impacted out-of-home activity participation in general and not just on transit tours. An increase in e-commerce or the substitution of out-of-home social activities for social media activities has been widely observed, and may account for this difference. We may expect to note lower non-transit tour complexity when the regional household survey is updated. The 2016 transit survey supports the general conclusion that IndyGo riders use the service to engage in many activities and often make more than one stop per outing.

The common assumption that transit tours involve fewer stops may have arisen from the fact that there are fewer non-home-based transit trips than non-home-based auto trips. The results of the IndyGo survey continue to support this assumption. If the number of non-home stops on tours were calculated based simply on the number of non-home-based trips (trips with neither origin nor destination at home) observed in the survey, the result would be 1.11 stops per tour. However, from the activity-based question, it is clear that there are more non-home-based trips on transit riders' tours. The implication is that some non-home-based trips on transit tours are non-transit trips, including walking trips. It is also possible that non-home-based transit trips, which tend to shorter, may have lower response rates since the respondent burden is larger relative to the trip's duration and riders may simply not have time to complete the survey during a brief trip. Ultimately, the activity-based question suggests that as much as 76% of non-home-based trips on transit tours were not otherwise captured in the on-board survey, either because these were walking (or other non-transit) trips or due to the short trip bias.

QUESTION 17

Question 17: If bus service was not available, how would you have made this trip?

About a quarter (26%) of riders reported that if IndyGo service was not available they would not make a trip. Nearly 73% of riders reported they would find another way to make the trip. The most popular alternate mode of transportation is riding with someone else (31%). The next most popular choice is walking (13%), using a car service (11%) or biking / driving myself (6%).

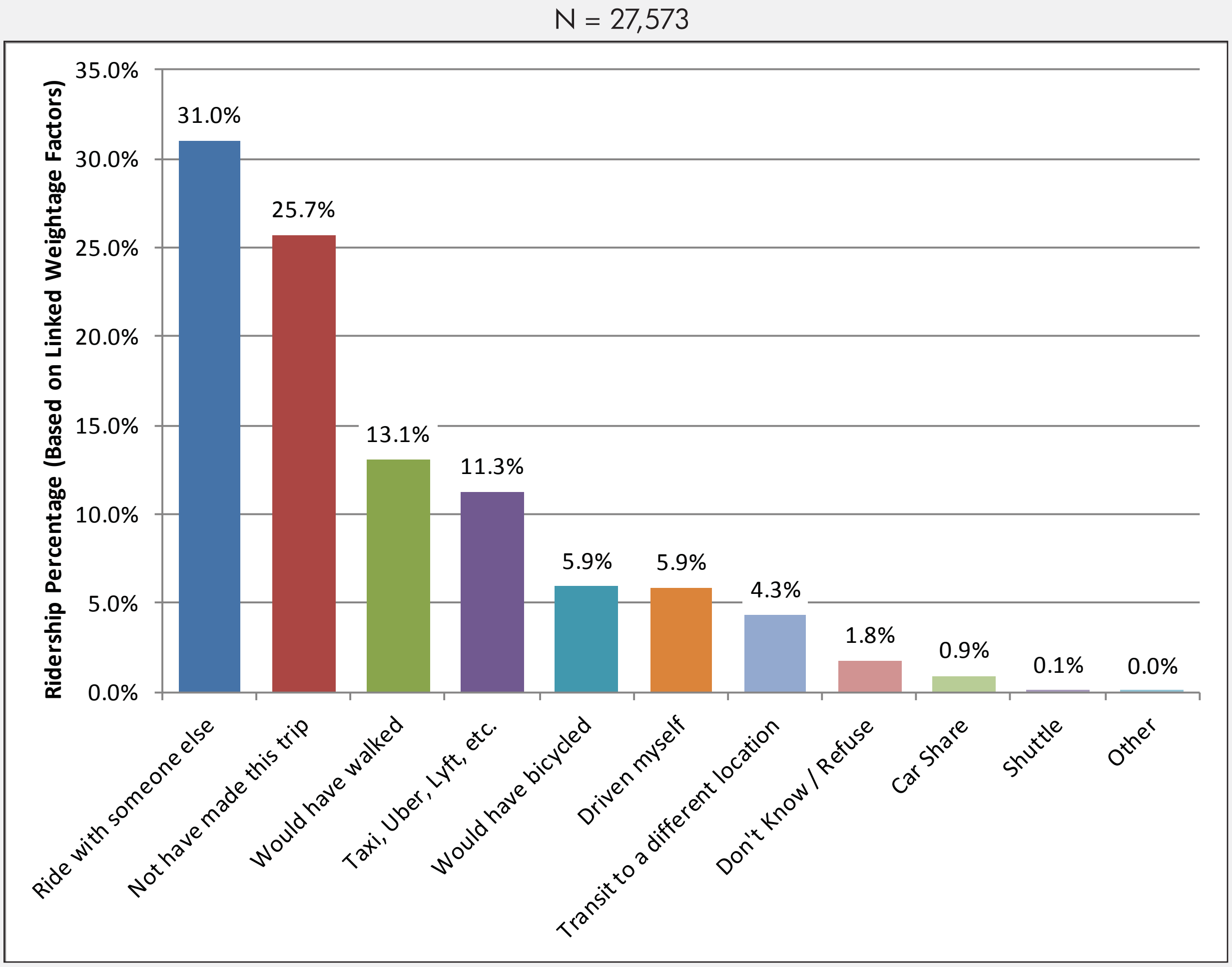


Figure 2-22: How would riders make a trip if IndyGo service wasn't available?

QUESTION 18

Question 18: How many days a week do you usually make this trip?

About 82% of IndyGo riders make their transit trip multiple times a week, with 48% of them making the trip three to five times a week. The 4% of passengers riding IndyGo for the first time is noteworthy; this corresponds to about 1,100 riders using IndyGo's services for the first time. It suggests that recent investments in transit, such as the Downtown Transit Center and route restructuring to emphasize more frequent service in key corridors, may be attracting new and/or occasional ridership.

It's important to note that a small percentage (about 3%) of the riders surveyed didn't answer this question, so the ridership percentages were adjusted accordingly.

N = 26,741

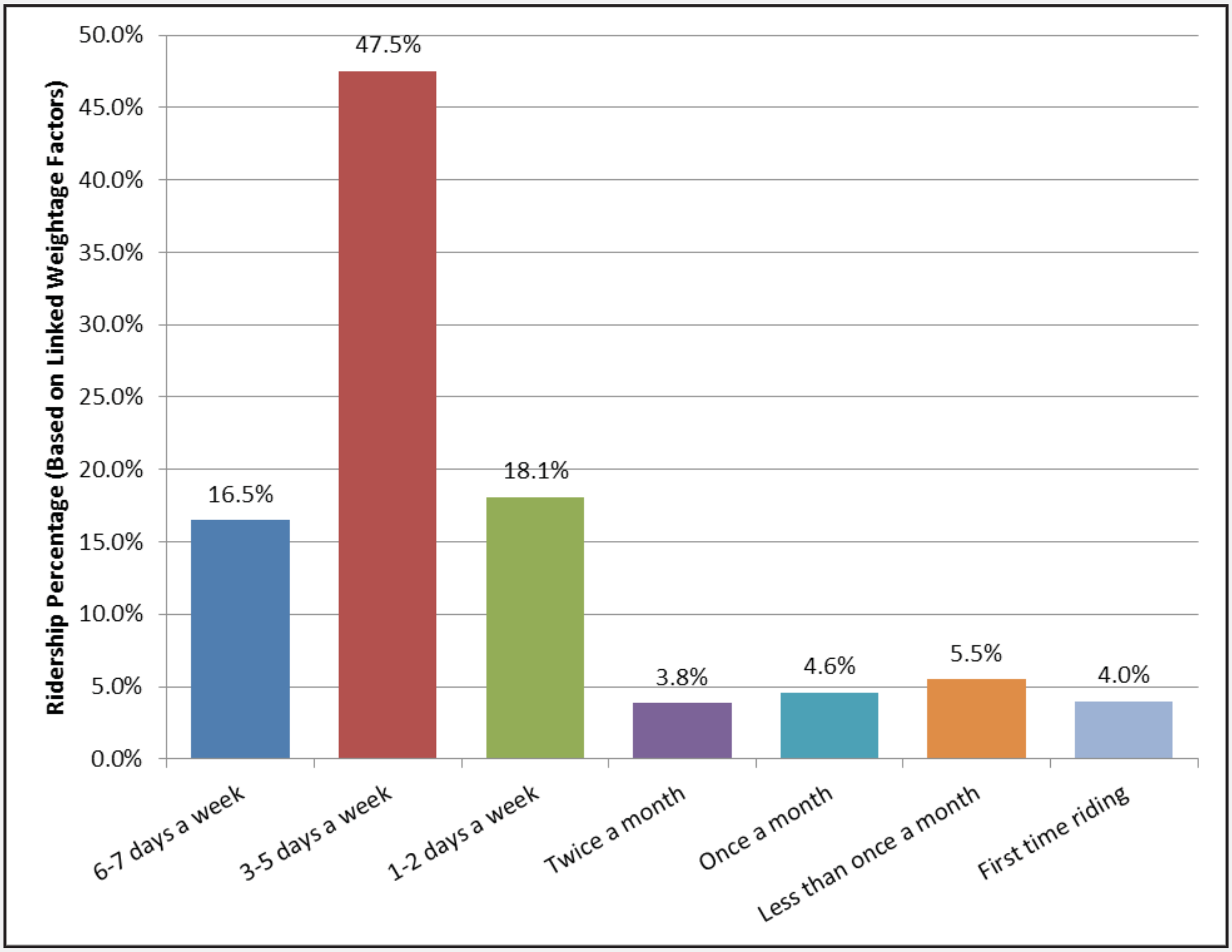


Figure 2-23: How frequently do IndyGo riders make this trip?

QUESTION 18

Comparing the transit frequency of senior riders to the transit frequency of the total ridership population, seniors ride less frequently than the rest of the riders. Nearly 60% of seniors ride 1-2 days a week or less frequently (compared to 36% of the total ridership). It should be noted that the sample size for seniors is smaller.

N = 1,231

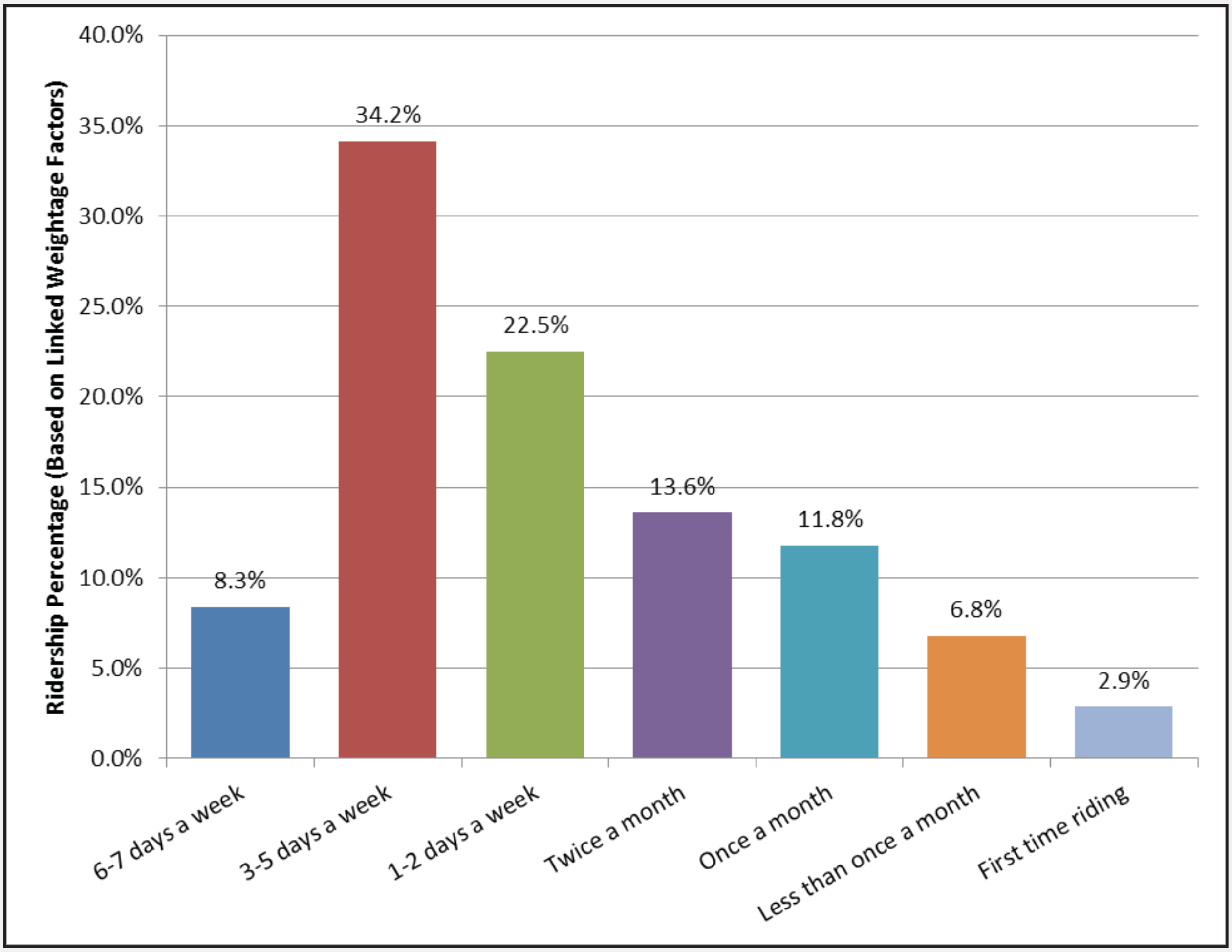


Figure 2-24: How frequently do seniors make this trip?

QUESTION 19

Question 19: Are you a visitor to the Indianapolis region?

While the majority of IndyGo passengers are not visitors (96%), a small but important portion are in fact visitors (nearly 4%). This corresponds to about 1,000 riders daily that are visitors. This suggests that IndyGo is doing a good job of reaching out and marketing its service to visitors, especially considering that many of these visitors may be from other cities which have a higher level of transit availability. It is important to note that the data was collected over a long period of time (several months) to avoid overestimating visitors due holidays or other factors.

N = 27,573

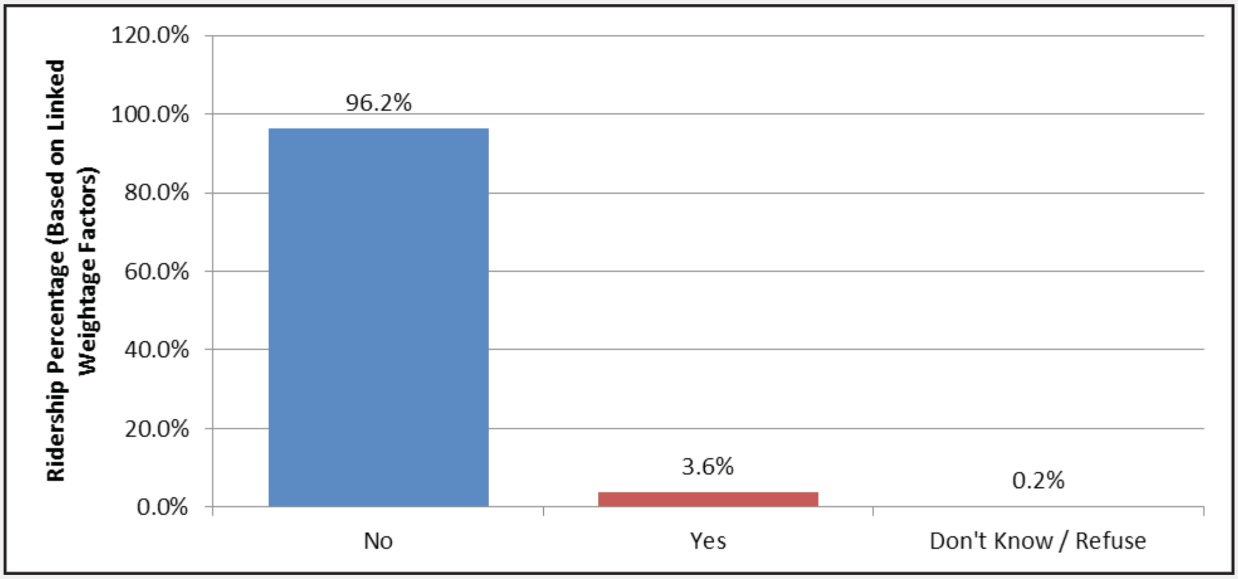


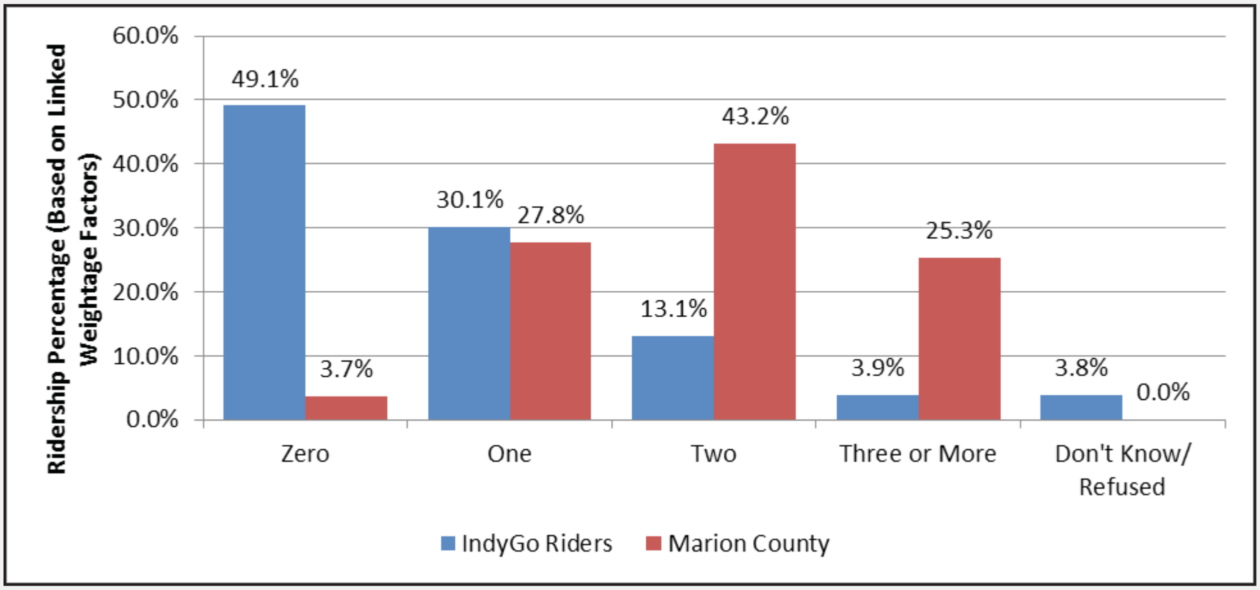
Figure 2-25: What percentage of IndyGo riders are visitors?

QUESTION 20

Question 20: How many vehicles (cars, trucks, or motorcycles) are available to your household?

Nearly half of IndyGo riders reported that there is no vehicle available to their household while only about 20% reported having two or more vehicles available to their household. Comparing this to the vehicles per households for Marion County residents, it can be seen that there is a much lower percentage of households with no vehicles (49% compared to 4%) and a higher percentage of households with two or more vehicles (20% compared to 69%). This indicates a strong relationship between the lack of household vehicle availability and use of IndyGo service.

N = 27,573



Source for Marion County Data: 5 Year ACS Data – 2015 (Table B08141)

Figure 2-26: How many vehicles per household are available to IndyGo riders/Marion County residents?

Nearly 90% of single vehicle households have more than one individual living in the household.

N = 8,295

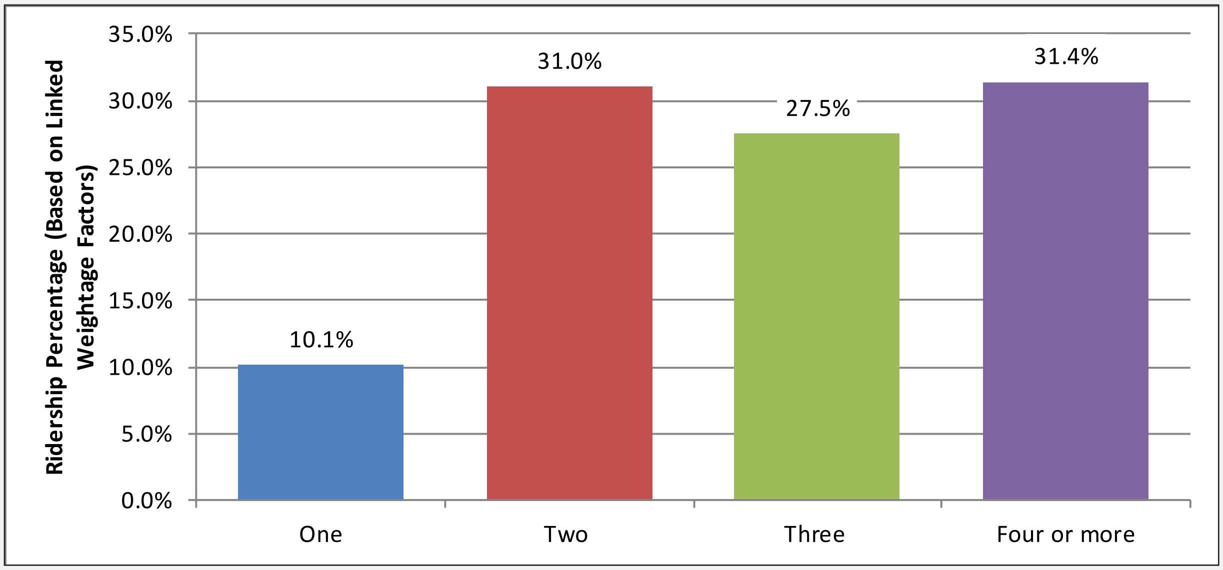


Figure 2-27: How many members do single vehicle households have?

QUESTION 20

The majority (nearly 86%) of IndyGo riders do not have a vehicle available to them while about 14% do in fact have a vehicle available to them. Comparing this to national transit averages[6], it can be seen that there is a smaller percentage of IndyGo riders with a car available to them. Additionally, IndyGo riders average only about 0.26 cars per person.

N = 27,573

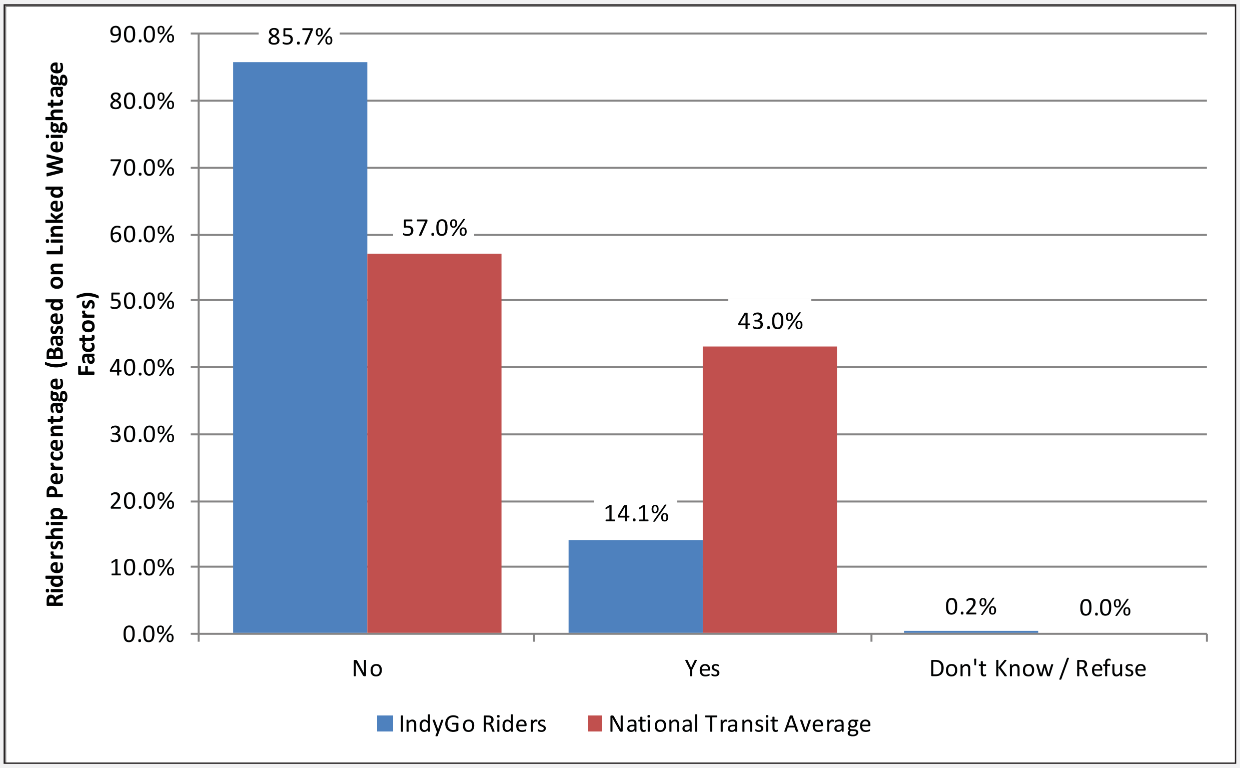


Figure 2-28: Is there a vehicle available to IndyGo riders?

6 Clark, Hugh M. (2017). *Who Rides Public Transportation*, 48.

QUESTION 21

Question 21: Including YOU, home many people live in your household?

A quarter (25%) of IndyGo riders have two individuals in their household. About 22% of riders report one individual per household, followed by about 20% having three people per household. Finally, 15% of riders report having four individuals in their household.

N = 27,573

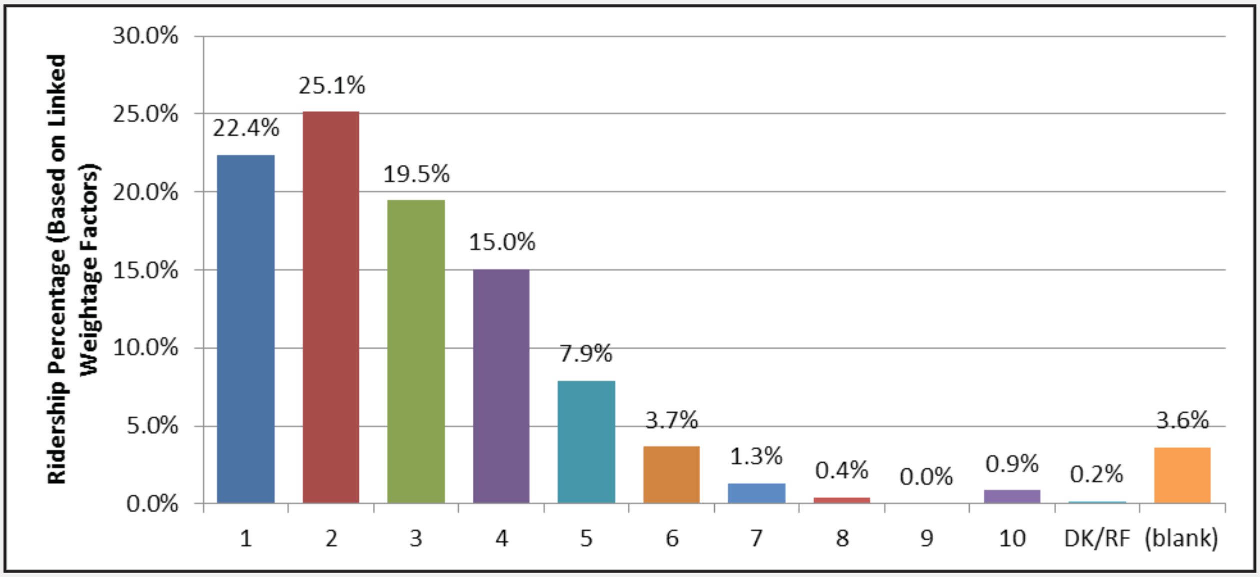


Figure 2-29: How many people live in IndyGo riders' households?

QUESTION 22

Question 22: Including YOU, how many people (over age 15) in your household are employed full/part-time?

About 36% of riders' households have one individual who is employed. Nearly 31% report having two individuals employed in their household. About 13% stated they have three people employed in their household. Finally, 12% report having no employed individuals in their household.

N = 27,573

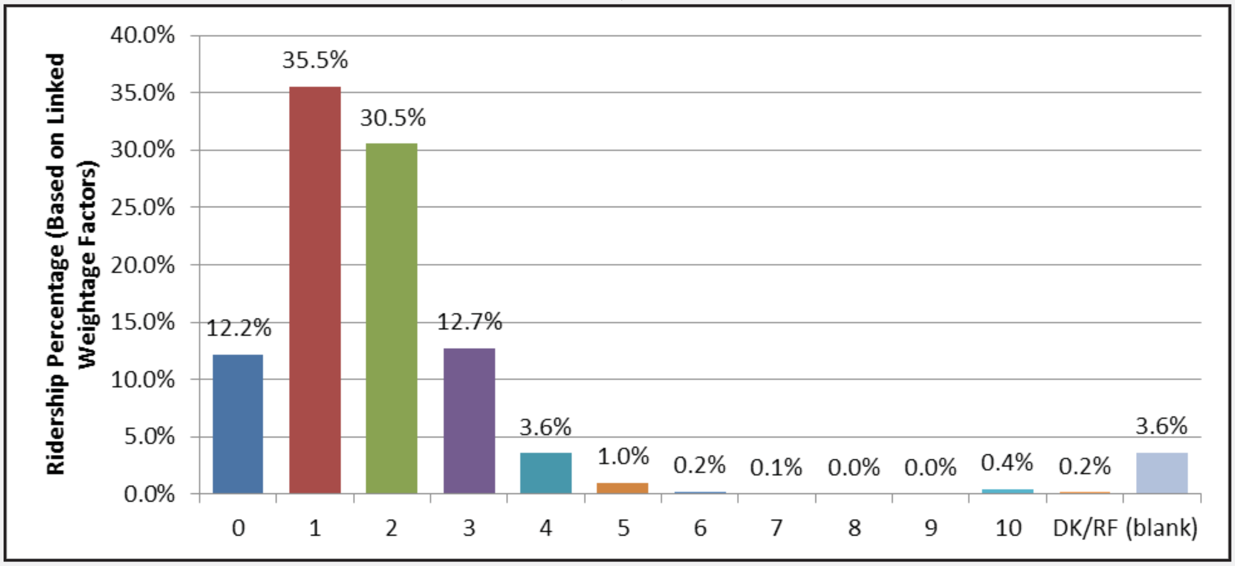


Figure 2-30: How many people in IndyGo riders' households are employed?

QUESTION 23

Question 23: What is your employment status?

The majority of IndyGo passengers are employed, with about 51% working full-time and 20% working part-time. Even though the majority of riders are employed, many of them have a low household income.

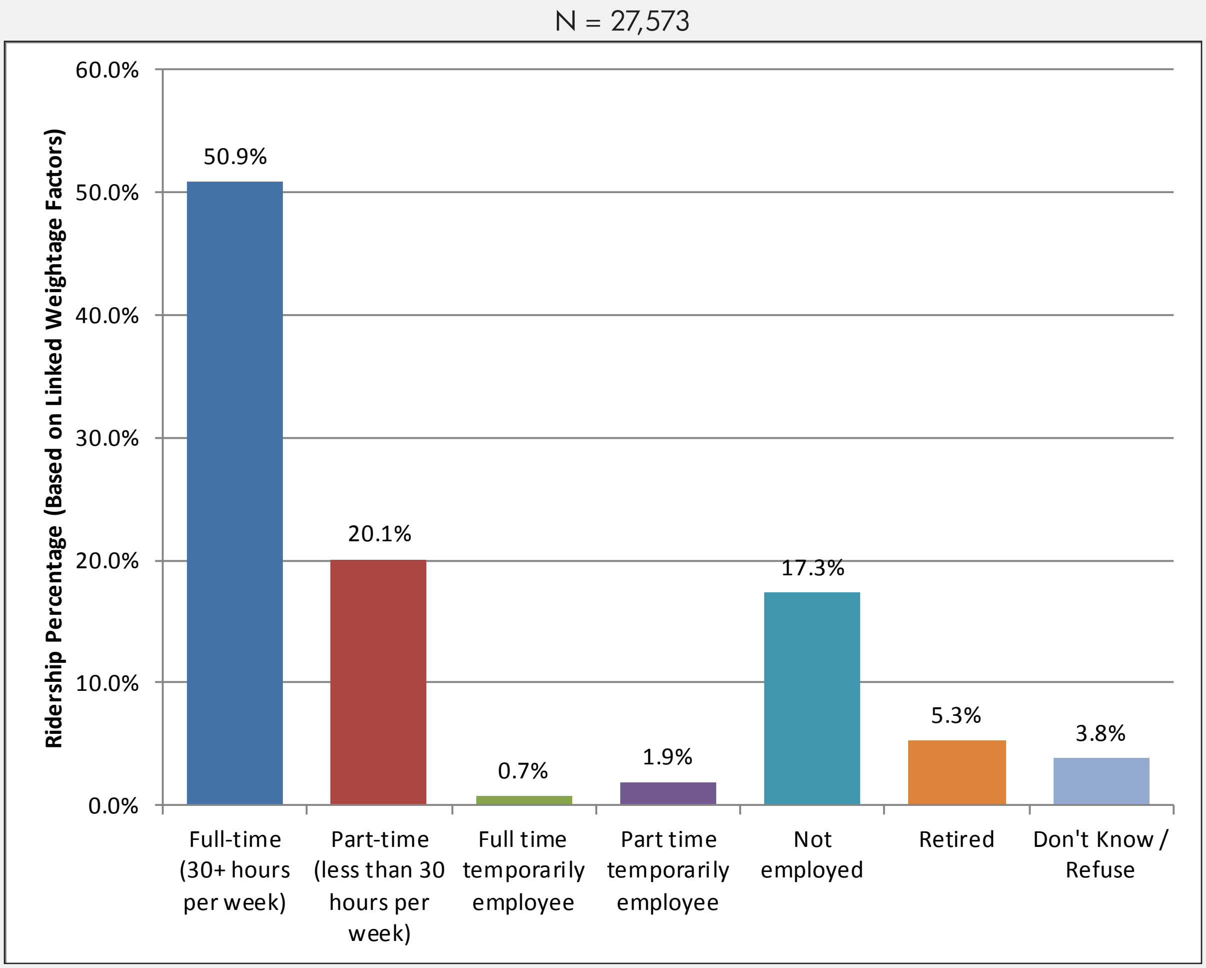


Figure 2-31: What is the employment status of IndyGo riders?

QUESTION 24

Question 24: What is your student status?

About one-fifth (20.1%) of IndyGo riders are students. Of the student population, 66% go to college/university/community college, followed by 20% going to K-12 schools. About 14% go to vocational/technical/trade schools.

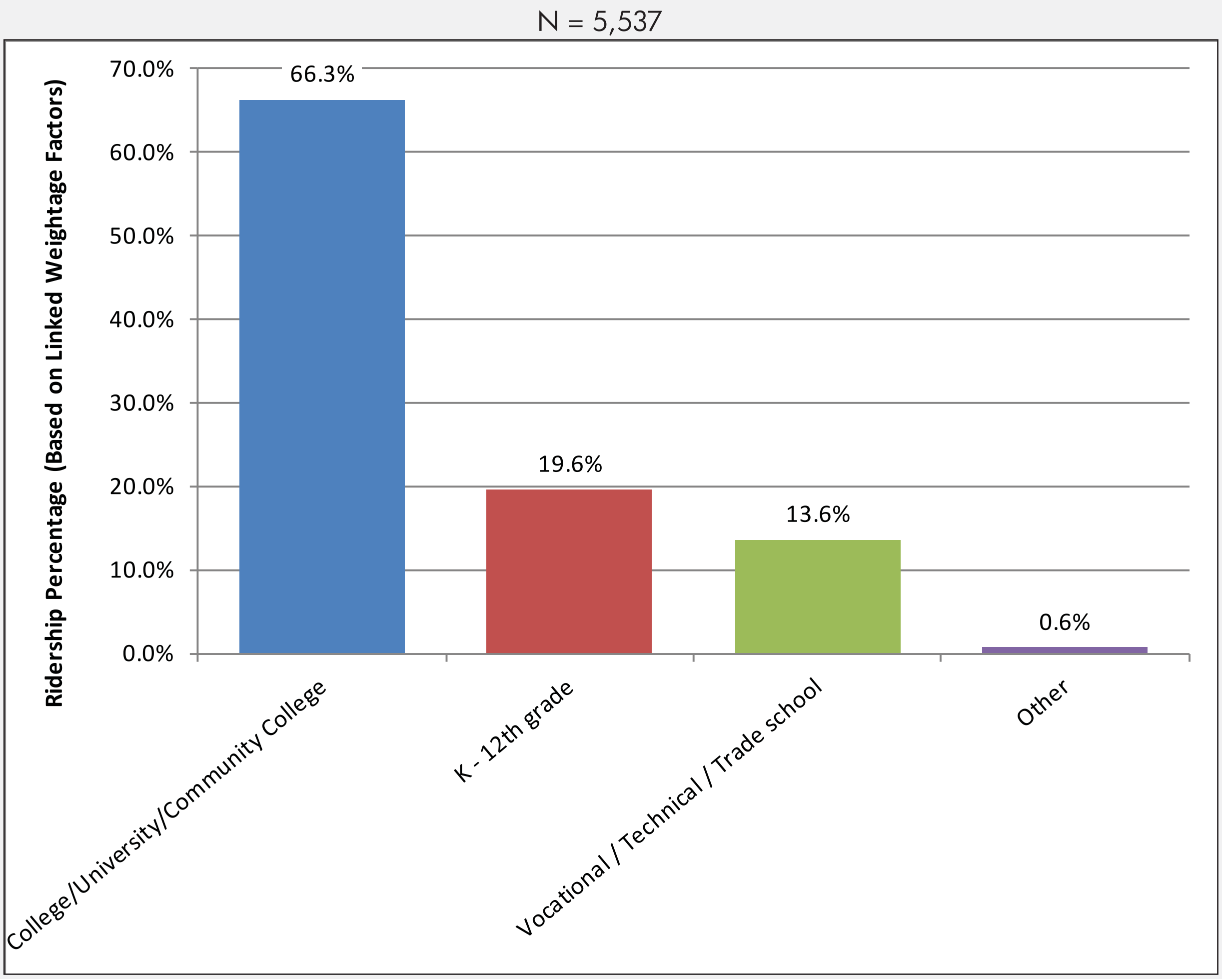


Figure 2-32: What type of educational institutions do IndyGo riders attend?

QUESTION 25

Question 25: Do you have a valid driver's license?

More than half of IndyGo riders do not have a driver's license. Comparing IndyGo's statistics to national transit averages[7], it can be seen that there is a smaller percentage of IndyGo riders with driver's license.

N = 27,573

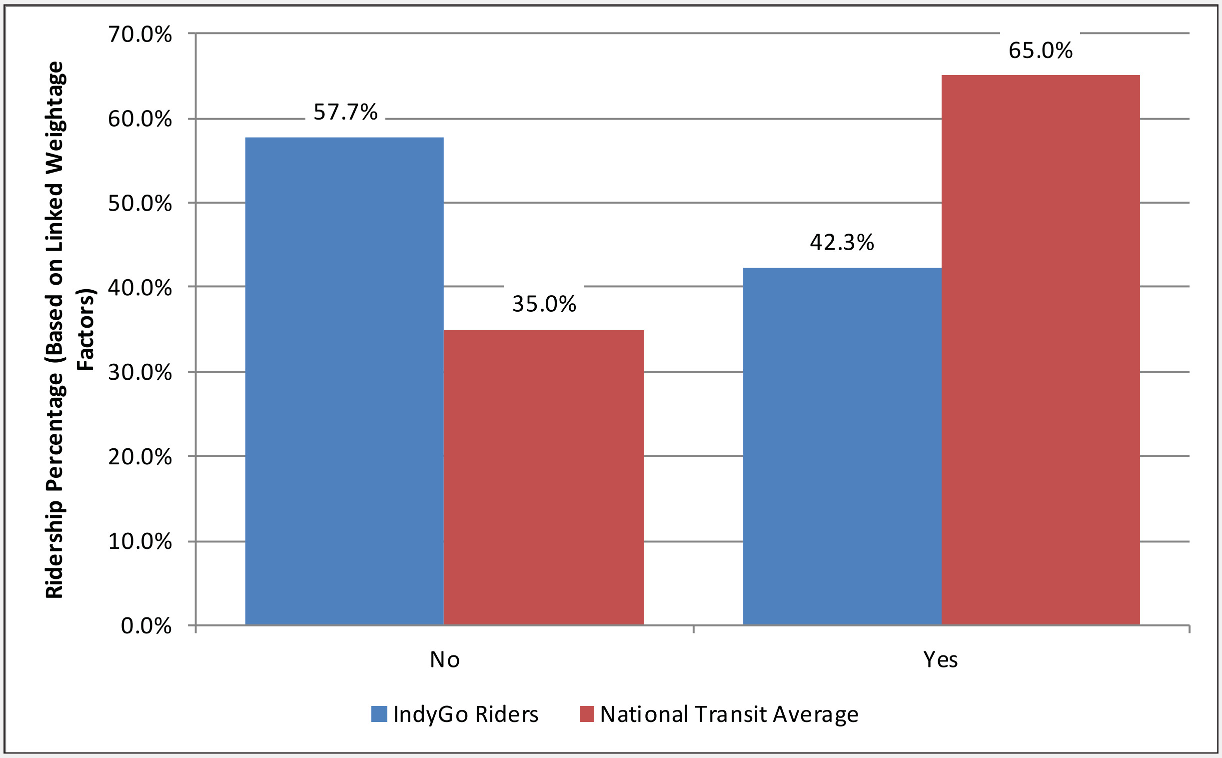


Figure 2-33: Do IndyGo riders have a driver's license?

7 Clark, Hugh M. (2017). *Who Rides Public Transportation*, 48.

QUESTION 26

Question 26: What is your age?

About 89% of IndyGo riders are adults between the ages of 19 and 65. Of the remaining riders, 6% are youths (18 and under) while 5% are seniors (65 and older).

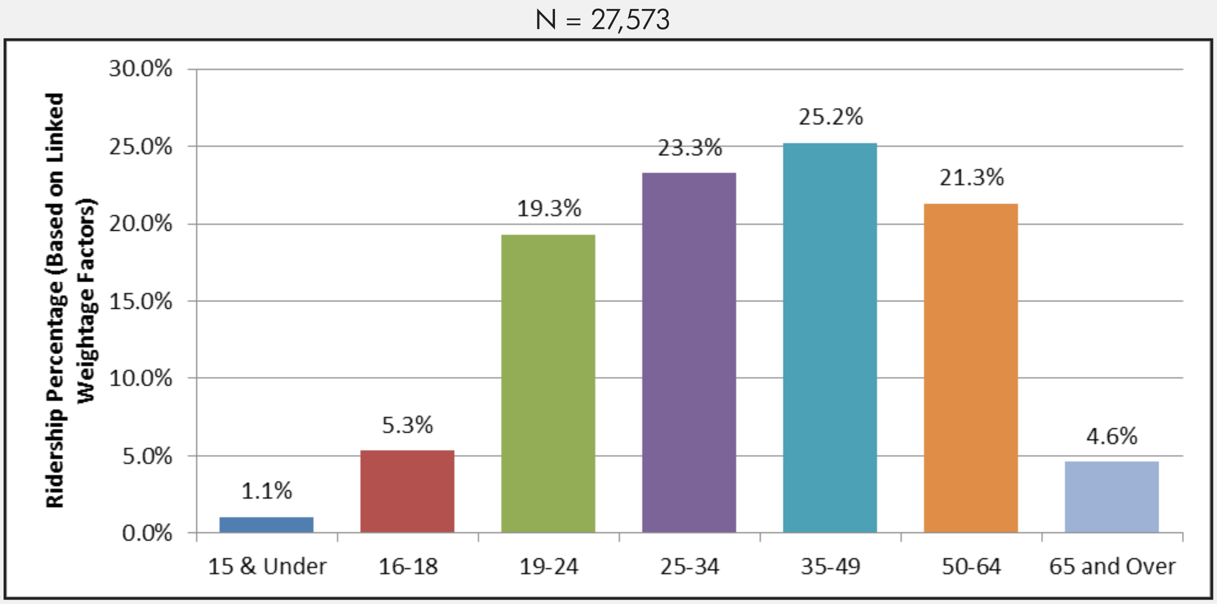


Figure 2-34: How old are IndyGo riders?

QUESTION 27

Question 27: What is your race / ethnicity? [8]

More than half of IndyGo riders are African American and nearly a third are white. About 6% of riders are of mixed ethnicities. Other reported ethnicities include Hispanic/Latino, Asian, American Indian/Alaskan Native and Native Hawaiian/Pacific Islander. It is important to note that Spanish speaking surveyors translated the English version of the survey to help riders who don't know English to complete these surveys.

N = 27,573

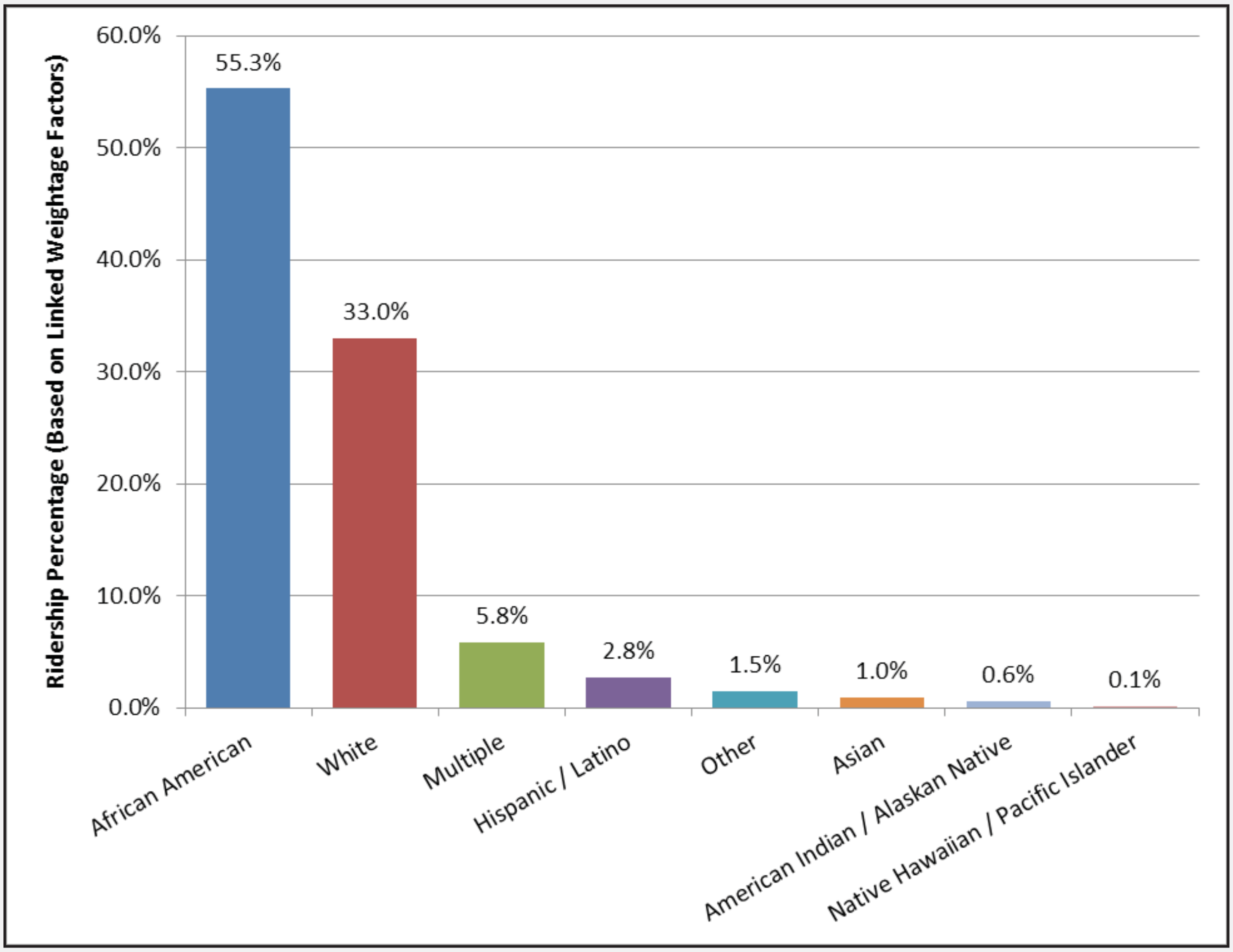
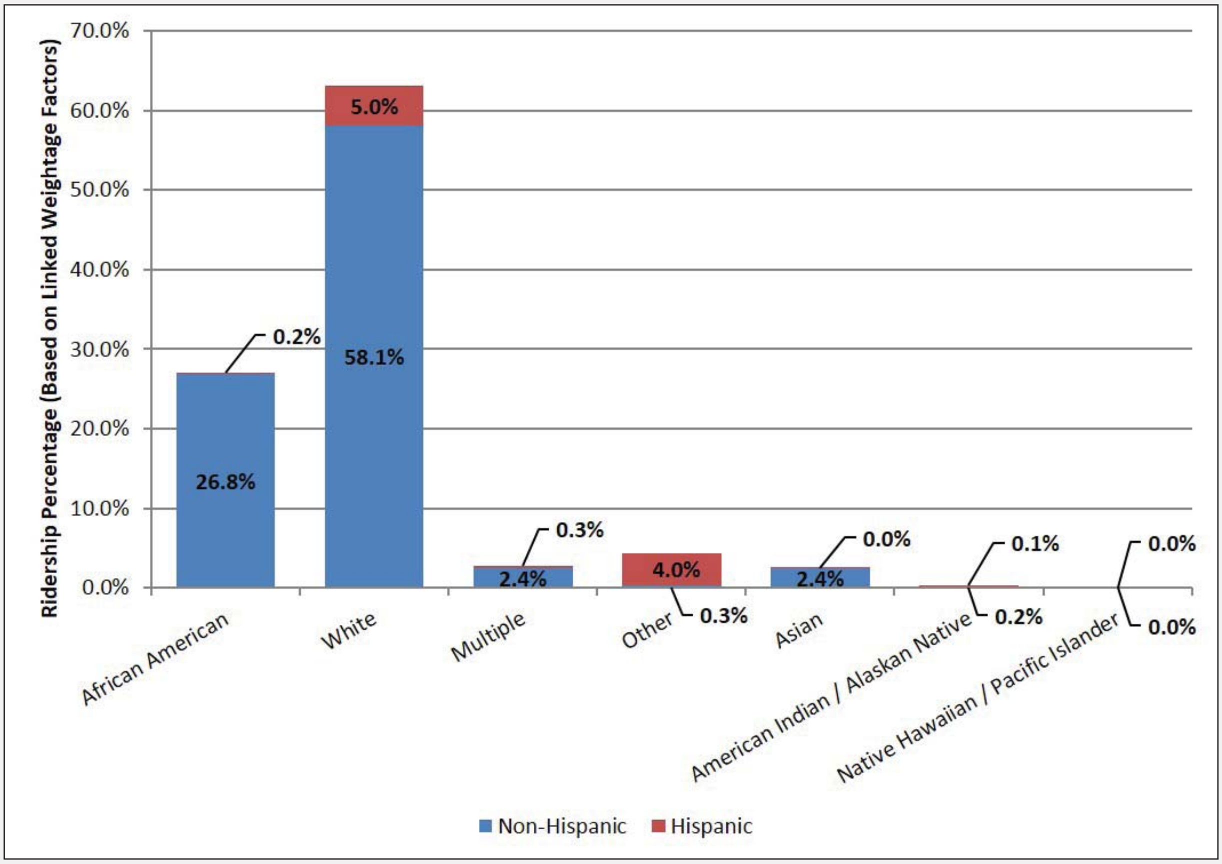


Figure 2-35: What are the ethnicities of IndyGo riders?

8 It is important to note that the survey form included options for both race and ethnicity for this question. Taking this into account, riders were allowed to select multiple responses for the race/ethnicity question, leading to the "Multiple" category in the results.

QUESTION 27

Comparing the racial and ethnic breakdown for the IndyGo riders to that of Marion County residents[9], there is a much lower percentage of African Americans for Marion County residents (27% compared to 55%) and a much higher percentage of White people (58% compared to 33%).



Source: 5 Year ACS Data – 2015 (Table B03002)

Figure 2-36: What are the ethnicities of Marion County residents?

9 It is important to note that ACS data specifies Hispanic/Latino as an ethnicitiy, not a race. To account for this, the Hispanic/Latino population was subtracted from the appropriate races to obtain the non-Hispanic/Latino population for each race. The Hispanic/Latino data shown includes all races.

QUESTION 27

The distribution of ages were generally similar for all ethnic groups with some variation. One variation is that nearly half of Asian riders are between the ages of nineteen and twenty-four.

N = 27,573

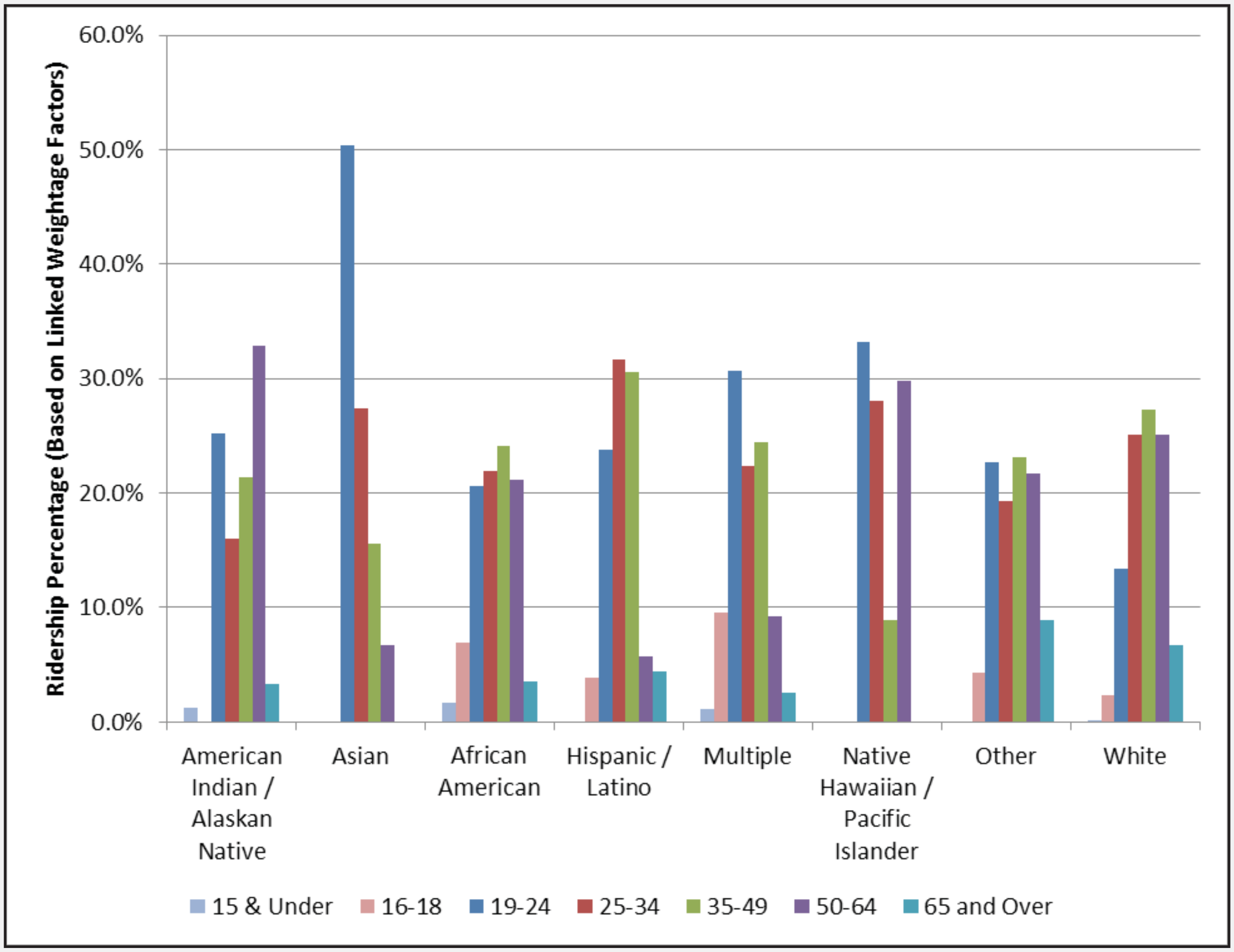


Figure 2-37: How old are IndyGo riders based on their ethnicity?

QUESTION 28

Question 28: What is your gender?

Based on the 2016 survey results, about 54% of IndyGo riders are male and 46% are female. In contrast to this, the 2009 IndyGo survey indicated that more females rode the bus than males.

N = 27,573

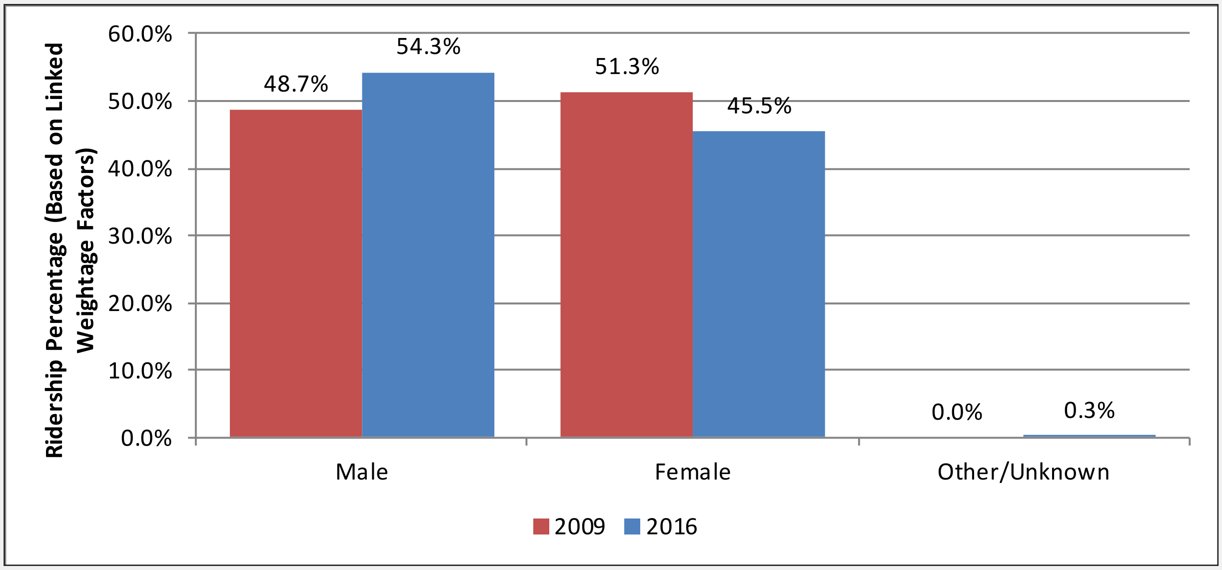


Figure 2-38: What is the gender of IndyGo riders?

QUESTION 28

There is a higher percentage of females in the younger age categories and a higher percentage of males in the older categories.

N = 27,501

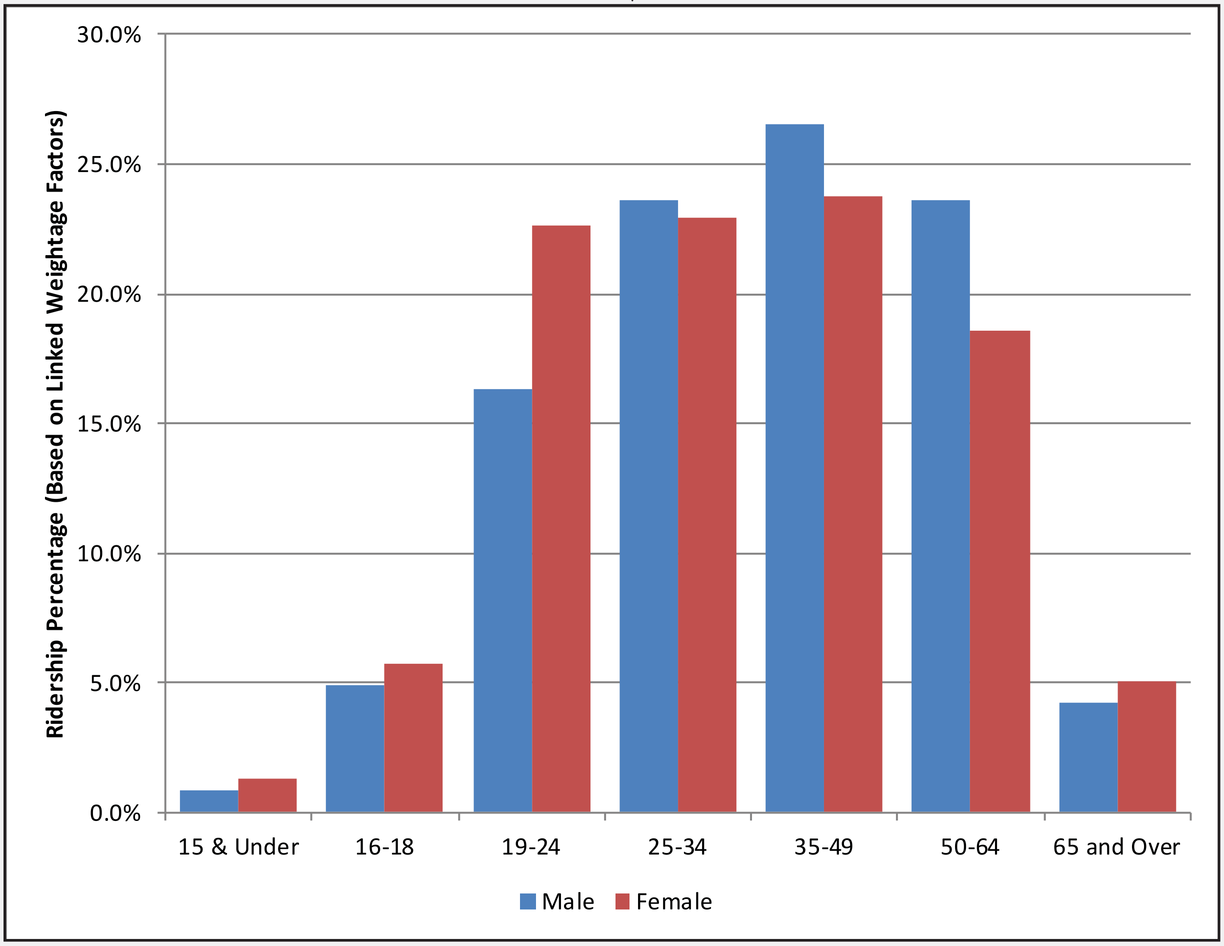


Figure 2-39: What is the gender of IndyGo riders based on age?

QUESTION 29

Question 29: Which of the following best describes your total annual household income in 2015 before taxes?

A large proportion of IndyGo riders are from households with lower incomes. Despite about 50% of passengers being employed full-time, annual household incomes tend to be low with more than half of the riders (about 57.4%) having a household income less than $25,000. Only about 8% have a household income greater than $60,000.

It's important to note that a substantial percentage (about 15%) of the riders surveyed didn't answer this question, so the ridership percentages were adjusted accordingly. Both adjusted and unadjusted graphs are shown below.

N = 23,509

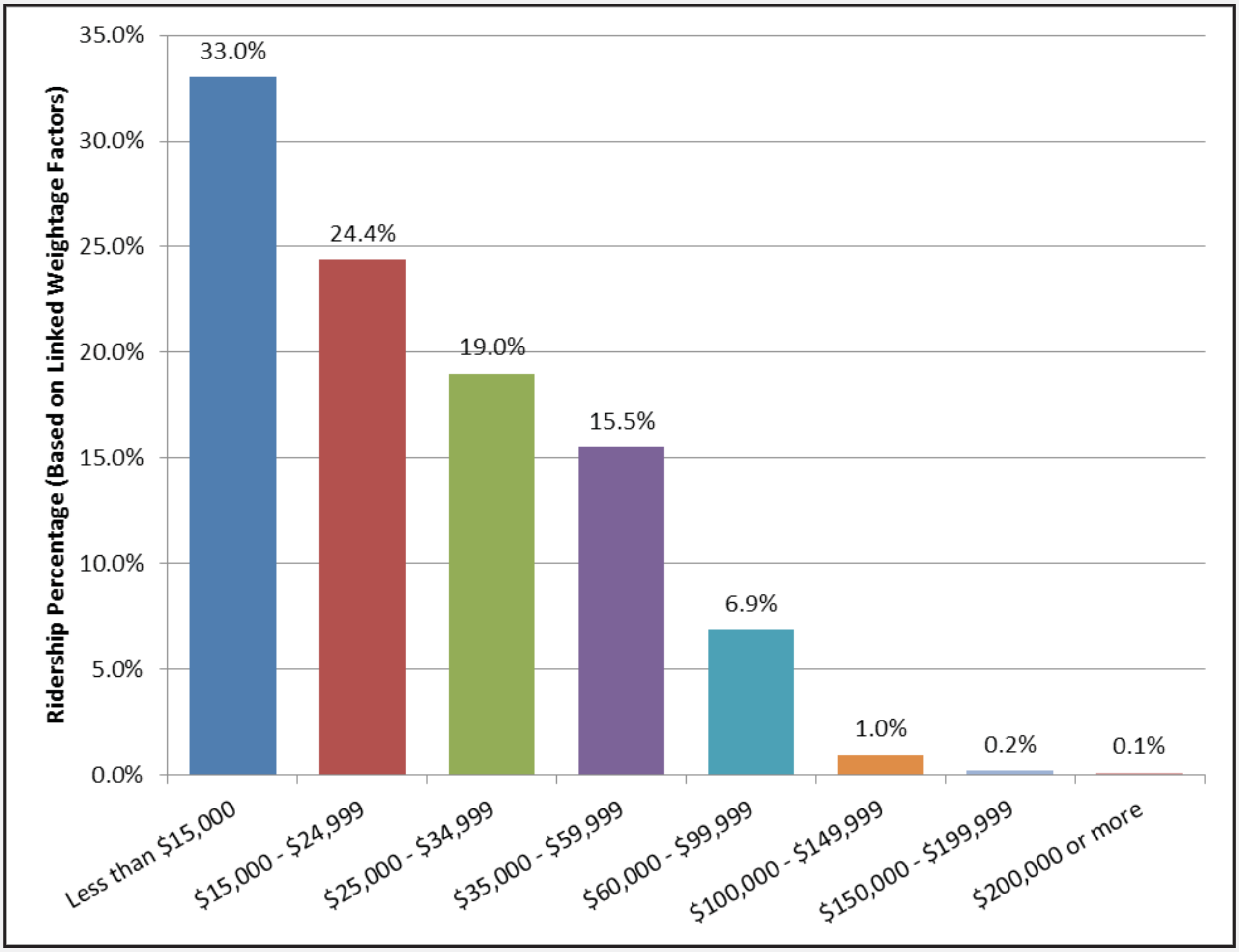


Figure 2-40: What are IndyGo riders' income levels (Adjusted)?

QUESTION 29

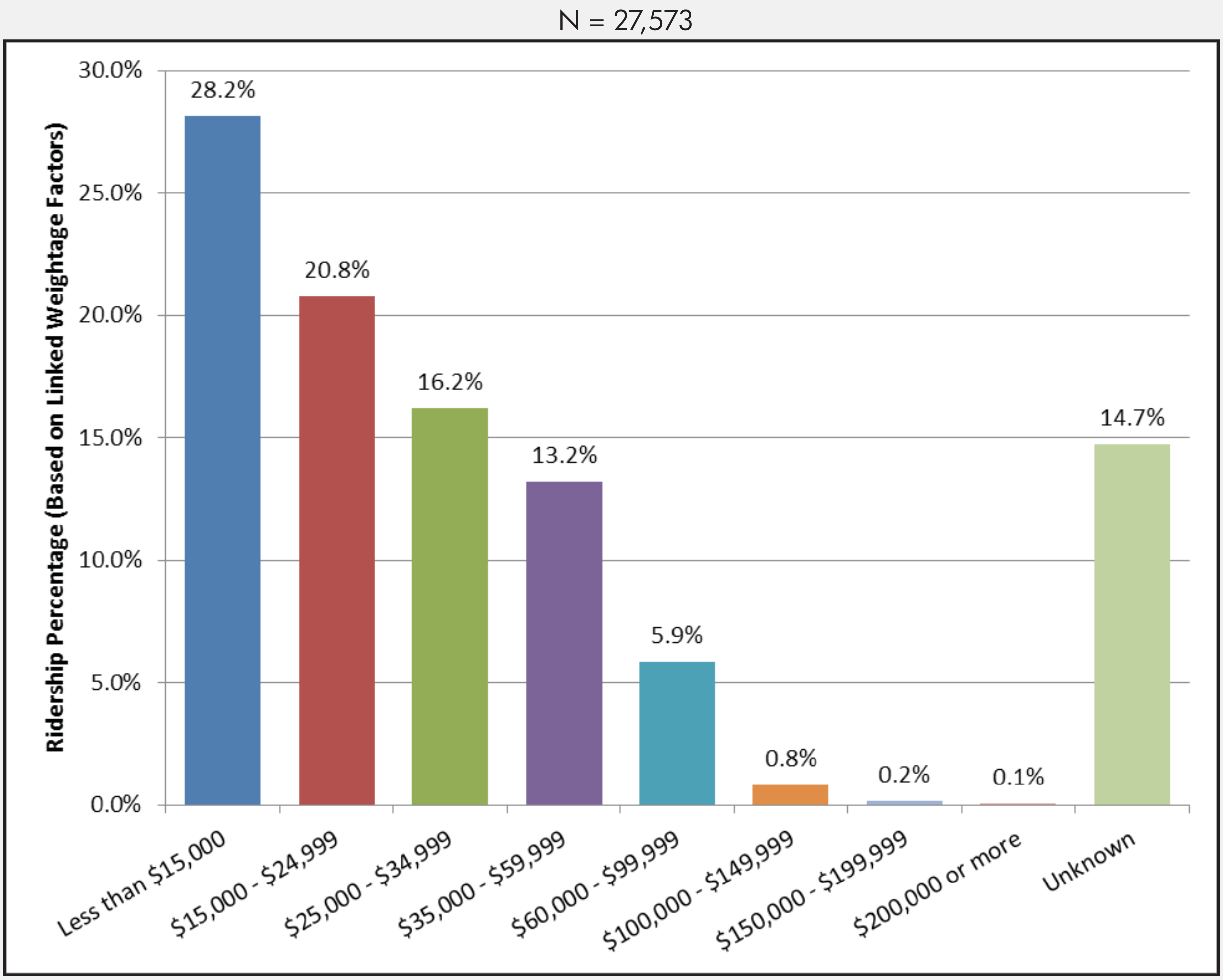
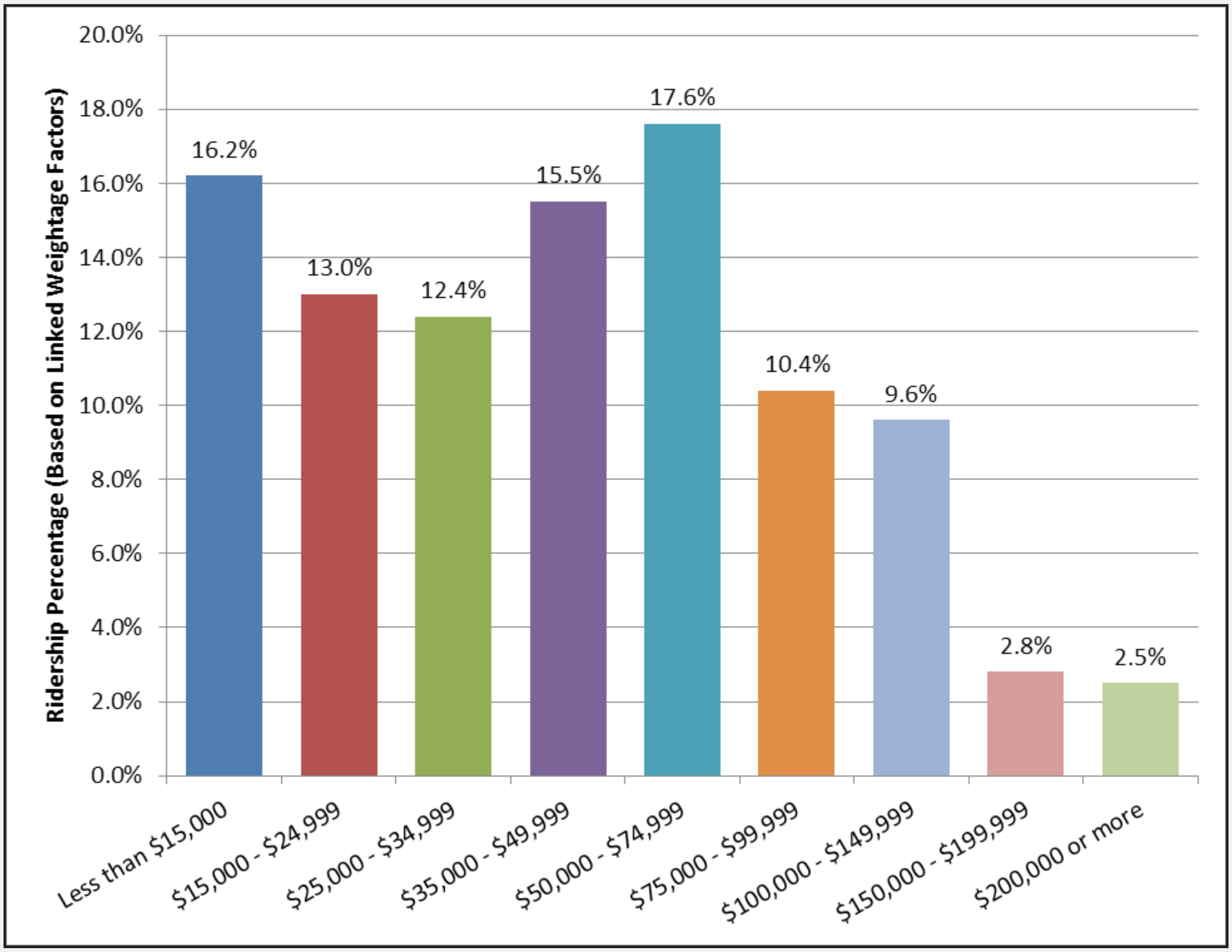


Figure 2-41: What are IndyGo riders' income levels (Unadjusted)?

QUESTION 29

Comparing the household income of IndyGo riders to that of Marion County residents, Marion County has a much lower percentage of households with income less than $25,000 (29.2% compared to 57.4% of IndyGo riders) and a much higher percentage of higher-earning households. About 25% of Marion County households have an annual income greater than $75,000 compared to 8% of households that have an income greater than $60,000 for IndyGo riders.

It is important to note that the category limits between $35,000 and $100,000 do not match up exactly for the IndyGo survey and Marion County's ACS Data.



Source: 5 Year ACS Data – 2015 (Table S1901)

Figure 2-42: What are Marion County residents' income levels?

QUESTION 29

When observing the two predominant ethnicities (African American and White), the general trend is the same: as income increases, transit ridership decreases. These percentages were adjusted to account for those not responding.

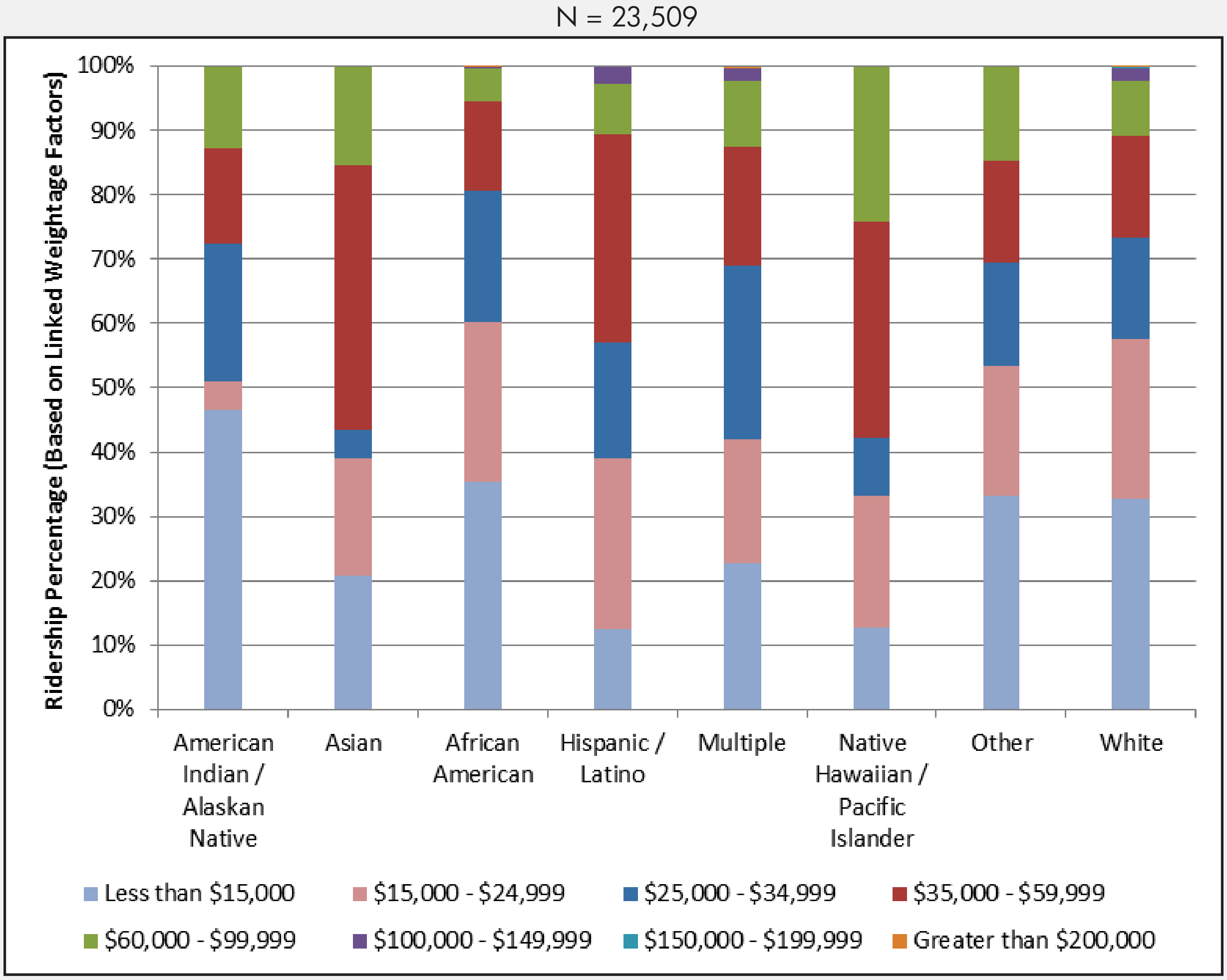


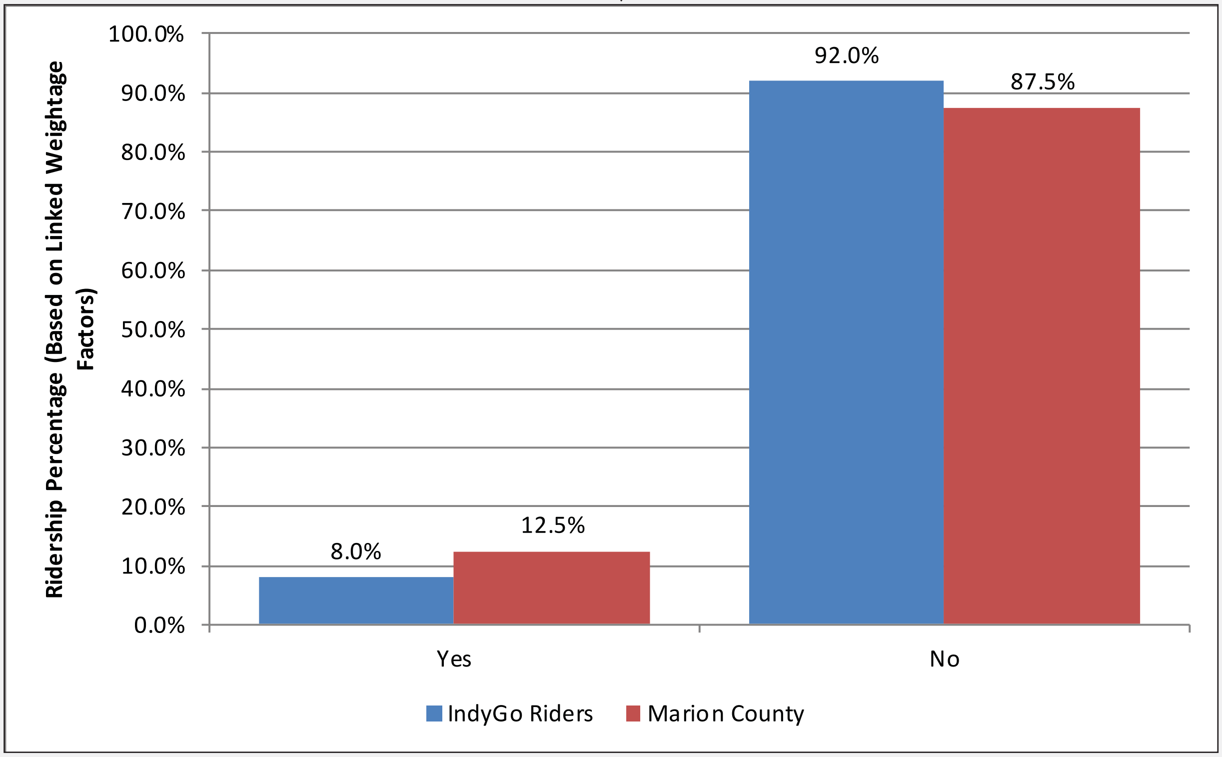
Figure 2-43: What are IndyGo riders' income levels base on ethnicity?

QUESTION 30

Question 30: Do you speak a language other than English at home?

The majority of IndyGo riders (92%) reported speaking English at home while 8% said they spoke a language other than English at home. Comparing this to Marion County, a higher percentage (12.5%) speak a language other than English at home for Marion County as a whole.

N = 27,573



Source: 5 Year ACS Data – 2015 (Table S1601)

Figure 2-44: Do IndyGo riders/Marion County residents speak a language other than English at home?

QUESTION 31

Question 31: Do you have any of the following (check all that apply):

Nearly 77% of riders have a smartphone.

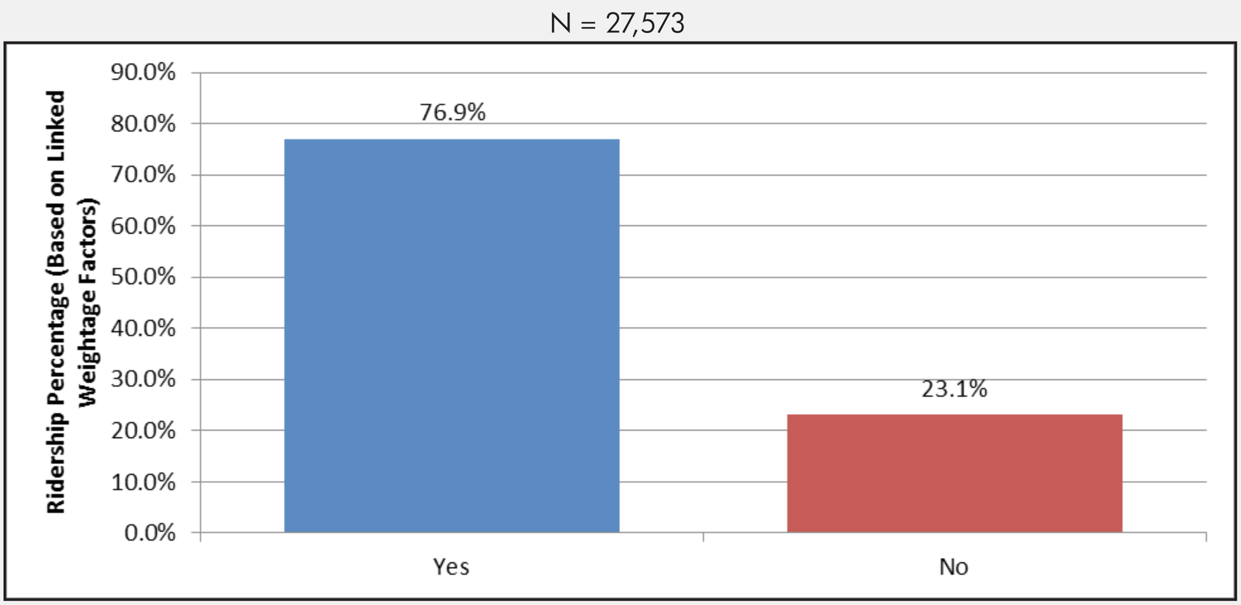


Figure 2-45: Do IndyGo riders have a smart phone?

About half (51%) of riders have a checking account.

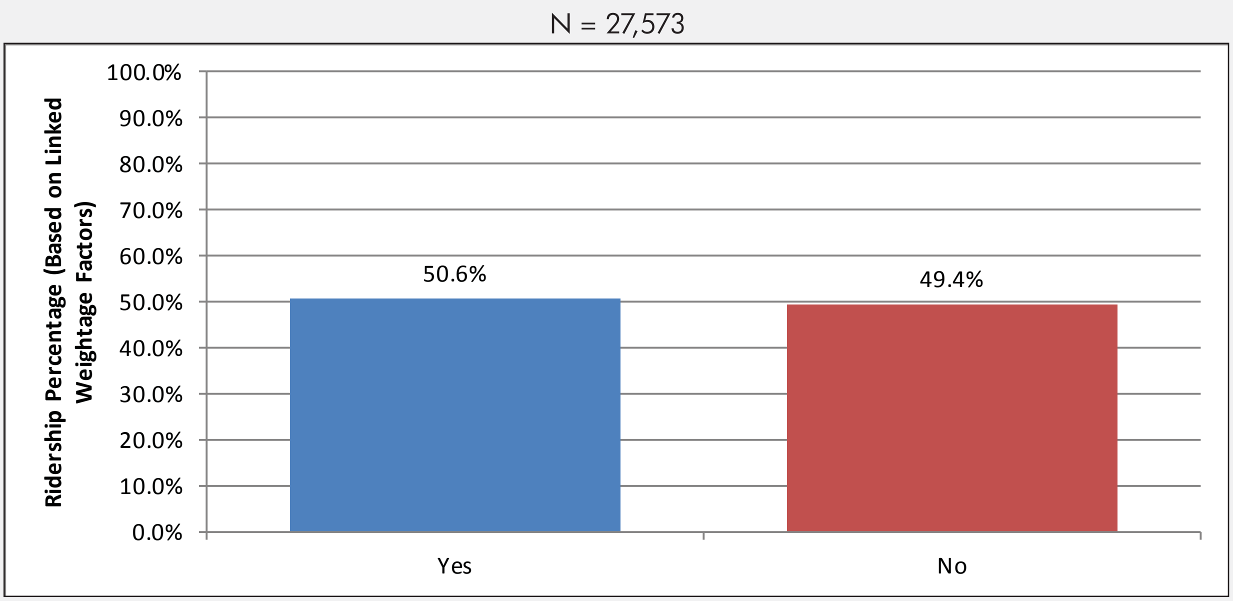


Figure 2-46: Do IndyGo riders have a checking account?

QUESTION 31

About 66% of riders have a debit card. By comparison, only 51% of riders reported having a checking account. Some riders apparently use pre-paid debit cards which are not associated with a checking account.

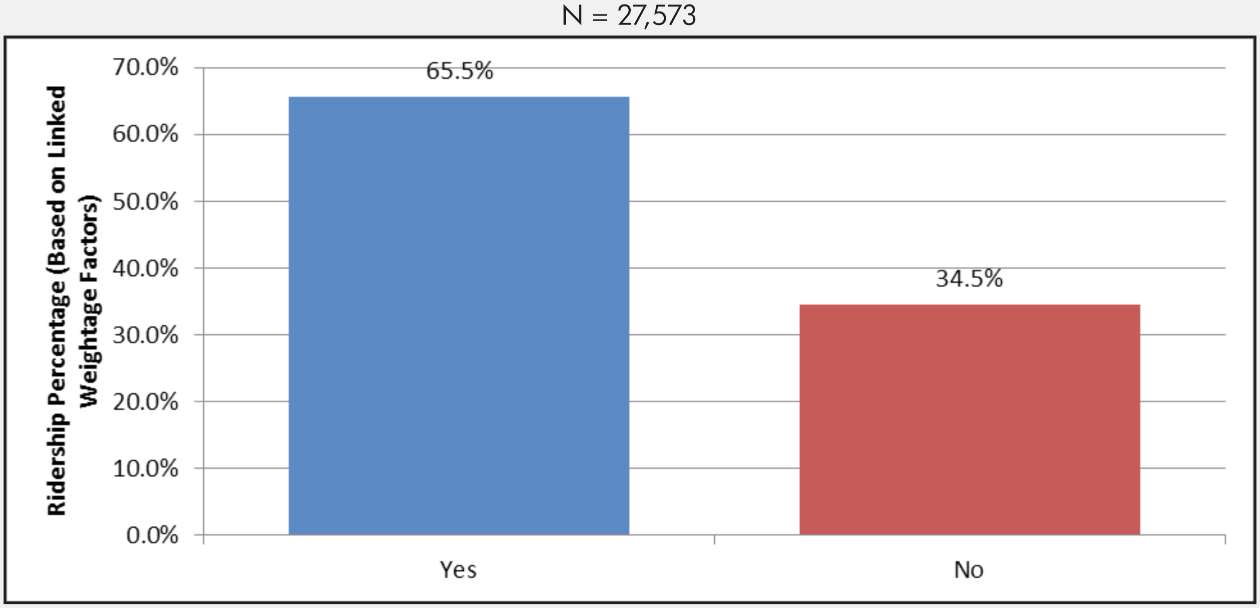


Figure 2-47: Do IndyGo riders have a debit card?

The majority (76%) of riders said they did not have a credit card.

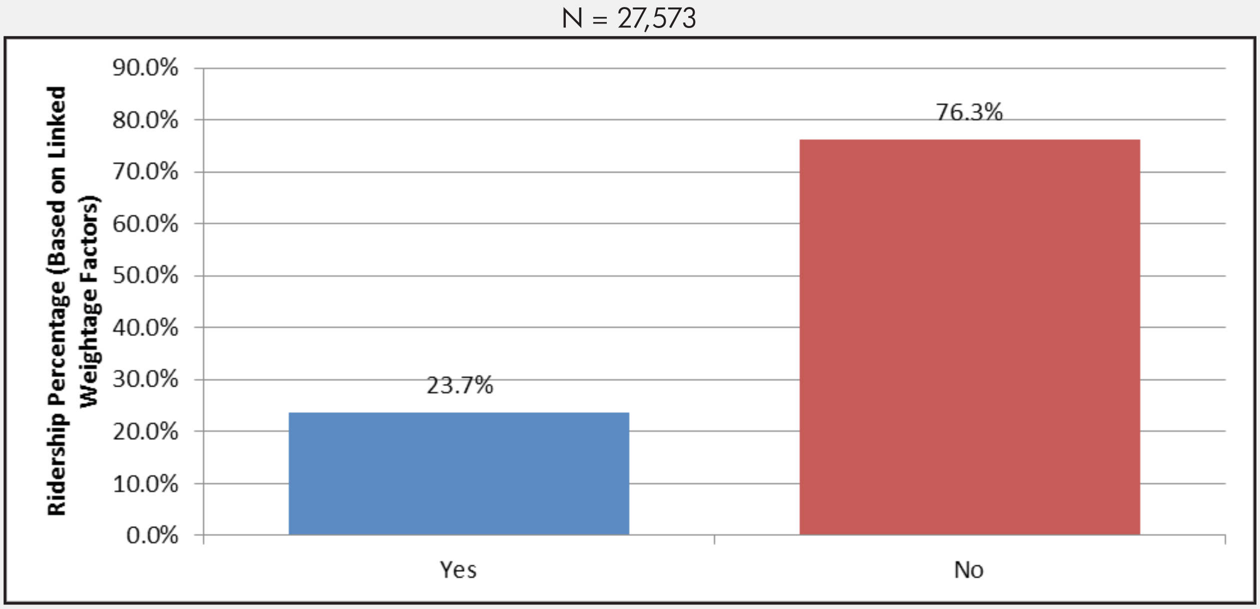


Figure 2-48: Do IndyGo riders have a credit card?

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CHAPTER 3
SAMPLING PLAN

This chapter describes the procedures used for carrying out the sampling of bus riders. Three major areas are addressed by these procedures:

(1) sampling goals,

(2) methods for selecting survey participants, and

(3) other techniques used to manage the sampling process.

3.1 SAMPLING GOALS

In order to ensure that the distribution of completed surveys mirrored the actual distribution of riders, ETC Institute developed a sampling plan that would ensure the completion of the On-to-Off survey with at least 4,015 of the system's riders, and 3,500 surveys of the full Origin Destination (OD) based on Tuesday – Thursday average ridership.

ETC Institute will prepare sampling plans for two separate and sequential surveys. The first survey will be an On-to-Off count that collects passenger boarding and alighting information only. The data obtained in the On-to-Off counts will aid in data expansion. The second survey will be a tablet-based Origin Destination (OD) Survey that focuses on understanding the travel patterns and key characteristics of current riders.

3.1.1 Sampling Goals for On-to-Off Survey

The sampling plan for the On-to-Off survey was designed to obtain completed surveys from a minimum of 20% of the daily ridership on each route operated by IndyGo that has a minimum daily ridership of 1,000, and four routes of interest. In addition, individual cells (route/direction/time of day) that contained high ridership were added to the on-to-off sampling plan. Table 3-1 on page 56 shows the goals and the actual number of completed On-to-Off surveys that were obtained for each bus by Route, Time Period, and Direction. IndyGo provided the estimated weekday ridership and ETC Institute developed the sample goals based on this information.

Table 3-1 shows that ETC collected 1,784 (44%) more responses than the sampling goal. Responses on a per route level ranged from 15% to 94% over the sample goal.

Route #	Route Name	Direction	SAMPLING GOALS						COMPLETED						
			AM Peak (3:00am-9:00am)	Midday (9:01am-3:00pm)	PM Peak (3:01-6:00pm)	Night (6:01pm-2:59am)	Total	TOTAL SURVEYS	AM Peak (3:00am-9:00am)	Midday (9:01am-3:00pm)	PM Peak (3:01-6:00pm)	Night (6:01pm-2:59am)	Total	TOTAL SURVEYS	% of Sampling Goal
8	Washington	EASTBOUND	78	206	132	36	452	**909**	136	230	174	102	**642**	**1240**	**136%**
		WESTBOUND	101	212	111	34	457		115	289	129	65	**598**		
10	10th Street	EASTBOUND	67	194	114	28	404	**811**	108	197	119	12	**436**	**929**	**115%**
		WESTBOUND	92	191	97	28	407		74	293	98	28	**493**		
17	College	INBOUND	24	36	20	11	91	**189**	29	39	53	19	**140**	**284**	**151%**
		OUTBOUND	15	44	29	9	97		28	46	41	29	**144**		
18	Nora	INBOUND	19	27	20	8	73	**148**	29	36	25	11	**101**	**220**	**149%**
		OUTBOUND	19	27	24	6	75		34	46	27	12	**119**		
19	Castleton	INBOUND	28	47	31	12	117	**253**	7	86	57	22	**172**	**389**	**154%**
		OUTBOUND	30	57	38	10	136		41	88	69	19	**217**		
22	Shelby	INBOUND	13	19	14	4	51	**109**	20	24	23	7	**74**	**169**	**155%**
		OUTBOUND	12	24	20	3	59		24	39	31	1	**95**		
31	Madison	INBOUND	26	42	23	4	95	**196**	23	53	24	40	**140**	**288**	**147%**
		OUTBOUND	18	46	31	6	100		23	53	42	30	**148**		
34	ML King/Michigan Rd	INBOUND	27	36	24	12	99	**204**	38	50	24	23	**135**	**263**	**129%**
		OUTBOUND	20	43	32	11	106		33	52	31	12	**128**		
37	Park 100	INBOUND	38	55	57	17	167	**367**	24	97	80	153	**354**	**714**	**194%**
		OUTBOUND	55	79	43	23	200		111	96	127	26	**360**		
38	West 38th St	INBOUND	15	68	34	30	148	**296**	17	77	41	43	**178**	**408**	**138%**
		OUTBOUND	17	69	35	28	149		17	79	92	42	**230**		
39	East 38th St	INBOUND	71	129	54	23	277	**533**	69	195	141	68	**473**	**895**	**168%**
		OUTBOUND	42	121	74	20	256		71	196	134	21	**422**		
		TOTALS	**826**	**1,771**	**1,056**	**362**	**4,015**	**4,015**	**1,071**	**2,361**	**1,582**	**785**	**5,799**	**5,799**	**144%**

Table 3-1: Bus Sampling Goals and On-to-Off Surveys Completed by Time of Day and Direction

3.1.2 Sampling Goals for OD Survey

ETC Institute developed a sampling plan that would ensure the completion of the full Origin-and-Destination Survey by approximately 3,500 of the system's riders. ETC Institute also set a goal to be within either 10 surveys or 10% of the established survey total goal based on the overall ridership estimate. The time periods for this survey were as follows: "AM Peak" time period (3am-9am), "Midday" time period (9am-3pm), "PM Peak" time period (3pm-6pm), and "Evening" time period (6pm-3am).

Table 3-2 shows the goals and the actual number of completed surveys that were obtained by route, time period, and direction. The sampling plan for the origin-destination survey was designed to obtain completed surveys from a minimum of 10% of the ridership on each of the bus routes operated by IndyGo. The total estimated weekday ridership was provided by IndyGo.

A survey was considered "complete" if all of the contractually required information was collected. A survey was considered "useable" if it met 100% of the quality assurance and quality control tests (see Chapter 5) that were applied to each record. Overall, the total number of "complete and useable surveys" exceeded the sample goal by more than 689 surveys.

Route #	Route Name	Direction	SAMPLING GOALS					TOTAL SURVEYS	COMPLETED					TOTAL SURVEYS
			AM Peak (3:00am-9:00am)	Midday (9:01am-3:00pm)	PM Peak (3:01-6:00pm)	Night (6:01pm-2:59am)	Total		AM Peak (3:00am-9:00am)	Midday (9:01am-3:00pm)	PM Peak (3:01-6:00pm)	Night (6:01pm-2:59am)	Total	
2	East 34th St	INBOUND	10	12	6	3	31	**65**	10	15	8	10	**43**	**83**
		OUTBOUND	6	13	11	4	34		5	13	10	12	**40**	
3	Michigan Street	EASTBOUND	9	15	17	3	44	**91**	34	31	23	14	**102**	**176**
		WESTBOUND	18	17	10	2	47		11	40	18	5	**74**	
4	Fort Harrison	INBOUND	12	14	10	3	40	**80**	12	14	18	6	**50**	**95**
		OUTBOUND	7	14	14	5	40		9	15	18	3	**45**	
5	East 25th St	INBOUND	9	16	8	4	36	**69**	9	13	8	8	**38**	**76**
		OUTBOUND	4	14	10	4	33		6	16	12	4	**38**	
6	Harding	INBOUND	6	13	6	3	27	**50**	7	15	9	3	**34**	**66**
		OUTBOUND	3	10	7	3	23		5	11	9	7	**32**	
8	Washington	EASTBOUND	39	103	66	18	226	**454**	34	148	65	34	**281**	**574**
		WESTBOUND	50	106	55	17	229		49	148	74	22	**293**	
10	10th Street	EASTBOUND	34	97	57	14	202	**406**	41	128	49	17	**235**	**486**
		WESTBOUND	46	95	49	14	204		36	135	59	21	**251**	
11	East 16th St	INBOUND	4	6	3	0	13	**26**	2	11	3	0	**16**	**33**
		OUTBOUND	3	5	4	1	13		2	9	4	2	**17**	
12	Minnesota	INBOUND	3	4	1	1	9	**18**	3	6	4	4	**17**	**26**
		OUTBOUND	2	4	2	1	10		3	3	2	1	**9**	

Table 3-2: Bus Sampling Goals and OD Surveys Completed by Time of Day and Direction

Route #	Route Name	Direction	SAMPLING GOALS AM Peak (3:00am-9:00am)	Midday (9:01am-3:00pm)	PM Peak (3:01-6:00pm)	Night (6:01pm-2:59am)	Total	TOTAL SURVEYS	COMPLETED AM Peak (3:00am-9:00am)	Midday (9:01am-3:00pm)	PM Peak (3:01-6:00pm)	Night (6:01pm-2:59am)	Total	TOTAL SURVEYS
13	Raymond Street	INBOUND	3	2	1	0	6	**14**	3	6	2	0	**11**	**22**
		OUTBOUND	1	4	3	1	8		0	3	4	4	**11**	
14	Prospect	INBOUND	5	7	5	2	19	**42**	6	11	6	2	**25**	**49**
		OUTBOUND	4	8	8	3	23		4	8	7	5	**24**	
15	West 34th St	INBOUND	16	17	7	5	44	**88**	20	26	16	5	**67**	**115**
		OUTBOUND	6	15	17	5	43		15	13	15	5	**48**	
16	Beech Grove	INBOUND	6	9	7	1	23	**50**	5	12	9	5	**31**	**64**
		OUTBOUND	7	11	8	2	28		4	10	18	1	**33**	
17	College	INBOUND	12	18	10	5	46	**94**	12	29	14	5	**60**	**117**
		OUTBOUND	8	22	15	5	49		5	31	14	7	**57**	
18	Nora	INBOUND	10	13	10	4	37	**74**	7	9	12	3	**31**	**75**
		OUTBOUND	9	13	12	3	37		10	16	15	3	**44**	
19	Castleton	INBOUND	14	24	15	6	59	**127**	8	52	29	14	**103**	**218**
		OUTBOUND	15	29	19	5	68		23	44	38	10	**115**	
21	East 21st St	INBOUND	11	12	8	3	34	**69**	15	25	8	1	**49**	**107**
		OUTBOUND	8	14	12	2	35		18	28	9	3	**58**	
22	Shelby	INBOUND	7	10	7	2	25	**55**	10	22	9	2	**43**	**83**
		OUTBOUND	6	12	10	1	29		12	17	11	0	**40**	
24	Mars Hill	INBOUND	5	6	6	1	18	**40**	5	8	9	6	**28**	**51**
		OUTBOUND	7	8	5	2	22		7	7	6	3	**23**	
25	West 16th St	INBOUND	8	11	6	2	27	**59**	12	23	11	14	**60**	**123**
		OUTBOUND	5	14	11	3	32		9	26	20	8	**63**	
26	Keystone Crosstown	NORTHBOUND	12	14	10	3	39	**69**	10	23	7	8	**48**	**84**
		SOUTHBOUND	6	11	9	4	30		7	13	9	7	**36**	
28	St. Vincent	INBOUND	11	10	6	2	28	**64**	6	20	16	10	**52**	**106**
		OUTBOUND	7	12	12	4	36		14	17	12	11	**54**	
30	30th Street Crosstown	EASTBOUND	6	10	6	2	25	**48**	0	12	14	5	**31**	**76**
		WESTBOUND	6	10	4	2	23		6	23	12	4	**45**	
31	Madison	INBOUND	13	21	11	2	48	**98**	14	29	15	5	**63**	**118**
		OUTBOUND	9	23	15	3	50		11	26	14	4	**55**	
34	ML King/Michigan Rd	INBOUND	13	18	12	6	49	**102**	16	22	18	13	**69**	**134**
		OUTBOUND	10	21	16	6	53		12	27	18	8	**65**	

Table 3-2: Bus Sampling Goals and OD Surveys Completed by Time of Day and Direction (Continued)

Route #	Route Name	Direction	SAMPLING GOALS					TOTAL SURVEYS	COMPLETED					TOTAL SURVEYS
			AM Peak (3:00am-9:00am)	Midday (9:01am-3:00pm)	PM Peak (3:01-6:00pm)	Night (6:01pm-2:59am)	Total		AM Peak (3:00am-9:00am)	Midday (9:01am-3:00pm)	PM Peak (3:01-6:00pm)	Night (6:01pm-2:59am)	Total	
37	Park 100	INBOUND	19	27	29	9	83	**184**	27	50	32	17	**126**	**235**
		OUTBOUND	28	39	22	12	100		29	44	25	11	**109**	
38	West 38th St	INBOUND	8	34	17	15	74	**148**	5	35	16	17	**73**	**167**
		OUTBOUND	8	34	17	14	74		12	44	24	14	**94**	
39	East 38th St	INBOUND	36	65	27	12	139	**267**	27	119	48	21	**215**	**410**
		OUTBOUND	21	60	37	10	128		32	102	39	22	**195**	
55	English	INBOUND	4	4	1	1	10	**21**	2	3	8	2	**15**	**36**
		OUTBOUND	2	4	4	1	10		4	7	9	1	**21**	
86	86th St Crosstown	EASTBOUND	6	11	8	3	27	**52**	11	21	14	5	**51**	**97**
		WESTBOUND	5	10	7	3	25		10	20	10	6	**46**	
87	Eastside Circulator	CIRCULAR	11	25	14	6	56	**56**	22	37	15	13	**87**	**87**
		TOTALS	676	1,301	821	281	3,079	3,079	765	1,891	1,050	483	4,189	4,189

Table 3-2: Bus Sampling Goals and OD Surveys Completed by Time of Day and Direction (Continued)

3.2 PROCESS FOR IDENTIFYING COMPLETE RECORDS

To classify a survey as being completed, the record must have contained all elements of the one-way trip. ETC Institute has classified required trip data as containing the complete answers to the following:

- Route / Direction
- Time of trip
- Transfers made
- Home address
- Origin address
- Destination address
- Origin type place
- Destination type place
- Access mode
- Egress mode
- Boarding location
- Alighting location

In addition to the required trip data questions, a survey must be marked as complete by the online survey program which occurs only if the interviewer has navigated through every required question on the online survey instrument including demographic questions.

3.3 METHODS FOR SELECTING SURVEY PARTICIPANTS

For the OD survey, a random number generator was used to determine which passengers were asked to participate in the survey after boarding a bus. If four people boarded a bus, the tablet PC randomly generated a number from 1 to 4. If the answer was 2, the second person who boarded the bus was asked to participate in the survey. If the answer was 1, the first person was asked to participate in the survey, and so forth. If only one passenger boards the vehicle, then the tablet selects that individual to be surveyed. The selection was limited to the first six people who boarded a bus at any given stop to ensure the interviewer could keep track of the passengers as they boarded. For the on-to-off counts, every rider was sampled of a sampled trip.

3.3.1 Other Techniques Used to Manage the Sampling Process

Some of the other techniques used to manage the sampling of bus riders are described below:

- **Daily Reviews of Interviewer Performance**
  The survey team evaluated the performance of each interviewer each day. This included a review of the characteristics of the passengers who were interviewed with regard to demographics and trip characteristics. These reviews were completed while the interviewer is on the bus and the findings are discussed with that interviewer when they check in. This allowed the survey team to provide immediate feedback to interviewers to improve their overall performance. It also allowed the survey team to quickly identify and remove interviewers who were not conducting the survey properly.
- **Management of the Sample by Time of Day**
  In addition to managing the total number of surveys that were completed for each route, ETC Institute also managed the number of surveys that were completed during each of the following four time periods:
  - AM Peak
  - Midday
  - PM Peak
  - Evening

  These four time periods correspond to time periods that are used for regional travel demand forecasting. This was done to ensure that the number of completed surveys for each time period would adequately support data expansion requirements for travel demand forecasting. The data expansion process is further described in Chapter 6 of this report.

Figure 3-1 below shows the estimated ridership by time period. Figure 3-2 on page 62 shows the transit service supplied (revenue hours) by time period. Figure 3-3 on page 62 shows number of On-to-Off surveys that were collected by time period, and Figure 3-4 on page 63 shows the number of OD surveys that were collected by time period.

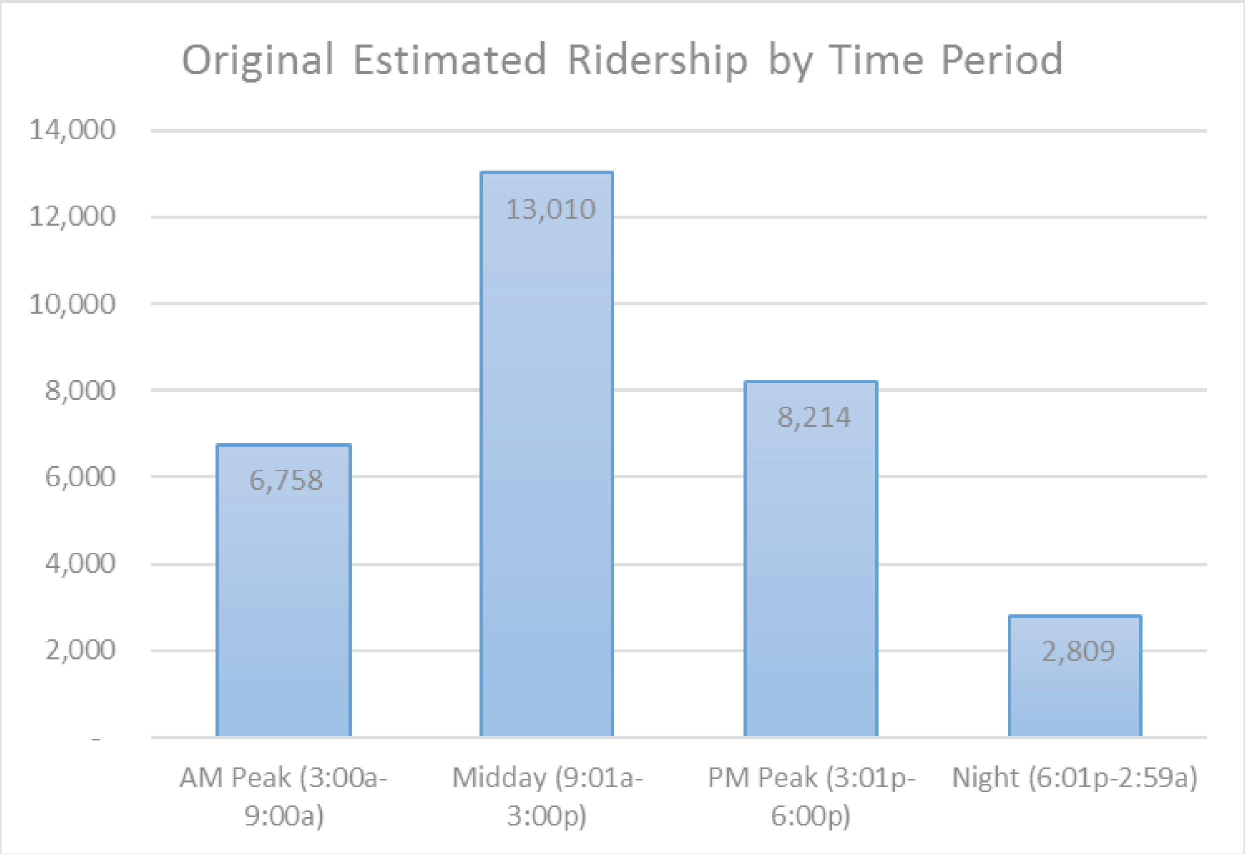

Figure 3-1: Estimated Ridership by Time Period

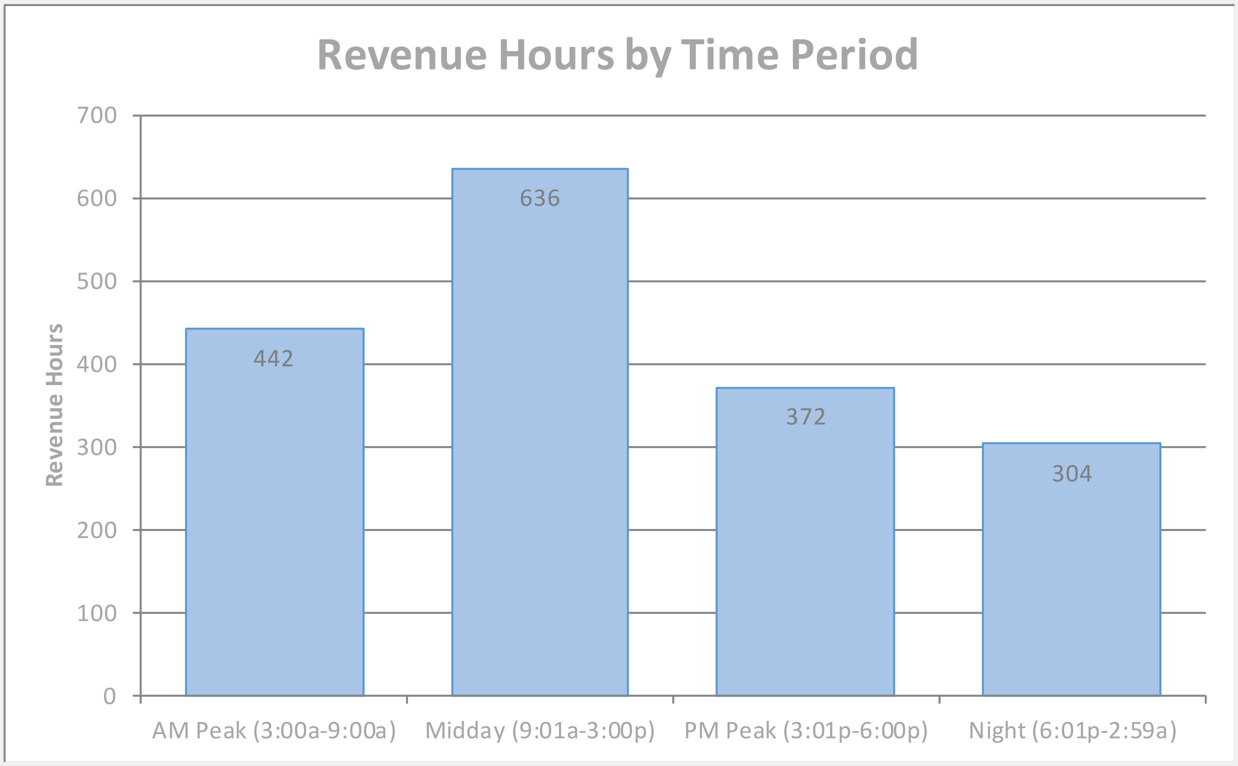

Figure 3-2: Transit Service Supplied by Time Period

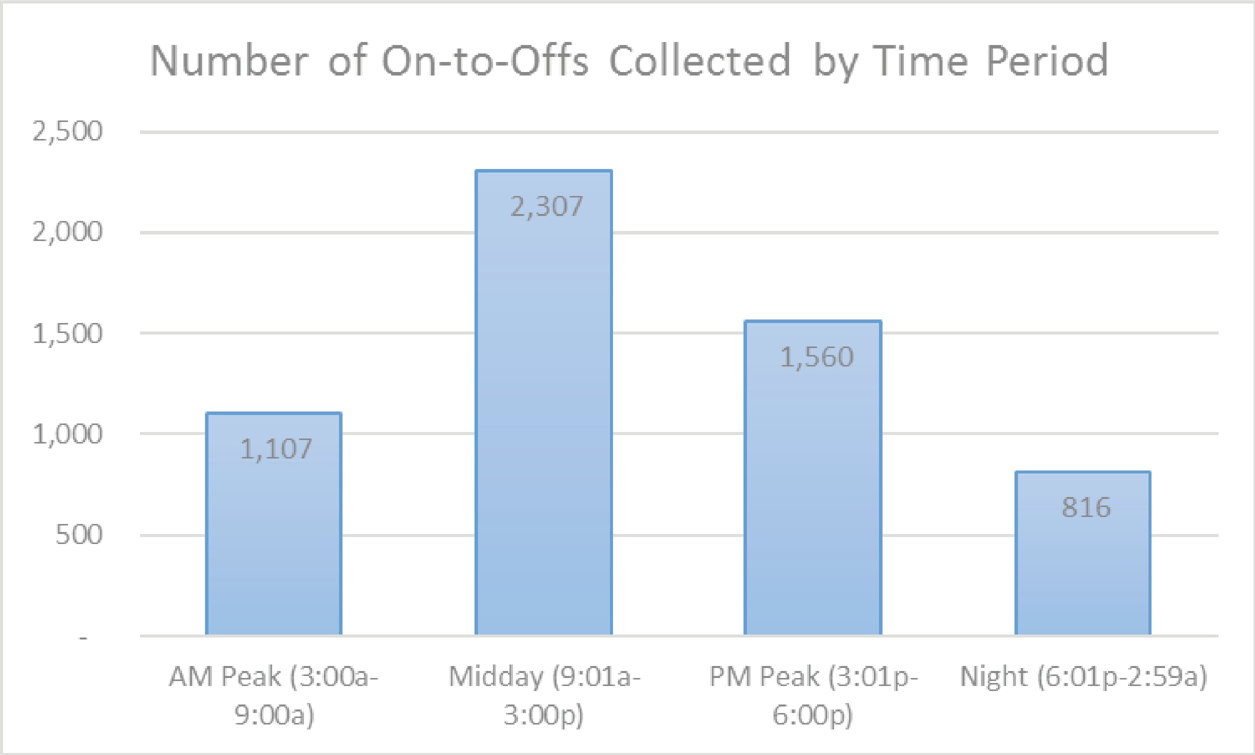

Figure 3-3: Number of On-to-Off Surveys Collected by Time Period

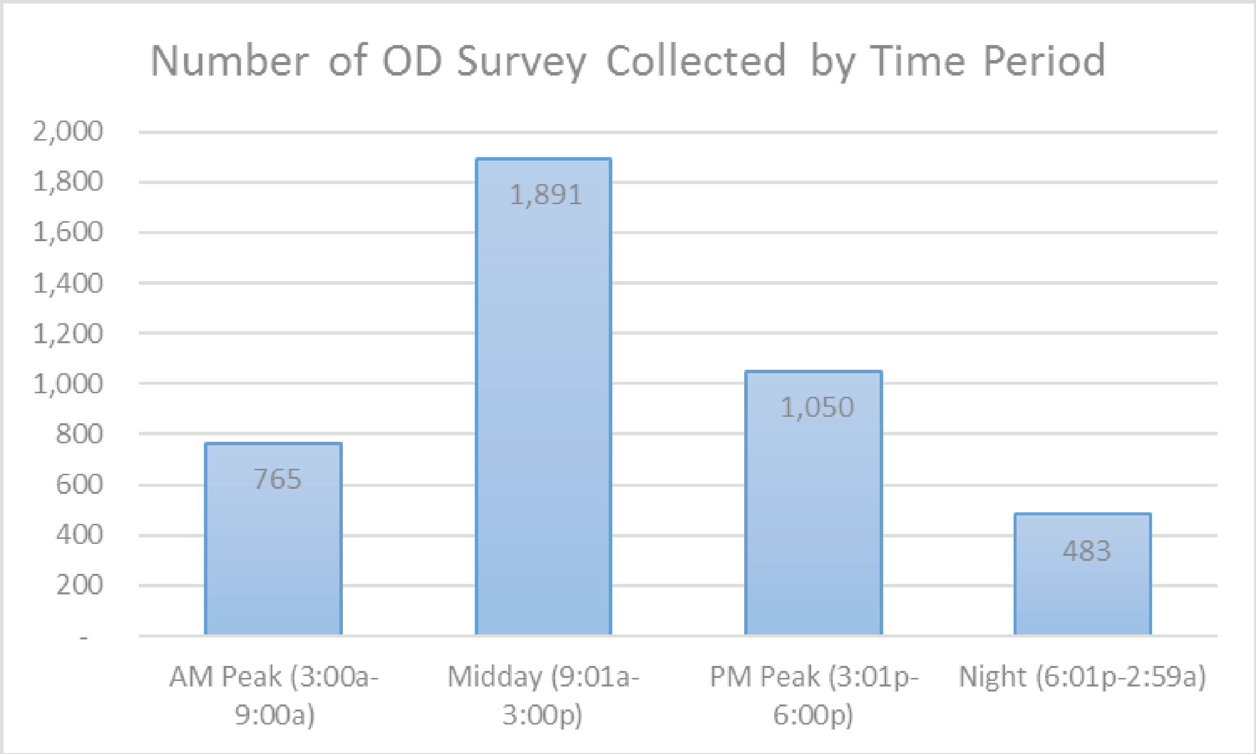

Figure 3-4: Number of OD Surveys Collected by Time Period

Figure 3-5 and Figure 3-6 illustrate IndyGo's service area.

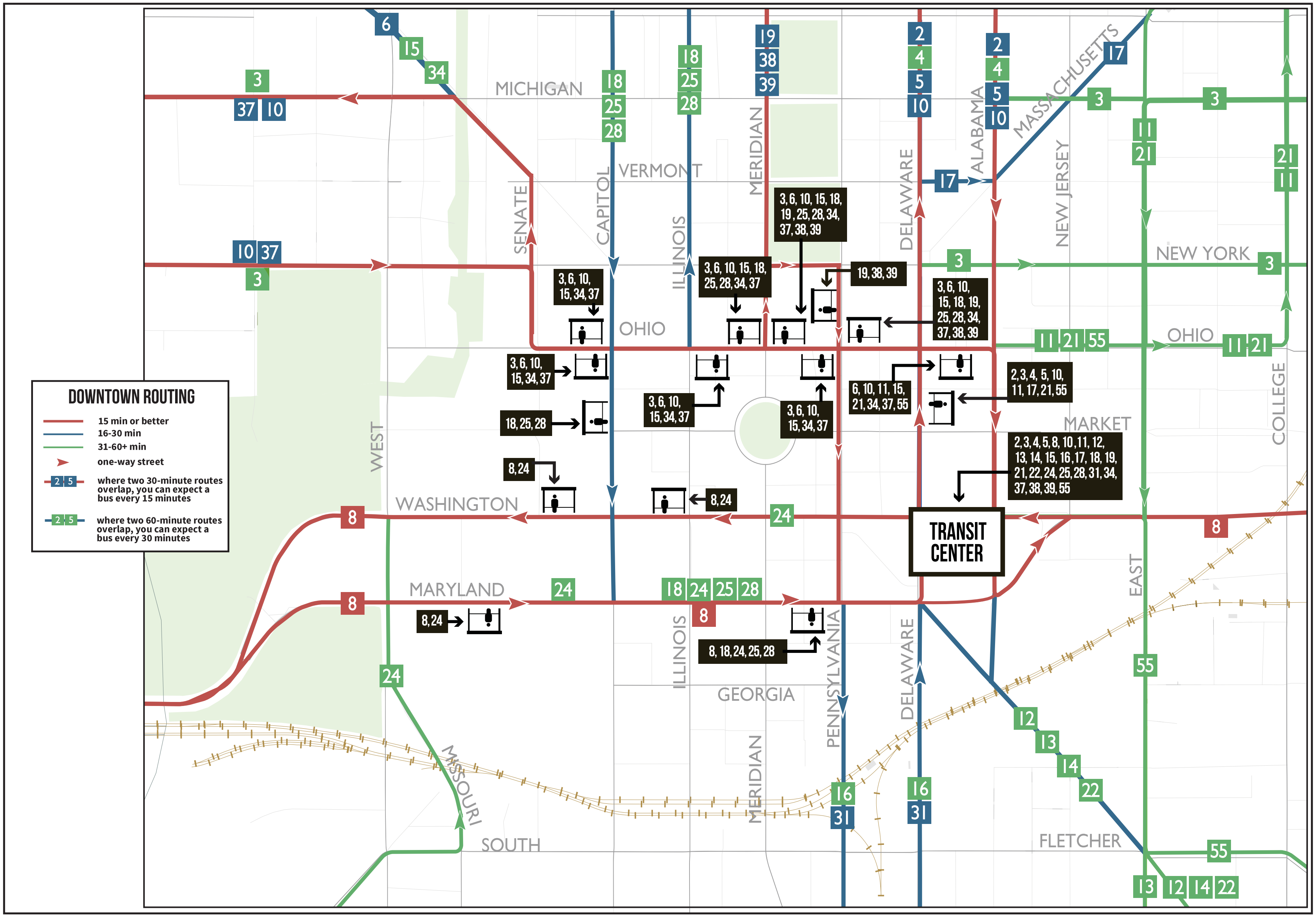

Figure 3-5: : IndyGo Service for the Downtown Area

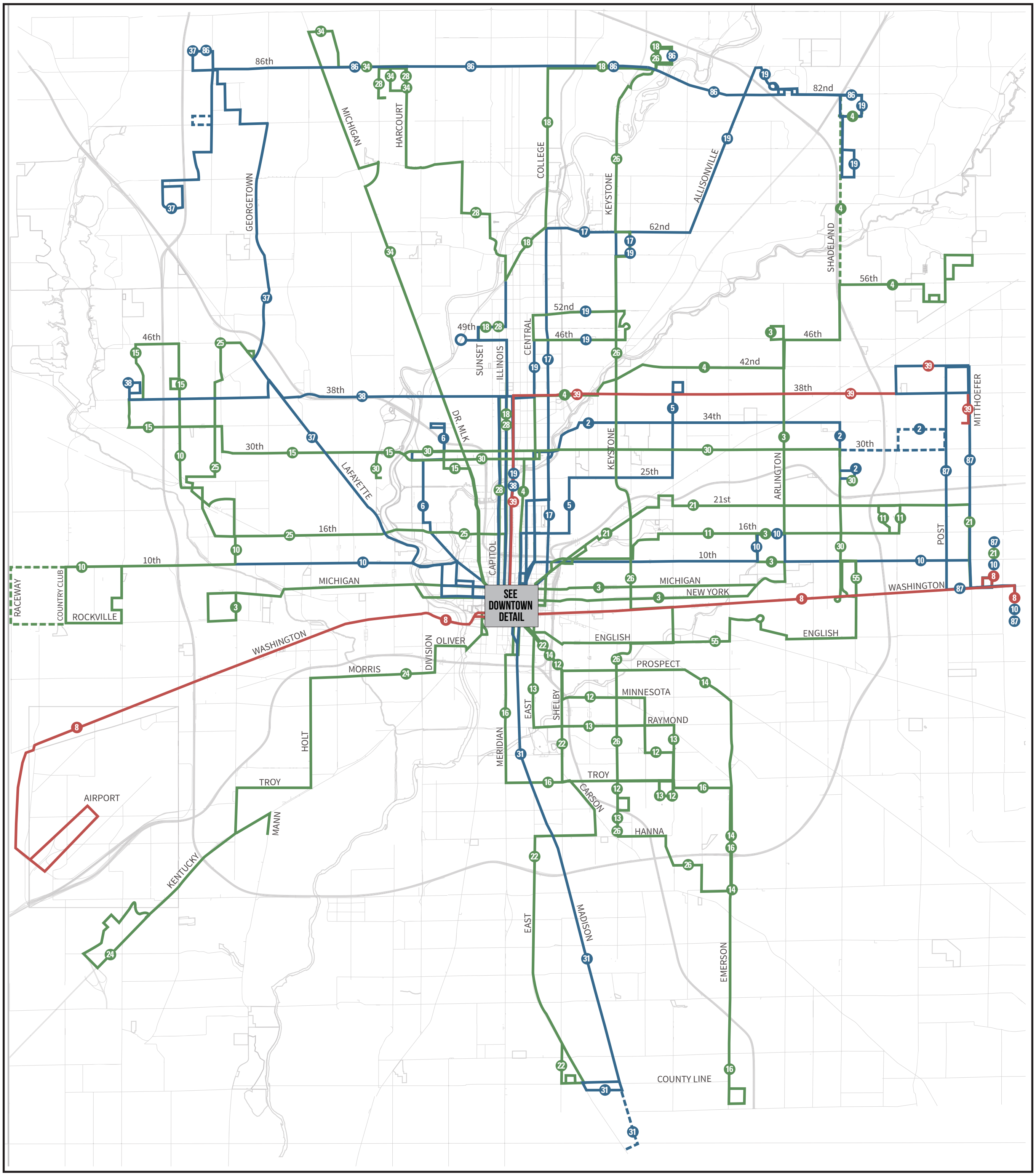

Figure 3-6: IndyGo Service Area

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CHAPTER 4
SURVEY INSTRUMENT

The survey instrument was designed to be administered as a face-to-face interview using tablet PCs. A handful of screenshots from the tablet PC survey are shown below and on the following page. The full survey instrument is available in Appendix B).

Respondents who did not have time to complete the survey during their bus trip were also given the option of providing their phone numbers. Those who provided their phone numbers were then contacted by ETC Institute's call center to complete the survey.

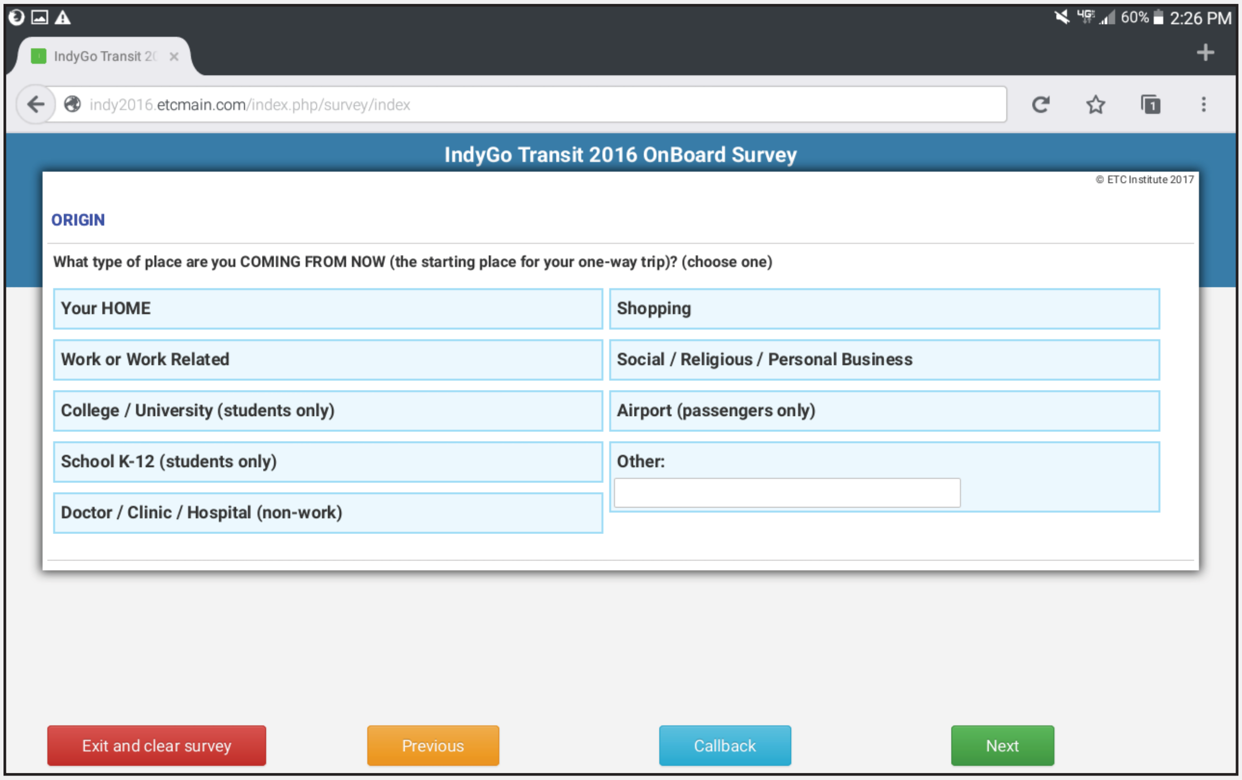

Figure 4-1: Tablet PC screenshot for Question: "What type of place are you COMING FROM NOW?"

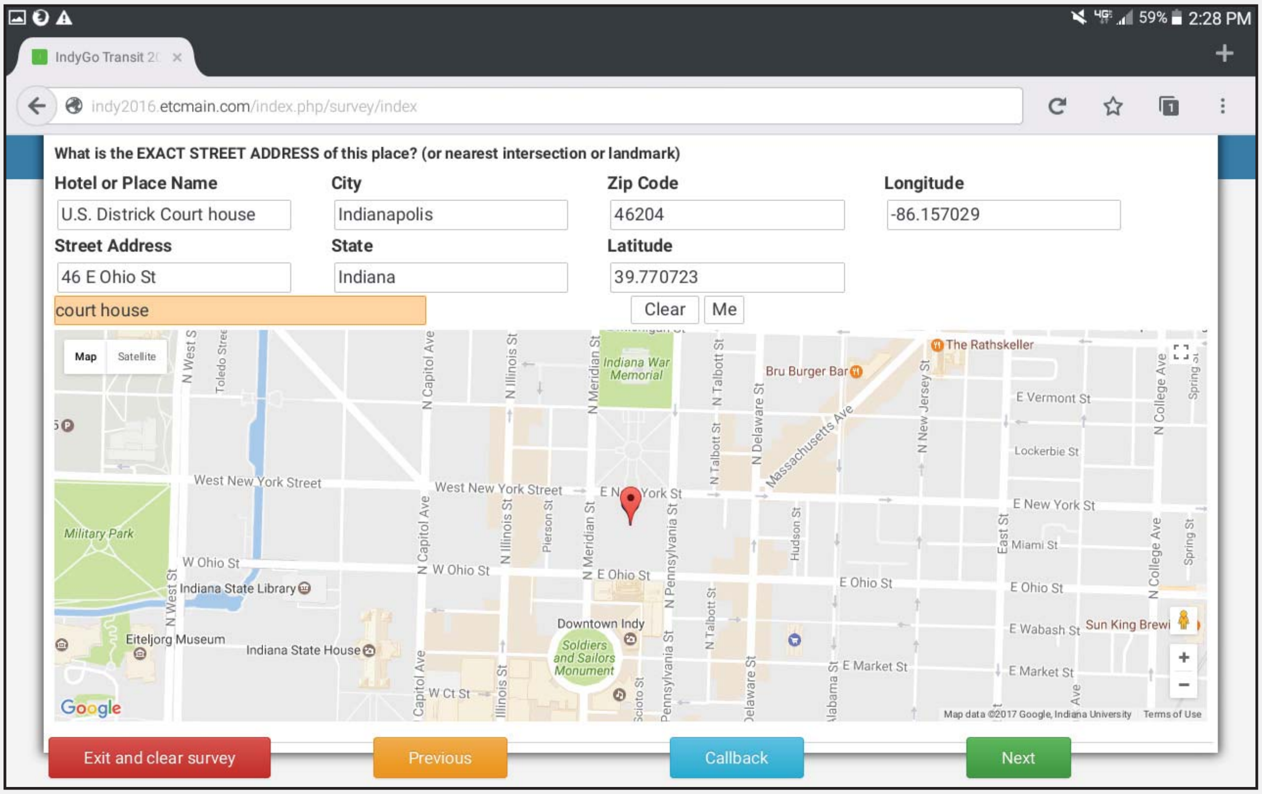

Figure 4-2: Tablet PC screenshot for Question: "What is the EXACT STREET ADDRESS of this place?"

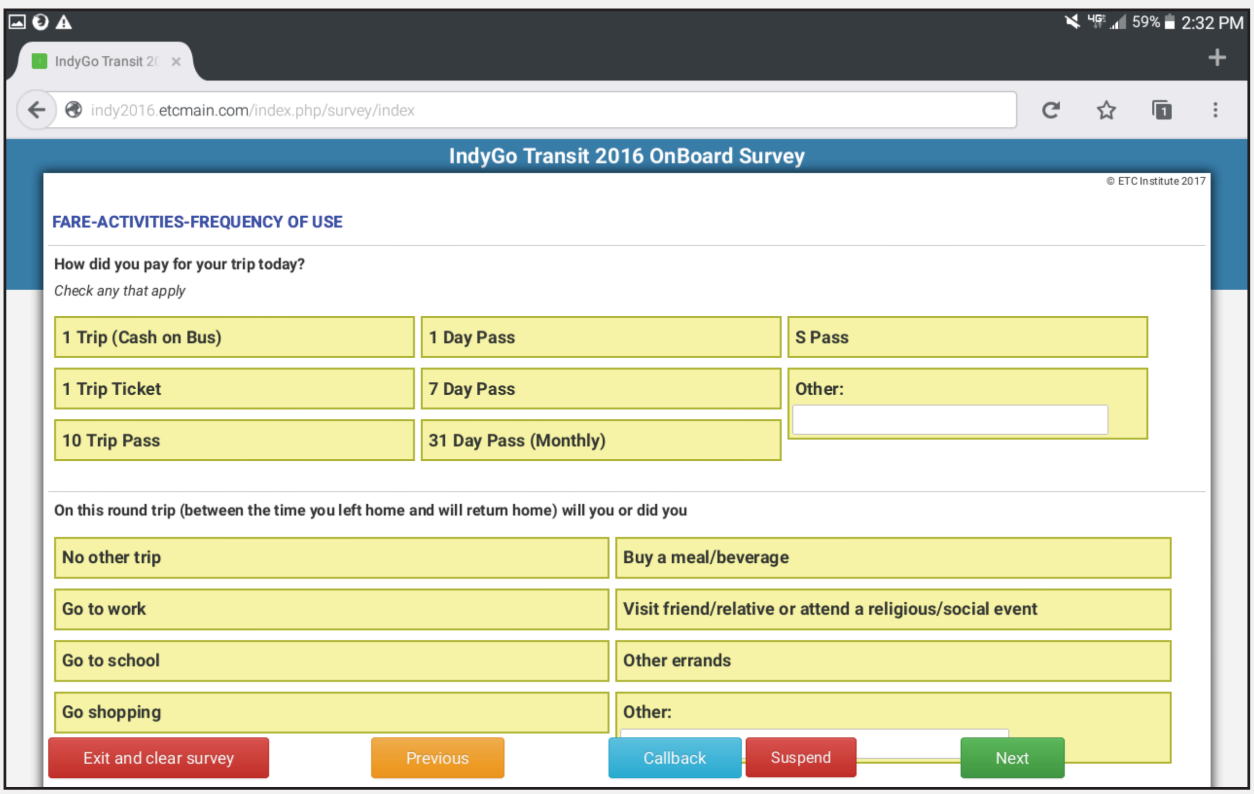

Figure 4-3: Tablet PC screenshot for Question: "How did you pay for your trip today?"

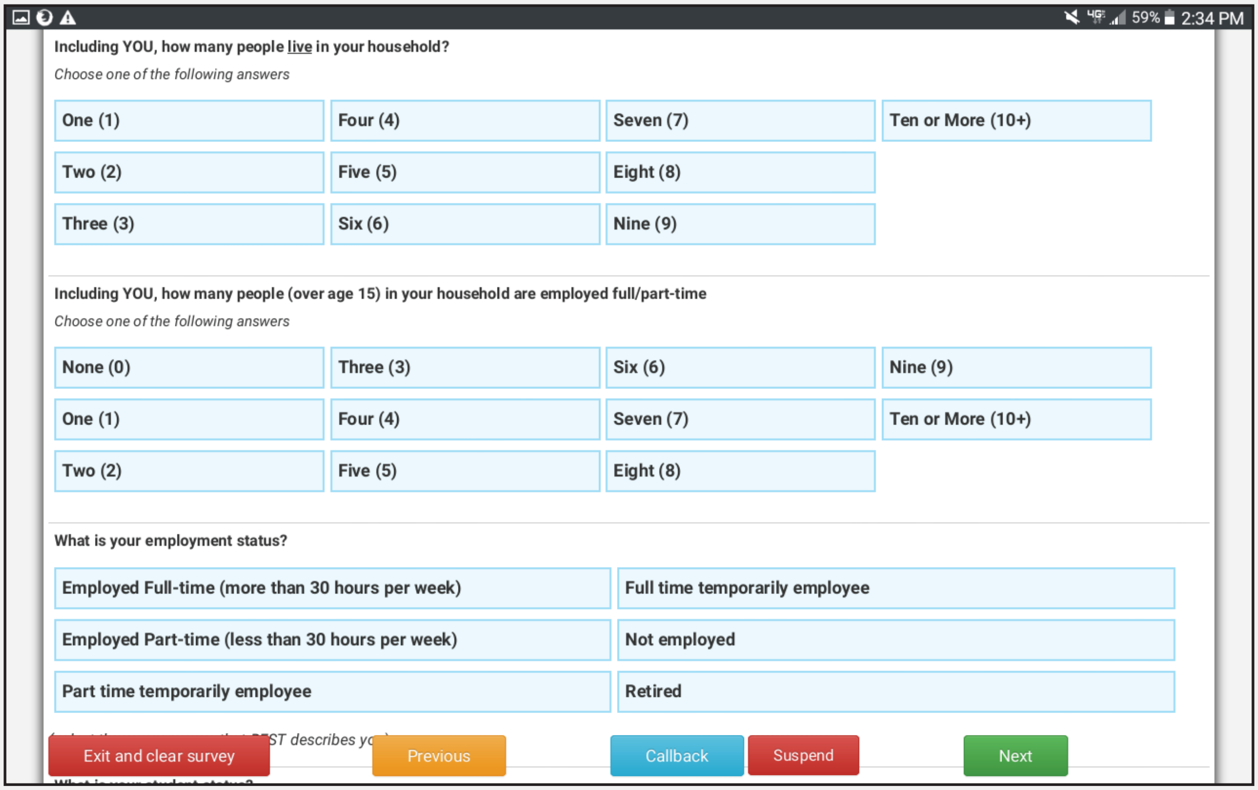

Figure 4-4: Tablet PC screenshot for Question: "Including you, how many people live in your household?"

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CHAPTER 5
DATA COLLECTION

Before administering the OD survey using an interviewer and a tablet PC, an on-to-off survey was conducted on predetermined fixed route service. An on-to-off survey is meant to capture the ridership flow of the bus route. In-other-words, the On-to-Off survey captures where the individual rider boarded the vehicle and the corresponding location where the rider alighted (exited). This allows for a more comprehensive understanding of the true ridership flow of the route, which then allows the OD survey data to be more accurately expanded.

The first step in the survey administration task for both the On-to-Off and OD survey was the selection of trips to be surveyed. The primary focus of the trip selection process was to identify blocks that would allow surveyors to ride one continuous route and in some instances interlined routes. A block is defined as a series of trips made by a single vehicle that is comprised of one or more routes that have a definitive start and end location. Ridership figures provided by IndyGo were taken into consideration to determine how many trips were needed in order to reach the goal that was proportionally allocated.

5.1 ON-TO-OFF SURVEY ADMINISTRATION METHODOLOGY

The purpose of the On-to-Off software program is to identify ridership patterns based on an individual's boarding and alighting locations which are used to help develop the sampling plan for the survey. This was accomplished by using ETC Institute's custom Android®-based on-to-off software which records the latitude and longitude of an individual's boarding and alighting location using a barcode system. ETC Institute barcodes eliminated language barriers, increased ridership participation, and provided more accurate boarding and alighting locations.

The On-to-Off surveying team used the On-to-Off software with a GPS-equipped tablet PC to record the rider's boarding latitude/longitude, alighting latitude/longitude, time of usage, route used, and direction.

The On-to-Off software was complemented with a barcode scanning system method as described below:

- Riders were handed a barcode card which was scanned by a surveyor.
- Riders were told to keep the barcode card during the duration of their trip.
- Riders were reminded to hand their cards back to the surveyor as they exited the bus.
- When riders' bus stops were approached, the surveyor took their barcode cards before they exited. The surveyor scanned riders' barcode cards as they departed the bus.
- The software then paired the boarding and the alighting location of each rider based on the unique barcode card each was handed.

A screen shot of the interface of the On-to-Off boarding/alighting software that was used to record the information is shown in Figure 5-1. The GPS mapping feature is also shown in Figure 5-1.

The On-to-Off survey was administered by teams that were directly supervised by ETC Institute. The supervisors were responsible for reviewing the performance of each team and ensuring that 1) all parts of the on-to-off procedure were being followed and 2) the sampling goals for each route were met. The supervisors operated from Julia M. Carson Transit Center, so that the performance of all teams could be evaluated.

The On-to-Off survey team sizes were determined by route ridership levels and bus size (articulated [3+ doors] or standard [1-2 doors]). A typical team consisted of two members, based on a medium to high ridership level on a standard size bus. The responsibilities of each of the positions on the On-to-Off teams are described below:

- The team leader was responsible for route and direction selection for On-to-Off software, offering riders an opportunity to participate in the survey, scanning barcode cards for boarding riders, answering rider questions, and overseeing On-to-Off operations of his/her bus.
- The support surveyor was responsible for collecting and scanning barcode cards for alighting riders, reminding riders to keep their cards ready to hand in to a surveyor when they exited at their bus stop, and answering rider questions.

The On-to-Off survey was administered Tuesday through Thursday with the exceptions of holidays and breaks for colleges/schools.

Administration of the On-to-Off survey began as early as 6 am and continued as late as 9 pm. This was to ensure that the On-to-Off data would provide the OD survey with an accurate sampling plan for administration and for the data expansion. The On-to-Off survey was administered from September 7th, 2016 through October 20th, 2016 while the OD survey was administered from September 13th, 2016 through November 3rd, 2016.

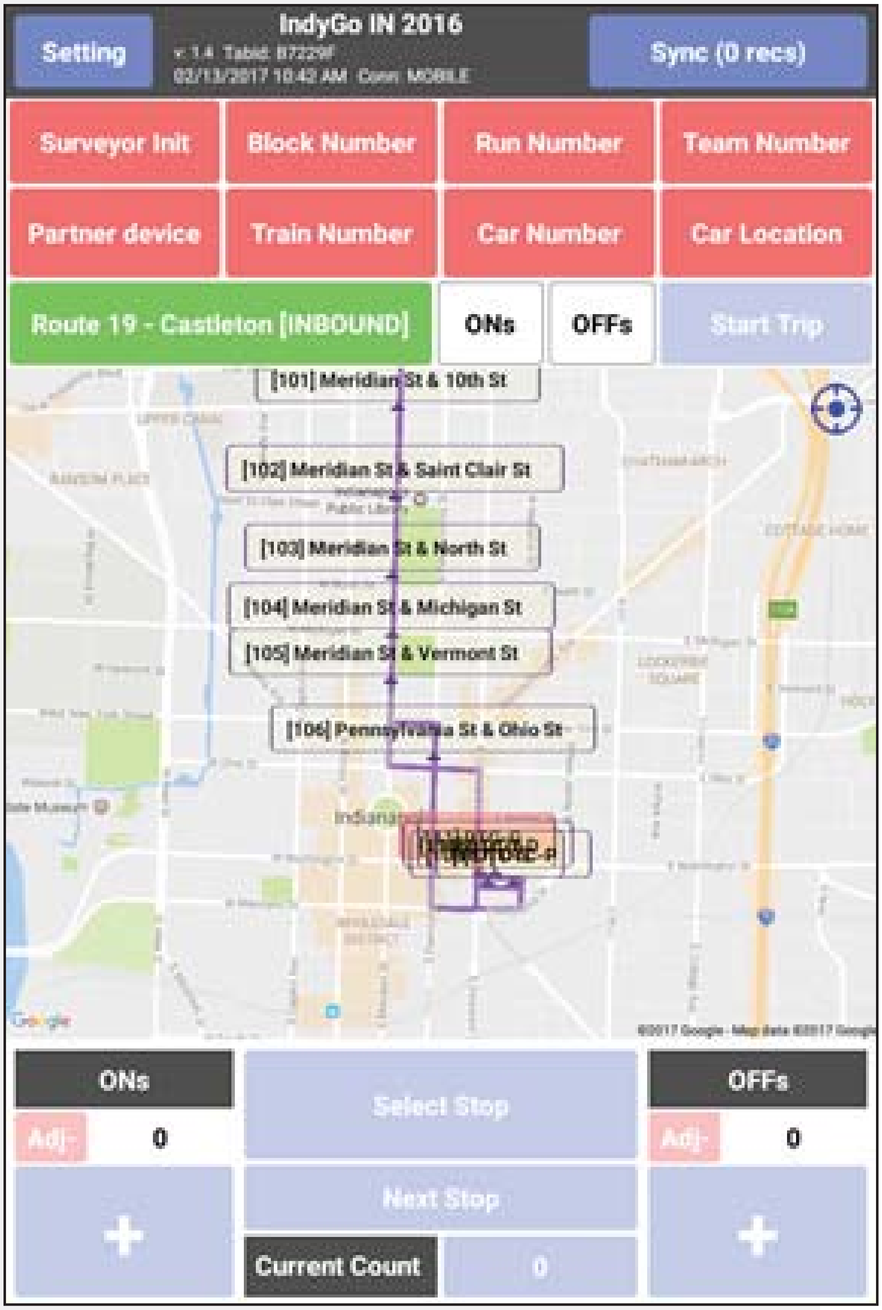


Figure 5-1: On-to-Off Survey Interface Screenshot

5.2 OD SURVEY ADMINISTRATION METHODOLOGY

The following sections describe the methodology used for the 2016 On-Board OD survey. This methodology includes recruiting and training of interviewers, procedures used for the survey, and organization of the survey teams.

5.2.1 Labor Recruitment and Training

Assembling a team of high-quality interviewers was one of the most important steps in the OD survey administration process. ETC Institute used local temporary workers who were recruited by a staffing agency to administer the survey.

Interviewers recruited by the agency were required to have some familiarity with the bus service area. They were also required to document a solid work history, show a professional attitude and appearance, illustrate to supervisors an ability to interact positively with the public, have an ability to work a tablet PC, and show proficiency with ETC Institute's surveying program.

Each interviewer was required to attend ETC Institute's training session. IndyGo, Indianapolis Metropolitan Planning Organization and Lochmueller Group staff also attended training sessions to familiarize themselves with the survey administration process and meet with the recruited interviewers. During this training session, interviewers were presented with the following:

- An overview of the on-board survey objectives
- Instructions on how to operate the tablet PC and surveying software
- Instructions on how to approach riders and sampling procedures
- Survey etiquette protocol
- Instructions on how to deal with various situations that could be encountered during a survey
- Role-playing and one-on-one tutoring with an ETC Institute supervisor

Once all training was completed, and each interviewer was approved by an ETC Institute supervisor, interviewers spent several days under the supervision of a supervisor, who assessed each interviewer's ability to properly conduct surveys. Those who did not demonstrate proficiency in all of the required tasks for the OD survey were released.

All routes were classified as fixed routes and were surveyed using the tablet PCs. Fixed routes are routes that provide regular/continuous service throughout the day. Interviewers selected people for the survey in accordance with the sampling procedures described in Chapter 2 of this report.

Once an interviewer had selected a person for the survey, the interviewer:

- Approached the person who was selected and asked him or her to participate in the survey.
- If the person refused, the interviewer ended the survey.
- If the person agreed to participate, the interviewer asked the respondent if he/she had at least 5 minutes to complete the survey.
- If the person did not have at least 5 minutes on the bus, the interviewer asked the person to provide his/her boarding location, alighting location, name, and phone number. A phone interviewer from ETC Institute's call center contacted the respondent and asked him/her to provide the information by phone. This methodology ensured that people who completed "short-trips" on public transit were well represented.
- If the person had at least 5 minutes on the bus, the interviewer began administering the survey to the respondent as a face-to-face interview using a tablet PC.

The OD survey was administered by teams who were directly supervised by an ETC Institute supervisor. The supervisors were responsible for reviewing the performance of each interviewer ensuring that all parts of the surveying procedure were being followed and the sampling goals for each route were met.

The responsibilities for each of the positions on the OD survey team are described below.

- The supervisor was responsible for ensuring that interviewers were properly trained, equipping interviewers to conduct surveys, scheduling interviewers, inspecting work, and reviewing the data collected.
- The interviewer was responsible for administering surveys while following surveying procedures.

The OD survey was administered at the time of day that coincided with the hours that each route was operational. This was to ensure that the adminitration of the survey began prior to peak ridership levels in the morning and continued after peak ridership levels in the evening.

5.2.2 In-Field Quality Assurance / Quality Control

On a daily basis, ETC Institute's field supervisor reviewed each employee's data with regard to the following issues to assess whether or not the employee was conducting the survey properly:

- Distribution of surveys by demographics
- Distribution of surveys by trip characteristics
- Length of each survey in minutes
- Percentage of refusals
- Percentage of short trips

ETC Institute's field supervisor also conducted checks on the locations where the interviews took place. These checks ensured data integrity and identified if an interviewer was being negligent. The ETC Institute field supervisor was able to verify if an interviewer was on their assigned route by viewing the displayed geographic locations of where the interviews were taking place.

If any item listed above was missing or incomplete, the supervisor flagged the record for reviewing. ETC Institute then forwarded all incomplete survey records and the corresponding name and phone number to ETC Institute's call center. Interviewers working in ETC Institute's call center then called respondents who had provided their names and phone numbers to retrieve the missing information by phone.

5.3 PILOT TEST

Prior to the data collection effort, a Pilot Test was administered over the course of two days in August 2016. The Pilot Test was a full dress rehearsal of all steps, previously discussed, to ensure all programs and procedures would adequately meet the needs of the Indianapolis Metropolitan Planning Organization (IMPO) and IndyGo. The results were summarized in a Pilot Report, and approved by the IMPO and IndyGo.

CHAPTER 6
DATA REVIEW PROCESS

6.1 DATA REVIEW PROCESS

Many of the processes described in previous chapters of this report were essential elements of the overall quality assurance/quality control (QA/QC) process that was implemented throughout the survey administration. The establishment of specific sampling goals and procedures for managing the goals ensured that a representative sample was obtained from each bus route. Training of interviewers and the high levels of oversight provided by team leaders and the project manager ensured that the survey was administered properly. The use of the latest geocoding tools contributed to the high quality of geocoding accuracy that was achieved.

The following sections describe the QA/QC processes that were implemented after the data was collected.

6.1.1 Online Visual Review Tool

ETC Institute has created an online visual review tool that allows for the review of all completed records within the database. This tool shows all components of each individual trip as well as a series of preprogrammed distance and ratio checks as described on subsequent pages. After directions were finalized, the next step was to run each record through the Speed/Distance/Time checks. Figure 6-1 shows an example of the online visual review tool.

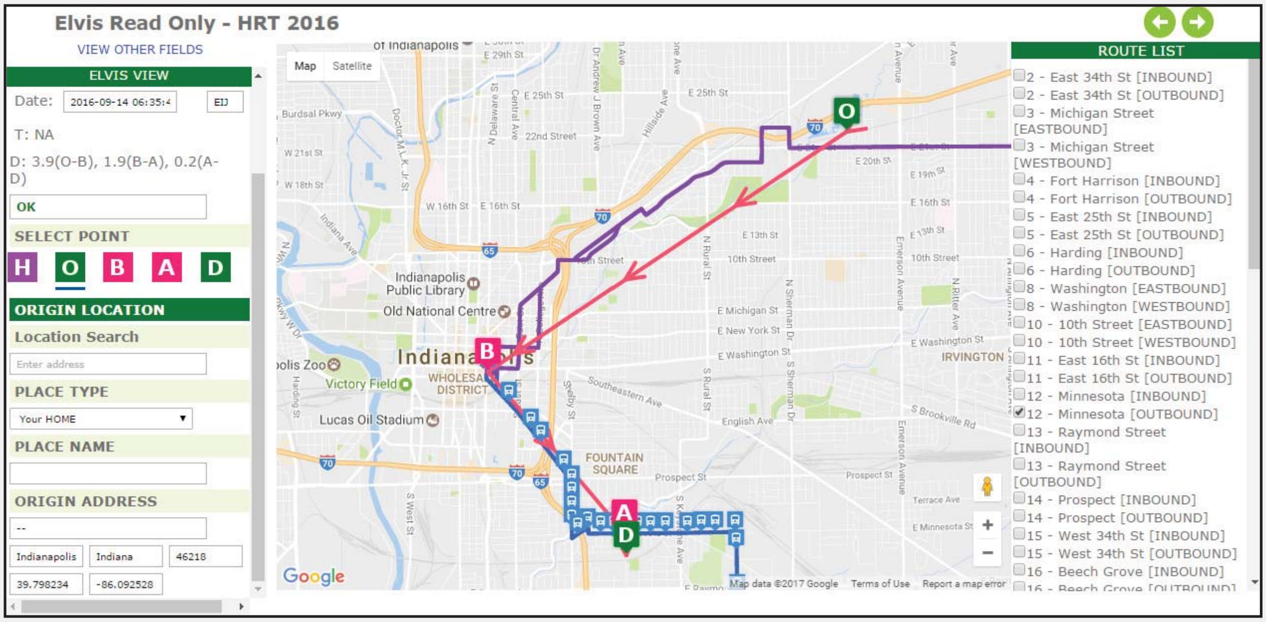


Figure 6-1: Online Visual Review Tool (Editable Version)

6.1.2 Pre-Processing Distance Checks

A series of distance and ratio checks are preprogrammed into the online visual review tool in order to allow for ETC Institute's Transit Review Team (TRT) to take a more systematic approach in reviewing complete records. The TRT process for editing surveys is described later in this section. Note: The distance and ratio checks described were meant to alert the reviewer that closer evaluation was needed. It did not necessarily indicate that the record was inaccurate or unusable.

The distances used for the checks were created using the great-circle distance formula which is based on a straight line from point A to point B that takes into account the curvature of the earth.

Access/Egress Mode Distance Check

Table 6-1 shows the distance checks for access (Origin to Boarding) and egress modes (Alighting to Destination). This table is for data quality checking purposes only.

DISTANCE CHECK NAME	CHECK	CONDITION 1	CONDITION 2	FLAG?
Origin to Boarding	Origin to Boarding distance is greater than 1.75 linear miles	Access Mode - ANY USE OF A VEHICLE (ie, dropped off, rode with others, drove, taxi...)		No
		Access Mode - Walk/Wheelchair/ Skateboard	There is at least one transfer from origin to boarding	No
		Access Mode - Walk/Wheelchair/ Skateboard	There are no transfers from origin to boarding	Yes
	Origin to Boarding distance is less than .25 linear miles	Access Mode - ANY USE OF A VEHICLE (ie, dropped off, rode with others, drove, taxi...)		Yes
		Access Mode - Every mode	There is at least one transfer from origin to boarding	Yes
		Access Mode - Walk/Wheelchair/ Skateboard	There are no transfers from origin to boarding	No
Alighting to Destination	Alighting to Destination distance is greater than 1.75 linear miles	Egress Mode - ANY USE OF A VEHICLE (i.e., will get picked up, ride with others, drive, taxi...)		No
		Egress Mode - Walk/Wheelchair/ Skateboard	There is at least one transfer from alighting to destination	No
		Egress Mode - Walk/Wheelchair/ Skateboard	There are no transfers from alighting to destination	Yes
	Alighting to Destination distance is less than .25 linear miles	Egress Mode - ANY USE OF A VEHICLE (i.e., will get picked up, ride with others, drive, taxi...)		Yes
		Egress Mode - Every mode	There is at least one transfer from alighting to destination	Yes
		Egress Mode - Walk/Wheelchair/ Skateboard	There are no transfers from alighting to destination	No

Table 6-1: Access/Egress Mode Distance Check

Origin to Destination Distance Check

Table 6-2 below shows the distance checks based on the origin and destination locations.

DISTANCE CHECK NAME	CHECK	FLAG?
Origin to Destination	Origin equals the Destination	Yes
	Origin to Destination is greater than 50 miles	Yes
	Origin to Destination is less than .25 miles	Yes

Table 6-2: Origin to Destination Distance Checks

Boarding and Alighting Distance Check

Table 6-3 below shows the distance checks based on the boarding and alighting locations.

DISTANCE CHECK NAME	CHECK	FLAG?
Boarding to Alighting	Boarding equals the Alighting	Yes
	Boarding to Alighting is less than .25 miles	Yes

Table 6-3: Boarding to Alighting Distance Checks

6.1.3 Pre-Processing Ratio Checks

After all transfer checks were completed, the next step in this process involved the application of a series of QA/QC Ratio Checks.

Three ratio checks were conducted for each record. First, the distance between boarding and alighting was divided by the distance between origin and destination. If the rider had a high ratio, then the rider was on the bus for an extensive time compared to the origin to destination distance. If the check created an extremely low ratio, the use of transit seemed unnecessary.

Second, the distance between origin and boarding was divided by the distance between origin and destination. If the rider had a high ratio, the origin to boarding distance was excessive compared to the origin to destination.

Third, the distance between alighting and destination was divided by the distance between origin and destination. If the rider had a high ratio, the alighting to destination distance was excessive compared to the origin to destination.

Table 6-4 on page 78 describes in more detail the ratio checks used, and the conditions in which a record would be flagged.

RATIO CHECKS	CHECK	RESULT OF FORMULA	CONDITION 1	CONDITION 2	FLAG?
Boarding to Alighting distance divided by Origin to Destination distance	Boarding to Alighting Distance/Origin to Destination Distance	the result of this formula is 1.5 or greater			Yes
	Boarding to Alighting Distance/Origin to Destination Distance	the result of this formula is less than .3	Access and Egress modes are both Walk/ Wheelchair/Skateboard	There are NO transfers involved in the trip	Yes
	Boarding to Alighting Distance/Origin to Destination Distance	the result of this formula is less than .3	Access or Egress mode - **ANY USE OF A VEHICLE**		No
	Boarding to Alighting Distance/Origin to Destination Distance	the result of this formula is less than .3	There is at least one transfer involved in the trip		No
Origin to Boarding distance divided by Origin to Destination distance	Origin to Boarding Distance/Origin to Destination Distance	the result of this formula is 1 or greater	there is at least one transfer from origin to boarding		No
	Origin to Boarding Distance/Origin to Destination Distance	the result of this formula is 1 or greater	Access Mode - **ANY USE OF A VEHICLE** (i.e., dropped off, rode with others, drove, taxi...)		No
	Origin to Boarding Distance/Origin to Destination Distance	the result of this formula is 1 or greater	Access Mode - Walk/ Wheelchair/Skateboard	there are no transfers from origin to boarding	Yes
Alighting to Destination divided by Origin to Destination	Alighting to Destination Distance/ Origin to Destination Distance	the result of this formula is 1 or greater	there is at least one transfer from alighting to destination		No
	Alighting to Destination Distance/ Origin to Destination Distance	the result of this formula is 1 or greater	Egress Mode - **ANY USE OF A VEHICLE** (i.e., will get picked up, ride with others, drive, taxi...)		No
	Alighting to Destination Distance/ Origin to Destination Distance	the result of this formula is 1 or greater	Egress Mode - Walk/ Wheelchair/Skateboard	There are no transfers from alighting to destination	Yes

Table 6-4: Ratio Checks for Reasonableness

6.2 TRANSIT REVIEW TEAM (TRT)

ETC Institute has a dedicated team whose priority is reviewing and editing completed records through the use of an online visual review tool. The TRT reviewed all completed records collected for the survey, paying special attention to records that were automatically flagged by the automated distance checks. Typically around 10% of all records receive an automatic flag. Prior to making edits to any survey, they first attempted to contact the respondent to clarify any questionable answer choices regarding the trip. If no contact was made, or if contact was not possible, which occurs in the vast majority of cases, the following actions detailed in Table 6-5 below were taken. These actions generally result in changes that allow about 30% of those records that are automatically flagged to be retained, or approximately 3% of all completed surveys.

Pre-Processing General Issues and Actions

Table 6-5 describes the general issues that could occur within a trip where changes may have been appropriate.

ISSUE	DESCRIPTION OF ISSUE	ACTION
Origin/Destination Condition 1	Origin/Destination appears incorrect because the wrong location of a multiple-location organization was selected	If for example, an Origin/Destination appears illogical based on the college campus that was selected, but an appropriate campus of the same college does appear logical given the other points and answer choices of the trip, then the appropriate campus will be selected.
Origin/Destination Condition 2	Origin/Destination appears to have been geocoded to the incorrect city/state	If for example, an Origin/Destination appears illogical based on the city/state that was geocoded, but the address/intersection is logical within the trip if the city/state are changed. This occurs occasionally because the surveyor selects the wrong choice from the list of possible address choices that appear in the online survey instrument, then the appropriate address information will be inserted.
Access/Egress Mode	Access/Egress Mode seems illogical based on trip	If the access/egress mode involves the use of a vehicle and the distance from either origin to boarding or alighting to destination is less than .2 miles then the access/egress mode is recoded to walk/walked and that change will be reflected in the database.
Directionality of Record	Boarding and alighting locations indicate that the trip is going in the opposite direction of what was selected by the surveyor.	Change Direction of Route Selected and if necessary update boarding and alighting locations based on appropriate direction.

Table 6-5: General Issues & Actions for Resolution

Transfer Issues and Actions

Table 6-6 describes the transfer issues that could occur within a trip where changes may have been appropriate.

ISSUE #	DESCRIPTION OF ISSUE	ACTION
Transfer Issue - 1	The transfer(s) seems illogical based on either the origin to boarding or alighting to destination	If the transfer appears to have been selected incorrectly based on surveyor misselection error (IE Route 24 selected which is illogical but Route 23 is logical) or passenger error (passenger gives inaccurate transfer), then an appropriate transfer(s) will be inserted based on the geocoded points of the trip (origin and destination), the time of day of the trip and the direction of travel. If no appropriate transfers can be found, then the record will be removed from the database.
Transfer Issue - 2	The transfer(s) seems unnecessary based on either the origin to boarding or alighting to destination	If the transfer(s) appears to be unnecessary because the distance from the origin to boarding or alighting to destination is less than 0.2 miles then the trip will be reviewed in further detail to determine if the transfer(s) are inappropriate. Aspects that will determine appropriateness are: the landscape (0.1 miles for example is a very short distance but a river in-between the origin and boarding location could require an individual to use a transfer as opposed to being able to walk), disability, age, and alternate access/egress modes (IE if someone indicates walking 1 mile from origin to boarding but then indicates taking 2 transfers from alighting to destination to travel a total of 0.1 miles they have likely indicated transfers for a future trip later in the day). *NOTE: The 0.2 distance is only used as guideline to create a flag for closer review. Typically only extreme distances have transfers removed.*
Transfer Issue - 3	The passenger indicated that they did not use a transfer but based on their access/egress mode and the distance between either the origin to boarding or alighting to destination suggests that a transfer should have been used.	If the access/egress mode is "walked/walk" and no transfer is indicated, and the distance between either origin to boarding or alighting to destination is greater than 2 miles, then an appropriate transfer(s) will be inserted based on the geocoded points of the trip (origin and destination), the time of day of the trip and the direction of travel. If no appropriate transfers can be found, then the record will be removed from the database.
Transfer Issue - 4	Duplicate Transfers in the Route Path	If duplicate transfers exist in the route path, the trip path is reviewed visually to determine which route(s) were incorrectly entered. If a review of the record suggests that the transfer route(s) is/are unnecessary then they will be removed. If the transfers suggest that trip is a round trip (IE home to home) and not a one-way trip then the record will be removed from the database.

Table 6-6: Transfer Issues

6.3 POST-PROCESSING ADDITIONAL CHECKS

After all records were reviewed by the TRT, the next step in this process involved the application of a series of QA/QC "non-trip" checks. Non-trip checks are described as anything not pertaining to the respondent's actual trip, i.e. demographic information.

Non-trip related checks included:

- Ensuring the respondents who indicated that they were employed also reported that at least one member of their household was employed.
- Ensuring the time of day a survey was completed was reasonable given the published operating schedule for the route.
- Ensuring that the appropriate fare type was used in response to the age of respondent.
- Checking that there is a representative demographic distribution based on age, gender, and income status.
- Removing any personal contact information used for quality control purposes during the data collection portion of the project in order to protect the anonymity of the respondents.

Once all records had gone through the pre-processing and post-processing QA/QC checks, those that were deemed complete and usable were then used to update the completion report used by the field staff to ensure that all contractual goals had been met. After the final high-level review was completed, metadata (a codebook) was created in order to suitably explain the data in the database.

CHAPTER 7 DATA WEIGHTING & EXPANSION

7.1 DATA EXPANSION OVERVIEW

When survey goals are created, they are typically based off of a percentage of the average weekday ridership for the routes in the system. That is further broken down by time periods and directions. The time periods that are created (6am to 9am for example) are based off of the specific needs of the client, generally aligning with the travel demand model. Once a sample percentage is agreed upon, the goals for the survey collection are based off of the ridership for each route by time period and direction, and then multiplied by the sampling percentage. For "circular" or "loop" routes, the ridership is typically only broken down into time period as there are many riders that will board going in one direction but alight going the other direction due to the functionality of the route. This typically is also the case if there are directional routes where many riders travel through the terminus and alight going the opposite direction of initial boarding.

The purpose of developing survey goals is to collect an appropriate number of survey records that will be "expanded" to represent the total average weekday ridership of each route by time period and direction. To further increase the specificity of the expansion process, segments were created for each route. Stops were grouped into segments along that route so that boarding segments could be paired with alighting segments when creating the expansion factor. Segmentation occurs on bus routes because it is unrealistic to expand bus survey data at the stop level. Stop, or station, level expansion is generally reserved for rail lines.

7.1.1 Route Segmentation with APC[10] Data

There are two ways ETC Institute creates segments for bus routes:

1) boarding percentages of the route from APC data, and

2) based on the number of stops for the route.

Segmenting routes using APC data is the preferred way to segment routes as opposed to segmenting routes based on the number of stops. Routes with APC data were separated based on direction, then divided into three segments based on the total boardings. After approximately one-third of the route's total APC ridership had boarded, a new segment began. After approximately two-thirds of the route's total APC ridership had boarded the final third segment began. Figure 7-1 on page 82 is a simplified example of APC Data Segmenting. *(Note: Iterative Proportional Fitting (IPF) is used in multiple types of expansion discussed later in this document. In order for IPF to work properly, the boarding totals must match the alighting totals. For this reason, APC alightings are adjusted using a multiplying factor in order to make sure their totals match the boarding totals. These are typically nominal alterations, however, if there are significant differences in boarding and alighting totals by direction of a route, it may require additional review of the functionality of the route to ensure that the surveys are both collected and expanded appropriately.)*

10 Automated Passenger Counters (APC) are devices that may be installed on transit vehicles to record boarding and alighting data.

Segmentation with APC Example					
Direction: Eastbound	APC DATA		Segmentation		
Stops	Boardings	Alightings	Running Total of Boardings	Running Percentage of Total Boardings	Segment
Stop 1	35	0	35	23.0%	1
Stop 2	20	10	55	36.2%	1
Stop 3	20	5	75	49.3%	2
Stop 4	15	10	90	59.2%	2
Stop 5	5	12	95	62.5%	2
Stop 6	4	4	99	65.1%	2
Stop 7	19	4	118	77.6%	3
Stop 8	12	3	130	85.5%	3
Stop 9	15	5	145	95.4%	3
Stop 10	3	10	148	97.4%	3
Stop 11	2	15	150	98.7%	3
Stop 12	2	11	152	100.0%	3
Stop 13	0	10	152	100.0%	3
Stop 14	0	15	152	100.0%	3
Stop 15	0	38	152	100.0%	3
	152	152			

Figure 7-1: Route Segmenting: APC Provided Routes

Direction: Eastbound	
Stops	Segment
Stop 1	1
Stop 2	1
Stop 3	1
Stop 4	1
Stop 5	1
Stop 6	2
Stop 7	2
Stop 8	2
Stop 9	2
Stop 10	2
Stop 11	3
Stop 12	3
Stop 13	3
Stop 14	3
Stop 15	3

Figure 7-2: Route Segmenting: Non APC Provided Route

7.1.2 Route Segmentation without APC Data

Routes without APC data were divided into three segments based on the number of stops. After approximately one-third of the route's stops occurred, a new segment began. After approximately two-third of the route's stops occurred, the final third segment began. Figure 7-2 is an example of segmenting without APC Data.

7.2 TYPES OF BUS DATA EXPANSION

The type of bus data expansion conducted depended on the data available for the specific bus route. The three types of data that created the combinations that guided the type of expansion used were: APC data (from Client), On-to-Off Counts Data (collected by ETC Institute), and Origin Destination (OD) Survey Data (collected by ETC Institute). The figure below shows the data combinations, the corresponding route segmentation, and type of expansion used.

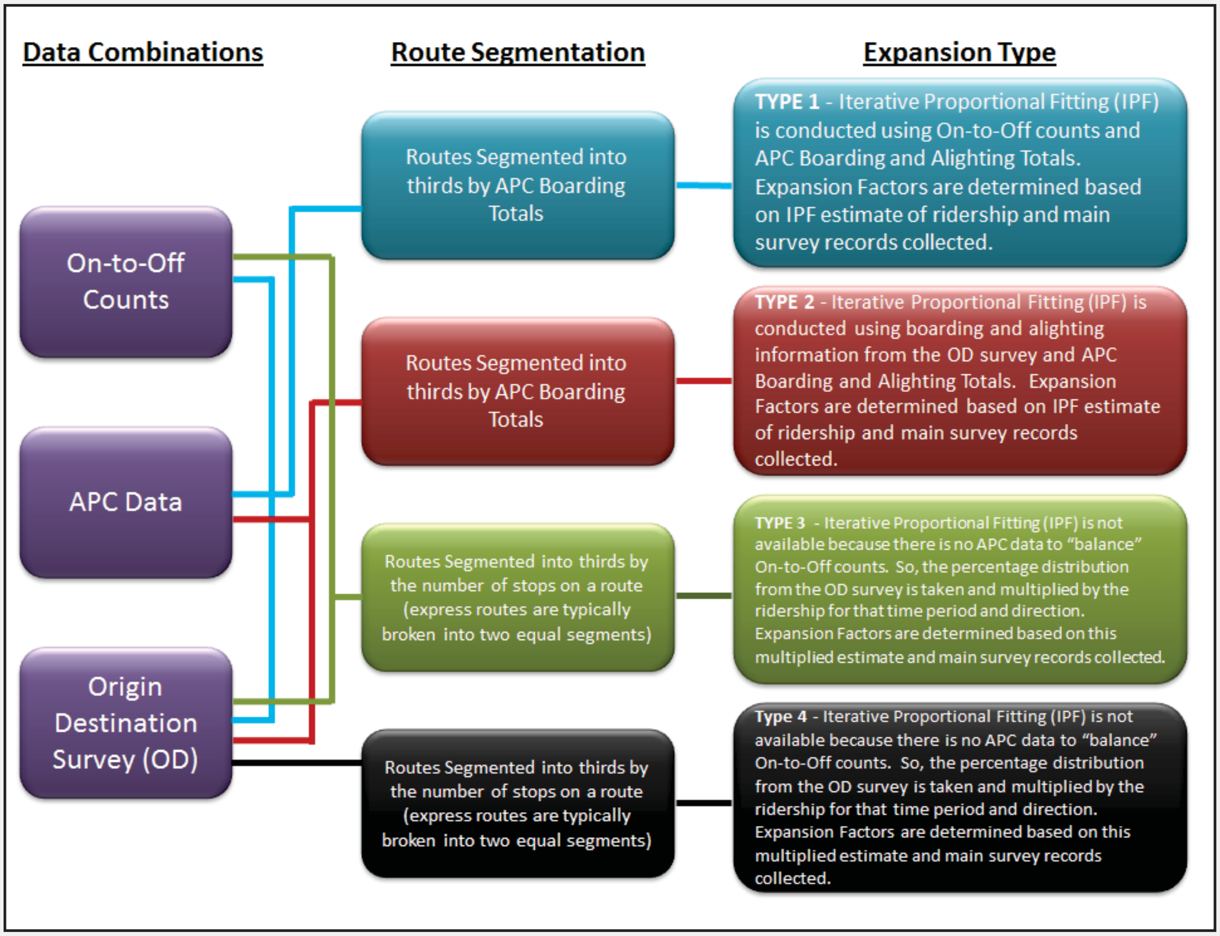
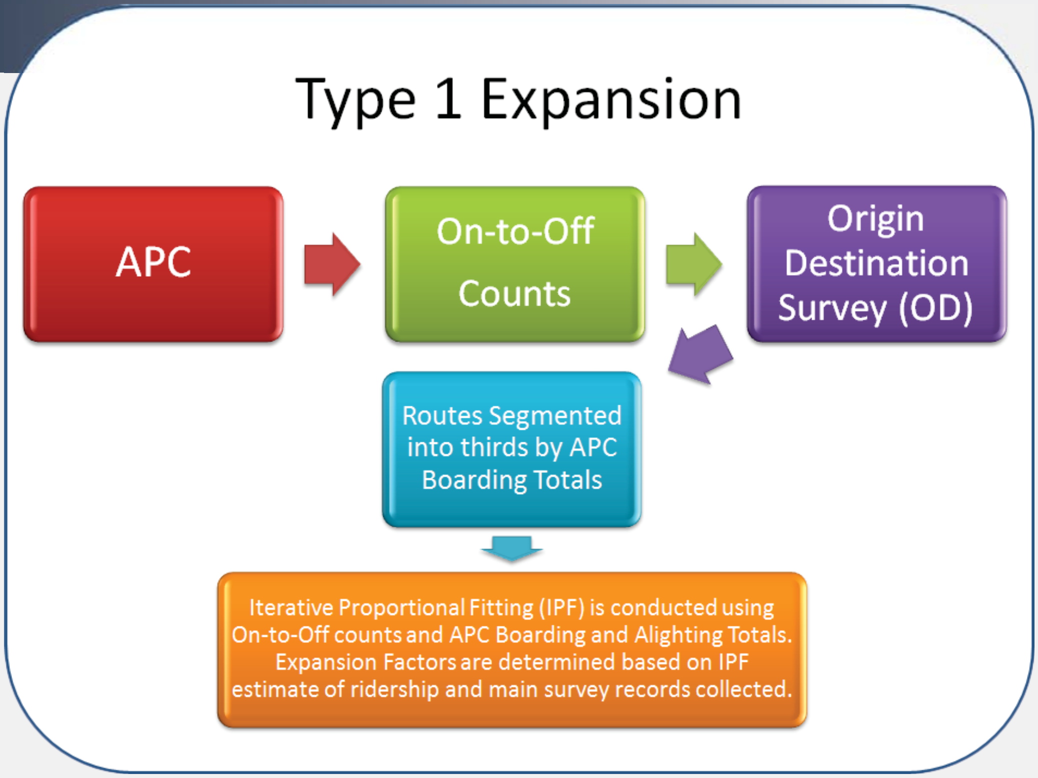


Figure 7-3: Data Expansion Flow Chart



TYPE 1

7.2.1 Type 1 Expansion: Bus Routes with APC data, On-to-Off Counts Data, and OD Survey Data

Of the four types of bus expansion discussed, Type 1 expansion was the preferred method as it incorporated all three types of data that were available. Typically On-to-Off data collection is reserved for more heavily traveled routes. These heavier ridership routes are also typically more likely to have available APC data. This type of expansion was conducted on the more heavily traveled routes in the system and occurred after route stops were divided into three segments based on total boarding distribution by direction, as described previously. The segments were then appended to both the On-to-Off counts and OD data based on the boarding and alighting locations. The methodology for Type 1 expansion is as follows:

Type 1

Expansion Methodology for Bus Routes with APC Data, On-to-Off Data and OD Survey Data

Once the segments were appended to the On-to-Off counts and OD survey databases, the records were ready for expansion. The process for how the data was expanded in Type 1 expansion is explained below:

Table 7-A-1 on page 85 shows the segmented results for the On-to-Off counts that was administered for a certain route, direction, and time period. Each row in the table identifies the segment where passengers boarded the bus. The columns in the table identify the segments where people alighted the bus. For example, 20 of the On-to-Off counts had riders board in segment 2 and alight in segment 3.

Table 7-A-2 shows the distribution of the data in Table 7-A-1 expressed as a percentage of all boardings for the specific time period and direction. Table 7-A-2 was created by dividing each on-to-off cell in Table 7-A-1 by the sum of all On-to-Off counts in Table 7-A-1, which is 115. For example, 20/115 (17.4%) of all trips boarded in segment 2 and alighted in segment 3 as shown in Table 7-A-2.

The total APC ridership for the route, time period, and direction was applied to the On-to-Off distribution percentages shown in Table 7-A-2. This produces an estimate of the ridership flow for the boarding segment to the alighting segment as shown in Table 7-A-3. Applying the actual ridership of 320 creates an initial estimate of 56 trips (17.4% x 320) boarding in segment 2 and alighting in segment 3.

Route: Example Eastbound (6am-9am)		ACTUAL RIDERSHIP COUNTS FROM THE ON/OFF SURVEY		
Segment	Total	1	2	3
1	60	5	15	40
2	45		25	20
3	10			10
Total	115	5	40	70

Table 7-A-1: Bus Data Expansion Table Results of On-to-Off Survey

Route: Example Eastbound (6am-9am)		PERCENTAGE DISTRIBUTION OF RIDERSHIP COUNTS FROM THE ON/OFF SURVEY		
Segment	Total	1	2	3
1	52.2%	4.3%	13.0%	34.8%
2	39.1%	0.0%	21.7%	17.4%
3	8.7%	0.0%	0.0%	8.7%
Total	100.0%	4.3%	34.8%	60.9%

Table 7-A-2: Bus Data Expansion Table Distribution of On-to-Off Survey

Route: Example Eastbound (6am-9am)		PROJECTED RIDERSHIP BASED ON THE ON-TO-OFF SURVEY		
Segment	Total	1	2	3
1	167	14	42	111
2	125	0	70	56
3	28	0	0	28
Total	320	14	111	195

Table 7-A-3: Bus Data Expansion Table Initial Estimate of Ridership Flows Between Segments

Route: Example Eastbound (6am-9am)				
Average Weekday Ridership	Total	1	2	3
BOARDINGS	320	100	100	120
ALIGHTINGS	320	20	100	200
DIFFERENCE FROM PROJECTED				
BOARDINGS	0	-67	-25	92
ALIGHTINGS	0	6	-11	5

Table 7-A-4: Boardings & Alightings by Station

In order to develop a more accurate estimate of the ridership flows between segments on each route, ETC Institute developed an Iterative Proportional Fitting (IPF) Algorithm to balance the differences between the ridership projected from the On-to-Off counts (shown in Table 7-A-3) and the APC ridership for each segment (shown in Table 7-A-4). The IPF process is described below:

Step 1: Correction for the Boardings

The estimated ridership from the On-to-Off counts for each route (as shown in Table 7-A-3) was multiplied by the ratio of the actual boardings from APC data for each segment by the estimated boardings for each segment. For example, if the actual boardings for Segment 1 were 120 and the estimated boardings were 100, each cell associated with Segment 1 would have been multiplied by 1.2 (120 / 100) to adjust the estimated boardings to actual boardings.

Step 2: Correction for the Alightings

Once the correction in Step 1 was applied, the estimated boardings would be equal to the actual boardings. However, the adjustment to the boardings total may have changed the alighting estimates. In order to correct the alighting estimates, the new values calculated in Step 1 were adjusted by multiplying the ratio of the actual alightings from the APC data for each stop by the estimated alightings for each segment from Step 1. For example, if the actual alightings for Segment 2 were 220 and the estimated alightings from Step 1 were 200, each cell associated with Segment 2 would have been multiplied by 1.1 (220 / 200) to adjust the estimated alightings from Step 1 to actual alightings.

The processes described in Steps 1 and Steps 2 were repeated sequentially until the difference between the actual and estimated boardings and alightings was zero. Table 7-A-5 shows that after seven balancing iterations in this algorithm, there were no differences between the projected distribution and the actual boardings and alightings.

7th STEP of ITERATIVE BALANCING TO CORRECT DISTRIBUTION OF RIDERSHIP BY ALIGHTING Location					
Segment	Total	DIFFERENCE FROM ACTUAL BOARDINGS	1	2	3
1	100	0	20	32	49
2	100	0	0	68	32
3	120	0	0	0	120
Total	320	0	20	100	200
DIFFERENCE FROM ACTUAL ALIGHTINGS	0		0	0	0

7th STEP of ITERATIVE BALANCING TO CORRECT DISTRIBUTION OF RIDERSHIP BY ALIGHTING Location					
Segment	Total	DIFFERENCE FROM ACTUAL BOARDINGS	1	2	3
1	100	0	20	32	48
2	100	0	0	68	32
3	120	0	0	0	120
Total	320	0	20	100	200
DIFFERENCE FROM ACTUAL ALIGHTINGS	0		0	0	0

Table 7-A-5: Iterative Balancing Process

The final estimate for ridership flows is shown in Table 7-A-6.

Route: Example Eastbound (6am-9am)				
Segment	Total	1	2	3
1	100	20	32	48
2	100	0	68	32
3	120	0	0	120
Total	320	20	100	200
DIFFERENCE FROM ACTUAL ALIGHTINGS	0	0	0	0

Table 7-A-6: Final Estimate of Ridership Flows between Stations

The actual number of OD records completed for each boarding to alighting segment pair is shown inTable 7-A-7. To calculate the expansion factors, the final estimate of ridership between segments shown in Table 7-A-6 was divided by the actual number of OD records collected, as shown in Table 7-A-7. This calculation produces the expansion factors shown in Table 7-A-8. For example, the 32 estimated riders projected to board in segment 2 and alight in segment 3 were divided by the 10 OD records to produce an expansion factor of 3.15 to be applied to records who board in segment 2 and alighting in segment 3 as shown in Table 7-A-8.

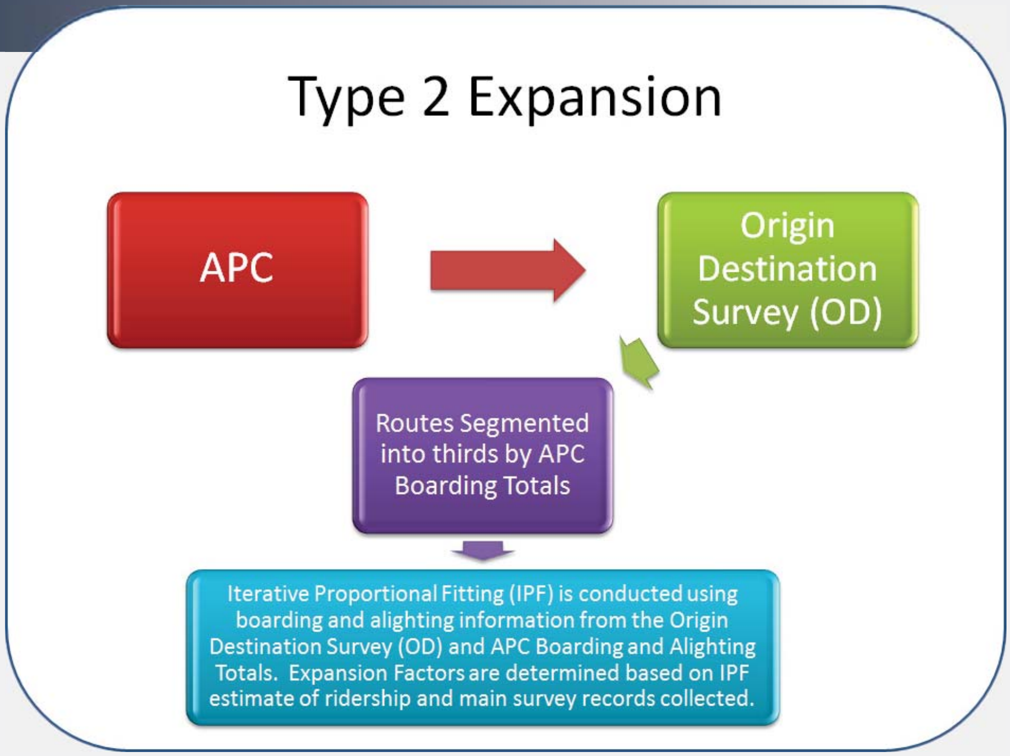
Route: Example Eastbound (6am-9am)				
Segment	Total	1	2	3
1	32	3	9	20
2	17		7	10
3	8			8
Total	57	3	16	38

Table 7-A-7: Number of Completed Surveys (Bus)

TABLE 8: WEIGHTING FACTORS				
Route: Example Eastbound (6am-9am)				
Segment	Total	1	2	3
1	3.13	6.67	3.50	2.42
2	5.88	0.00	9.78	3.15
3	15.00	0.00	0.00	15.00
Total	5.61	6.67	6.25	5.26

Table 7-A-8: Weighting Factors (Bus)

TYPE 2



7.2.2 Type 2 Expansion: Bus Routes with APC Data, OD Survey Data, but no On-to-Off Counts Data

On-to-Off counts are not collected for lower ridership routes. However, sometimes these routes will have APC data available. In this case, Type 2 expansion is appropriate. This type of expansion also divided stops into three segments based on total boarding distribution by direction. These segments were then appended to the OD records based on the boarding and alighting locations. The expansion method is similar to Type 1 expansion, the only difference being that the distribution of OD records was substituted for the On-to-Off count data in Table 7-A-1. The methodology for Type 2 expansion is as follows:

Type 2

Expansion Methodology for Bus Routes with APC Data, OD Survey Data, but No On-to-Off Counts Data

Table 7-B-1 shows the segmented results from the OD survey that replaced the On-to-Off counts. Each row in the table identifies the segment where passengers boarded the bus. The columns in the table identify the segments where people alighted. For example, 10 OD surveys had riders board in segment 2 and alight in segment 3.

Route: Example Eastbound (6am-9am)		Replacing On-to-Off Results		
Segment	Total	1	2	3
1	32	3	9	20
2	17		7	10
3	8			8
Total	57	3	16	38

Table 7-B-1: Bus Data Expansion Table Results of On-to-Off Survey

Table 7-B-2 shows the distribution of the data in Table 7-B-1, expressed as a percentage of all boardings for the time period and direction. Table 7-B-2 was created by dividing each cell in Table 7-B-1 by the sum of all records in Table 7-B-1, which is 57. For example, 10/57 (17.5%) of all trips boarded in segment 2 and alighted in segment 3 as shown in Table 7-B-2.

Route: Example Eastbound (6am-9am)		PERCENTAGE DISTRIBUTION OF RIDERSHIP COUNTS FROM THE ON/OFF SURVEY		
Segment	Total	1	2	3
1	56.1%	5.3%	15.8%	35.1%
2	29.8%	0.0%	12.3%	17.5%
3	14.0%	0.0%	0.0%	14.0%
Total	100.0%	5.3%	28.1%	66.7%

Table 7-B-2: Bus Data Expansion Table Distribution of On-to-Off Survey

The ridership for the route by time period and direction was applied to the "On-to-Off" (boarding to alighting information from the OD survey) distribution shown in Table 7-B-2. This produces an estimate of the ridership flow on the route based on the boarding segment to the alighting segment as shown in Table 7-B-3. Applying the actual ridership of 320 to the distribution created an initial estimate that 56 trips (17.5% x 320) boarded in segment 2 and alighted in segment 3.

Route: Example Eastbound (6am-9am)		PROJECTED RIDERSHIP BASED ON THE ON-TO-OFF SURVEY		
Segment	Total	1	2	3
1	180	17	51	112
2	95	0	39	56
3	45	0	0	45
Total	320	17	90	213

Table 7-B-3: Bus Data Expansion Table Initial Estimate of Ridership Flows Between Segments

In order to develop a more accurate estimate of ridership flows between segments for each route, ETC Institute developed an Iterative Proportional Fitting (IPF) Algorithm to balance the differences between the initial estimated ridership (shown in Table 7-B-3) and the ridership observed by APC data at each segment (shown in Table 7-B-4).

Route: Example Eastbound (6am-9am)				
Average Weekday Ridership	Total	1	2	3
BOARDINGS	320	100	100	120
ALIGHTINGS	320	20	100	200
DIFFERENCE FROM PROJECTED				
BOARDINGS	0	-80	5	75
ALIGHTINGS	0	3	10	-13

Table 7-B-4: Boardings & Alightings by Station

The key steps to the iterative process are described below:

Step 1: Correction for the Boardings

The estimated ridership from the "On-to-Off" data (boarding to alighting information from the OD survey) for each route (shown in Table 7-B-3) was multiplied by the ratio of the actual boardings from the APC data for each segment by the estimated boardings for each segment. For example, if the actual boardings for Segment 1 were 120 and the estimated boardings were 100, each cell associated with Segment 1 would have been multiplied by 1.2 (120 / 100) to adjust the estimated boardings to actual boardings.

Step 2: Correction for the Alightings

Once the correction in Step 1 was applied, the estimated boardings would equal the actual boardings. However, the adjustment to the boardings total may change the alighting estimates. In order to correct the alighting estimate, the new values calculated in Step 1 were adjusted by multiplying the ratio of the actual alightings from the APC data for each segment by the estimated alightings for each segment from Step 1. For example, if the actual alightings for Segment 2 were 220 and the estimated alightings from Step 1 were 200, each cell associated with Segment 2 would have been multiplied by 1.1 (220 / 200) to adjust the estimated alightings from Step 1 to actual alightings.

The processes described in Step 1 and Step 2 were repeated sequentially until the difference between the actual and estimated boardings and alightings was zero. Table 7-B-5 shows that after six balancing iterations in this algorithm, there were no differences between the projected distribution and the actual boardings and alightings.

6th STEP of ITERATIVE BALANCING TO CORRECT DISTRIBUTION OF RIDERSHIP BY ALIGHTING Location					
Segment	Total	DIFFERENCE FROM ACTUAL BOARDINGS	1	2	3
1	100	0	20	40	41
2	100	0	0	60	40
3	120	0	0	0	120
Total	320	0	20	100	200
DIFFERENCE FROM ACTUAL ALIGHTINGS	0		0	0	0

6th STEP of ITERATIVE BALANCING TO CORRECT DISTRIBUTION OF RIDERSHIP BY BOARDING Location					
Segment	Total	DIFFERENCE FROM ACTUAL BOARDINGS	1	2	3
1	100	0	20	40	40
2	100	0	0	60	40
3	120	0	0	0	120
Total	320	0	20	100	200
DIFFERENCE FROM ACTUAL ALIGHTINGS	0		0	0	0

Table 7-B-5: Iterative Balance Process

The final estimate for ridership flows is shown in Table 7-B-6 below.

Route: Example Eastbound (6am-9am)				
Segment	Total	1	2	3
1	100	20	40	40
2	100	0	60	40
3	120	0	0	120
Total	320	20	100	200
DIFFERENCE FROM ACTUAL ALIGHTINGS	0	0	0	0

Table 7-B-6: Final Estimate of Ridership Flows between Stations

The actual number of OD records that were completed for each boarding to alighting segment is shown in Table 7-B-7. To calculate the expansion factors, the final estimate of ridership between segments shown in Table 7-B-6 was divided by the actual number of OD records that were completed as shown in Table 7-B-7. This calculation produces the expansions shown in Table 7-B-8. So, the 40 estimated riders were divided by the 10 completed surveys to produce a factor of 3.96 to be applied to riders who board in segment 2 and alighting in segment 3, as shown Table 7-B-8.

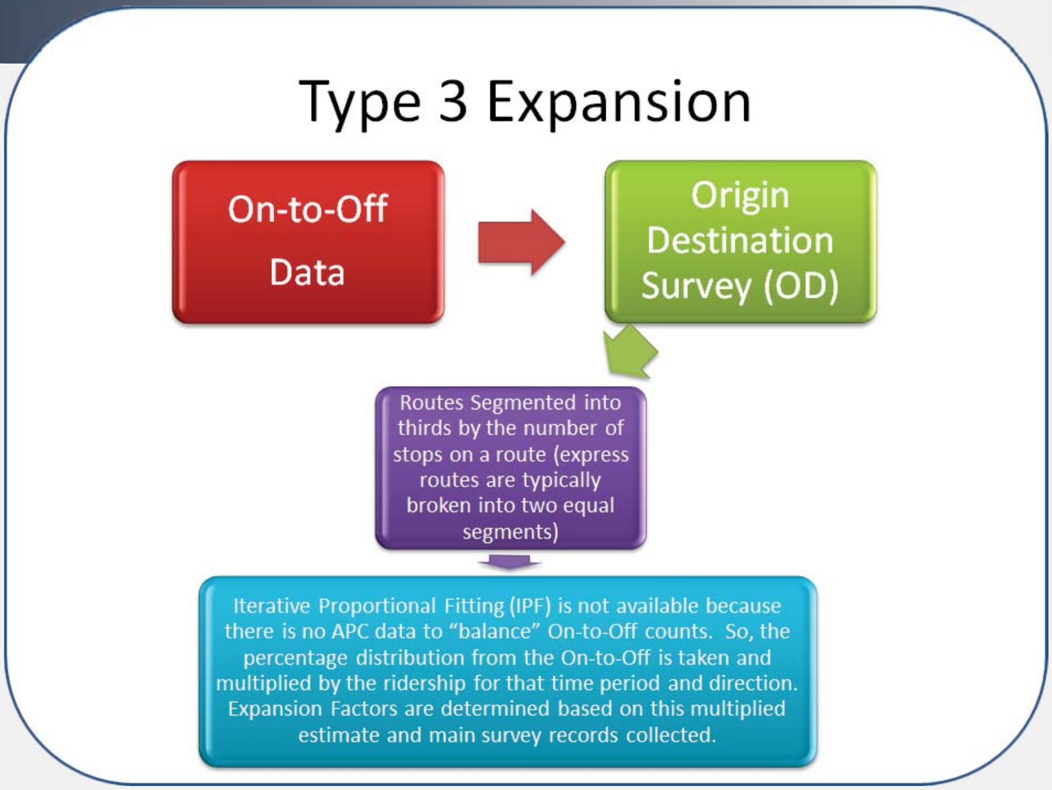
Route: Example Eastbound (6am-9am)				
Segment	Total	1	2	3
1	32	3	9	20
2	17		7	10
3	8			8
Total	57	3	16	38

Table 7-B-7: Number of Completed Surveys (Bus)

Route: Example Eastbound (6am-9am)				
Segment	Total	1	2	3
1	3.13	6.67	4.40	2.02
2	5.88	0.00	8.63	3.96
3	15.00	0.00	0.00	15.00
Total	5.61	6.67	6.25	5.26

Table 7-B-8: Weighting Factors (Bus)

TYPE 3



7.2.3 Type 3 Expansion: Bus Routes with On-to-Off Counts and OD Survey Data, but without APC Data

Expansion Type 3 is utilized for routes where On-to-Off counts are collected, but APC data is not available. Routes without APC data are segmented into three segments based on number of stops along a route. These segments were then appended to the On-to-Off and OD Survey databases. The expansion method is less complex than the two previously discussed types of expansion. The methodology for Type 3 expansion is as follows:

Type 3

Expansion Methodology for Bus Routes with On-to-Off Counts and OD Survey Data, but without APC Data

Table 7-C-1 displays the results for the On-to-Off counts. Each row in the table identifies the segment where passengers board the bus. The columns in the table identify the segments where people alight the bus. For example, 20 of the On-to-Off counts captured riders boarding on segment 2 and alighting on segment 3.

Total Boardings this Direction During this Time Period =	300

Route: Example Eastbound (6-9am)	DISTRIBUTION OF COMPLETED ON2OFF SURVEYS			
Segment		1	2	3
1	55	5	20	30
2	30		10	20
3	15			15
Total	100	5	30	65

Table 7-C-1: Bus Data Expansion Table Results of On-to-Off Survey

Table 7-C-2 shows the distribution of the data in Table 7-C-1 expressed as a percentage of all boardings for the route, time period, and direction. Table 7-C-2 was created by dividing each On-to-Off cell in Table 7-C-1 by the sum of all On-to-Off counts in Table 7-C-1, 100. For example, 20/100 (20.00%) of all trips board in segment 2 and alight in segment 3 as shown in Table 7-C-2.

Route: Example Eastbound (6-9am)	DISTRIBUTION OF ON2OFF SURVEYS AS % OF ALL COMPLETED ON2OFF SURVEYS			
Segment		1	2	3
1	55.00%	5.00%	20.00%	30.00%
2	30.00%	0.00%	10.00%	20.00%
3	15.00%	0.00%	0.00%	15.00%
Total	100%	5.00%	30.00%	65.00%

Table 7-C-2: Bus Data Expansion Table Distribution of On-to-Off Survey

The total ridership for the route, time period, and direction was applied to the On-to-Off distribution shown in Table 7-C-2. This produces an estimate of the ridership flow on the route based on the boarding to the alighting segment, shown in Table 7-C-3. Applying the actual ridership, 300 riders, to the distribution creates an estimate that 60 trips (20.00% x 300) boarded in Segment 2 and alighted in Segment 3.

Route: Example Eastbound (6-9am)	ESTIMATED RIDERSHIP BASED ON THE ON-TO-OFF SURVEY			
Segment		1	2	3
1	165	15	60	90
2	90	0	30	60
3	45	0	0	45
Total	300	15	90	195

Table 7-C-3: Bus Data Expansion Table Initial Estimate of Ridership Flows Between Segments

The actual number of OD records completed for each boarding-to-alighting segment is shown in Table 7-C-4. To calculate the expansion factors, the estimate of ridership between segments, shown in Table 7-C-3, was divided by the actual number of OD records completed between segments, shown in Table 7-C-4. The calculation produces the expansion factors shown in Table 7-C-5. So, the 60 estimated riders were divided by the 7 OD records to produce a factor of 8.57 to be applied to riders who board in segment 2 and alighting in segment 3 as shown in Table 7-C-5.

		Total Number of Surveys =	30	
Route: Example Eastbound (6-9am)	NUMBER OF COMPLETED SURVEYS			
Segment		1	2	3
1	16	4	4	8
2	10		3	7
3	4			4
Total	30	4	7	19

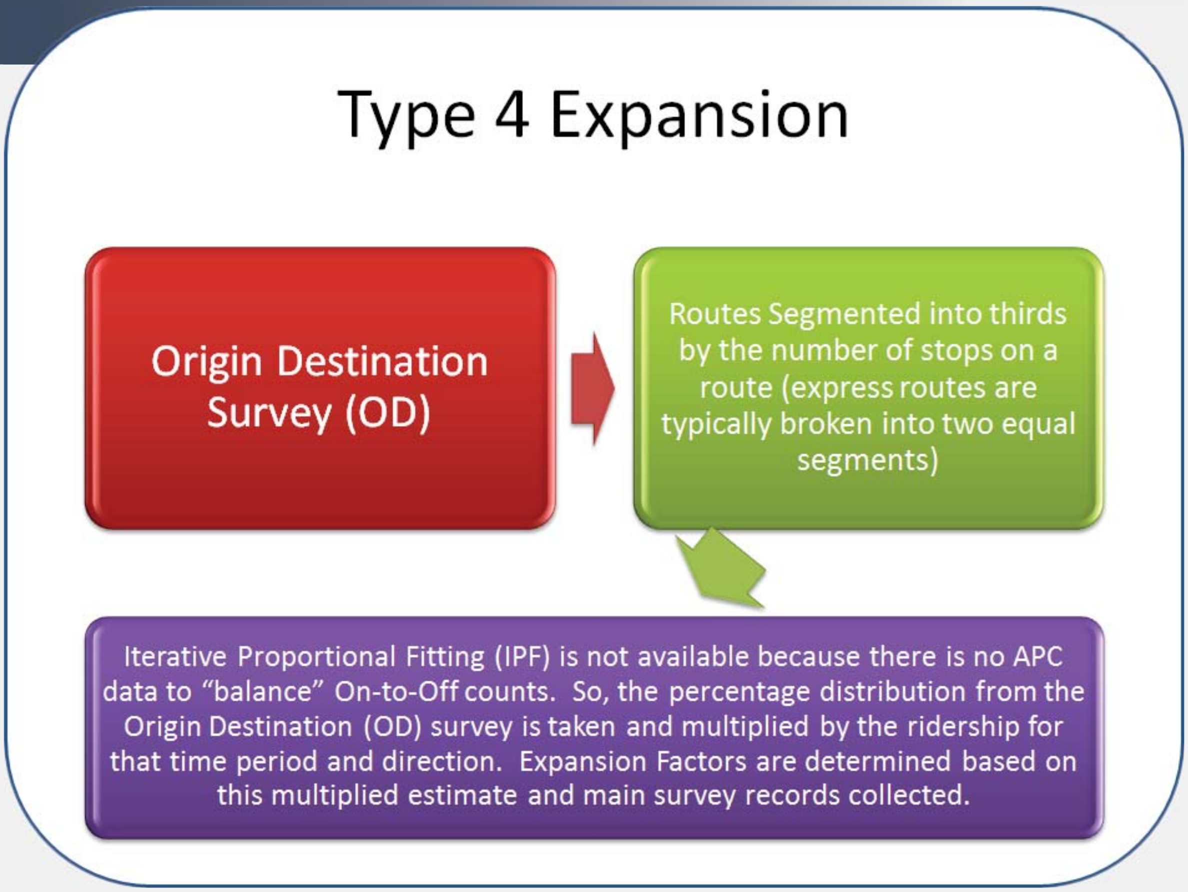
Table 7-C-4: Number of Completed Surveys

Route: Example Eastbound (6-9am)				
Segment		1	2	3
1	10.312500	3.750000	15.000000	11.250000
2	9.000000		10.000000	8.571429
3	11.250000			11.250000
Total	10.000000	3.750000	12.857143	10.263158

Table 7-C-5: Weighting Factors

Once all the expansion factors were calculated, each factor was applied to all surveys with the same route, direction, time of day, boarding segment, and alighting segment.

TYPE 4



7.2.4 Type 4 Expansion: Bus Routes with OD Survey Data, without On-to-Off Counts Data or APC Data

For routes that only have OD Survey data, Type 4 expansion is utilized. Routes are divided into three segments based on number of stops along a route. These segments were then appended to the OD Survey database. The methodology for Type 4 expansion is as follows:

Type 4

Expansion Methodology for Bus Routes with OD Survey Data, without On-to-Off Counts Data or APC Data

Table 7-D-1 shows the segmented results from the OD survey that replaced the On-to-Off counts. Each row in the table identifies the segment where passengers boarded the bus. The columns in the table identify the segments where people alighted. For example, 7 of the OD surveys had riders board in segment 2 and alight in segment 3.

			Total Boardings this Direction During this Time Period =	300
Route: Example Eastbound (6-9am)	DISTRIBUTION OF COMPLETED ON2OFF SURVEYS			
Segment		1	2	3
1	16	4	4	8
2	10		3	7
3	4			4
Total	30	4	7	19

Table 7-D-1: Bus Data Expansion Table Results of On-to-Off Survey

Table 7-D-2 shows the distribution of the data inTable 7-D-1 as a percentage of all boardings for the route. Table 7-D-2 was created by dividing each on-to-off cell in Table 7-D-1 by the sum of all OD records replacement data in Table 7-D-1, which is 30. For example, 7/30 (23.33%) of all trips boarded in segment 2 and alighted in segment 3 as shown in Table 7-D-2.

Route: Example Eastbound (6-9am)	DISTRIBUTION OF ON2OFF SURVEYS AS % OF ALL COMPLETED ON2OFF SURVEYS			
Segment		1	2	3
1	53.33%	13.33%	13.33%	26.67%
2	33.33%	0.00%	10.00%	23.33%
3	13.33%	0.00%	0.00%	13.33%
Total	100%	13.33%	23.33%	63.33%

Table 7-D-2: Bus Data Expansion Table Distribution of On-to-Off Survey

The total ridership for the route, time period, and direction was applied to the On-to-Off distribution shown in Table 7-D-2. This produces an estimate of the ridership flow on the route based on the boarding segment to the alighting segment as shown in Table 7-D-3. Applying the actual ridership of 300 to the distribution creates an estimate that 70 trips (23.33% x 300) board in Segment 2 and alight in Segment 3.

Route: Example Eastbound (6-9am)	ESTIMATED RIDERSHIP BASED ON THE ON-TO-OFF SURVEY			
Segment		1	2	3
1	160	40	40	80
2	100	0	30	70
3	40	0	0	40
Total	300	40	70	190

Table 7-D-3: Bus Data Expansion Table Initial Estimate of Ridership Flows Between Segments

The actual number of OD records that were completed for each boarding-to-alighting segment pair is shown in Table 7-D-4. To calculate the expansion factors, the estimate of ridership between segments, shown in Table 7-D-3, was divided by the actual number of OD records that were completed between segments shown in Table 7-D-4. This calculation produces the expansion factors shown in Table 7-D-5. So, the 70 estimated riders were divided by the 7 completed OD records to produce a factor of 10.00 to be applied to riders who boarded in segment 2 and alighted in segment 3 as shown in Table 7-D-5.

		Total Number of Surveys =	30	
Route: Example Eastbound (6-9am)	NUMBER OF COMPLETED SURVEYS			
Segment		1	2	3
1	16	4	4	8
2	10		3	7
3	4			4
Total	30	4	7	19

Table 7-D-4: Number of Completed Surveys

Route: Example Eastbound (6-9am)				
Segment		1	2	3
1	10.00	10.00	10.00	10.00
2	10.00		10.00	10.00
3	10.00			10.00
Total	10.00	10.00	10.00	10.00

Table 7-D-5: Weighting Factors

Once all the expansion factors are calculated, each factor is applied to all surveys with the same route, direction, time of day, boarding segment, and alighting segment.

General Rule for Expansion Factors

While there are no specific guidelines for the expansion factor values, ETC Institute uses a guideline of keeping expansion factors below 3 times the average expansion factor based on the sampling percentage. This is done in order to keep any one record from representing a markedly high number of riders in the system. The formula for determining this guideline is:

1/(Sampling %) x 3 = Guideline Weight Factor

If the expansion factor for a boarding segment to alighting segment pair is greater than 3 times the average expansion factor then it is aggregated into the adjacent boarding-to-alighting segment where it will have the least impact on the previously existing expansion factors. This guideline is standard for all the various expansion types.

Summary

After all the factors are appended to the OD survey database (regardless of type of expansion) the factors are summed by route, time period, and direction. If expansion was done properly, the summed factors will equal the boarding ridership provided in the APC data by route, time period, and direction.

7.3 LINKED TRIP EXPANSION FACTORS FOR ALL RECORDS

The linked trip expansion factor helps to account for the number of transfers that were made by each passenger, so the linked expansion factors should better represent the overall system. Linked expansion factors are generated after the unlinked expansion factors are created.

The equation that is used to calculate the linked trip multiplying factor is shown below:

Linked Trip Multiplying Factor = [1 / (1 + # of transfers)]

If a passenger did not make a transfer, the linked trip multiplying factor would be 1.0 because the person would have only boarded one vehicle. If a person made two transfers, the linked trip expansion factor would be 0.33 because the person would have boarded three transit vehicle during his/her one-way trip. An example of how the linked trip expansion factors were calculated is provided in Figure 7-4 below.

Number of Transfers	Calculation [1/(1+Number of Transfers)]	Linked Trip Multiplying Factor
0	[1/(1+0)]	1
1	[1/(1+1)]	0.5
2	[1/(1+2)]	0.33
3	[1/(1+3)]	0.25

Figure 7-4: Sample Calculations of Linked Trip Multiplying Factors

Once the linked trip multiplier is created it is multiplied by the unlinked expansion factor to create the linked expansion factor.

7.4 DECOMPOSITION ANALYSIS

Resource Systems Group (RSG), a subconsultant that specializes in statistical analyses, performed a decomposition analysis to understand how the linked-trip weights represent actual ridership. On a typical Origin-Destination (OD) study, an unlinked-trip weight is calculated based on the average weekday ridership for the route on which the respondent was surveyed, and does not consider whether they transferred to or from other routes during their trip. A second weight is calculated (the linked-trip weight) that considers the number of transfers made. This weight is calculated by taking the number of transfers made by a respondent, adding one, and then taking the inverse of that number. For example, if a rider made one transfer, the linked-trip weight would be the inverse of one plus one—or 1/2. If the rider made two transfers, then the linked-trip weight would be 1/3.

The decomposition analysis reviews all transit routes/lines used by survey respondents and looks to see how many riders transferred to each route and from each route. This allows us to determine whether the total ridership estimated from the linked trip weight using all the routes/lines adds up to the total boardings on a particular route as well as the total boardings for the entire system.

Table 7-E-1 below is an example of a simple transit system with 6,000 linked trips (riders) on three routes.

<table>
<tr><th>Route 1</th><th>Route 2</th><th>Route 3</th></tr>
<tr><td>1000</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td>1000</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>1000</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="2">1000</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">1000</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">1000</td></tr>
</table>

Table 7-E-1: Linked Trips example (# linked trips)

As one can see in the table above, these 6,000 linked trips are the equivalent of the number of riders on the system. However, these 6,000 riders (linked trips) are making 10,000 unique boardings (the number of times these riders get on a transit vehicle). The 10,000 boardings for these 6,000 riders are shown in Table 7-E-2. In this table, boardings in red indicate the additional boardings over what is shown in Table 7-E-1. The boardings in red are due to the transfers made by riders.

Route 1	Route 2	Route 3
1000		
	1000	
		1000
1000	1000	
	1000	1000
1000	1000	1000

Table 7-E-2: Unlinked Trips or Boardings Example

The analysis is summarized in a table like Table 7-E-3, which shows the number of respondents surveyed on a particular route along with the number of respondents surveyed on other routes that reported transferring to or from the route. The table then sums the total number of boardings reported in the survey (either by being surveyed on or transferred to/from) and compares this sum to the actual boardings obtained from APC or farebox data. Ideally, the system-wide difference between the two should be small but some amount of difference is to be expected at the route level.

	Linked Trips			Unlinked Trips			
Route Surveyed	# Resp. Surveyed on Route	# Resp. Transferring FROM Route	# Resp. Transferring TO Route	Total Board-ings (from survey)	Actual Boardings	Absolute Difference	Percent Difference
Route 1	1,500	700	800	3,000	3,100	-100	-3.2%
Route 2	3,000	2,000	1,000	6,000	5,000	1,000	20.0%
Route 3	500	250	250	1,000	975	25	2.6%

Table 7-E-3: Example Results

The purpose of this memo is to summarize RSG's decomposition analysis conducted on the IndyGo OD dataset. This analysis reviews all transit routes used by survey respondents and looks to see how many riders transferred to and from each route. This allows one to determine whether the total ridership estimated from the linked trip weight using all the routes/lines adds up to the total boardings on a particular route as well as the total boardings on the entire surveyed system. This analysis is a good QA/QC step to ensure the survey effort and weighting/expansion process was done properly.

RSG found virtually no difference between linked and unlinked boardings. Upon analysis by route size one finds very slight variability between large and small routes; this variability is expected as the analytical resolution increases. The differences between estimated and actual boardings seen on IndyGo are extremely small and validate the efficacy of the surveying and weighting undertaken.

	Segment	Estimated Boardings (Linked Trips + Transfers)*	Actual Boardings (Unlinked Trips)**	Absolute Difference	Percent Difference
Route Size	>1,000 actual boardings	23,188	23,011	178	0.8%
	<1,000 actual boardings	12,317	12,501	(184)	-1.5%
Overall	**Total**	**35,506**	**35,512**	**(6)**	**0.0%**

*using linked trip weights
**using unlinked trip weights

Table 7-E-4: Decomposition Analysis Summary

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APPENDIX A
SURVEY INSTRUMENT

IndyGo

IndyGo 2016 On-Board Ridership Survey

Please take a few minutes to be counted as we plan the future of your transit system.

What is your HOME ADDRESS (please be specific, ex: 123 W. Main St):
(*If you are visiting the Indianapolis area, please list the* ***hotel name*** *or address where you are staying*)

Street Address	**City**	**State**	**Zip Code**
______________________	__________	______	______

COMING FROM?

1. What type of place are you COMING FROM NOW?
(the <u>starting place</u> for your one-way trip)

- O Work or Work Related
- O College / University (students only)
- O School K-12 (students only)
- O Doctor / Clinic / Hospital (non-work)
- O Shopping
- O Social / Religious / Personal Business
- O Airport (passengers only)
- O Your **HOME** → *Go to Question #4*
- O Other: ____________________

2. What is the <u>NAME</u> **of the place you are coming from now?**

____

3. What is the <u>EXACT ADDRESS</u> **of this place? (**OR **Intersection if you do not know the exact address:)**

____

City: ______________ **State:** ______ **Zip:** ________

4. How did you GET FROM **your origin (the place in Question #1) TO THE VERY** FIRST **bus you used for this one-way trip?**

- O Walk / Wheelchair
- O Bike
- O Was dropped off by someone (answer 4a)
- O Drove alone and parked (answer 4a)
- O Drove or rode with others and parked (answer 4a)
- O Car share (e.g. BlueIndy, etc.) (answer 4a)
- O Taxi, Uber, Lyft, etc. (answer 4a)
- O Other_____________

4a. Where did you board the FIRST bus you used for this one-way trip
(Nearest intersection):

____

5. Where did you <u>**get ON**</u> **this bus?** Please provide the nearest intersection:

____

GOING TO?

6. What type of place are you GOING TO NOW?
(the <u>ending place</u> for your one-way trip)

- O Work or Work Related
- O College / University (students only)
- O School K-12 (students only)
- O Doctor / Clinic / Hospital (non-work)
- O Shopping
- O Social / Religious / Personal Business
- O Airport (passengers only)
- O Your **HOME** → *Go to Question #9*
- O Other: ____________________

7. What is the <u>NAME</u> **of the place you are going to now?**

____

8. What is the <u>EXACT ADDRESS</u> **of this place? (**OR **Intersection if you do not know the exact address:)**

____

City: ______________ **State:** ______ **Zip:** ________

9. How will you GET TO **your destination (listed in Question #6) after you get off the** LAST **bus you will use for this one-way trip?**

- O Walk / Wheelchair
- O Bike
- O Be picked up by someone (answer 9a)
- O Get in a parked vehicle & drive alone (answer 9a)
- O Get in a parked vehicle & drive/ride w/others (answer 9a)
- O Car share (e.g. BlueIndy, etc.) (answer 9a)
- O Taxi, Uber, Lyft, etc. (answer 9a)
- O Other_____________

9a. Where will you get off the LAST bus you are using for this one-way trip (Nearest intersection):

____

10. Where will you <u>**get OFF**</u> **this bus?** Please provide the nearest intersection:

____

11a. Did you transfer FROM another bus <u>**BEFORE**</u> **getting on this bus?** O Yes O No

11b. Will you transfer TO another bus <u>**AFTER**</u> **getting off this bus?** O Yes O No

11c. Please list the BUS ROUTES in the exact order you use them for this one-way trip

<u>START</u> →		→		→		→		→ <u>END</u>
	1st Route		2nd Route		3rd Route		4th Route	Continue

OTHER INFORMATION ABOUT THIS TRIP

12. What time did you BOARD this bus? ______ : ______ **am / pm (circle one)**

13. Will you (or did you) make this same trip in exactly the opposite direction today?
O No O Yes - At what time did/will you leave for this trip in the opposite direction? _____:_____ am/pm (circle one)

14. What fare payment methods were used for this one-way trip? *(select all that apply)*
O 1 Trip (Cash on bus) O 1 Day Pass O 7 Day Pass O 31 Day Pass (Monthly)
O 1 Trip Ticket O 10 Trip Pass O S Pass (If S Pass skip to Q16) O Other________________

15. What type of fare was this?
O Youth (6-18) O Regular O Senior (65 and older) O Disabled

16. On this round trip (between the time you left home and will return home) will you or did you *(check all that apply)*
O No other trip O Go to work O Go to school O Go shopping
O Buy a meal/beverage O Visit friend/relative or attend a religious/social event O Other errands
O Other (please specify):___________

17. If bus services were not available, how would you have made this trip?
O Would have walked O Would have driven myself O Car Share (e.g. Blue Indy, etc.)
O Would have bicycled O Would have taken a taxi, Uber, Lyft, etc. O Would not have made this trip
O Would have ridden with someone else O Would have taken transit to a different location

18. How many days a week do you usually make this trip?
O 6-7 days a week O Twice a month O First time riding
O 3-5 days a week O Once a month
O 1-2 days a week O Less than once a month

ABOUT YOU AND YOUR HOUSEHOLD

19. Are you a visitor to the Indianapolis region? ONo O Yes (if YES, please skip to Q25)

20. How many vehicles (cars, trucks, or motorcycles) are available to your household? ________ vehicles
20a. [If #20 is more than NONE] Could you have used one of these vehicles for this trip? OYes ONo

21. Including YOU, how many people live in your household? _______ people

22. Including YOU, how many people (over age 15) in your household are employed full/part-time?____ people

23. What is your employment status? (check the one response that BEST describes you)
O Employed full-time (more than 30 hours per week) O Not employed O Part time temporarily employee
O Employed part-time (less than 30 hours per week) O Full time temporarily employee O Retired

24. What is your student status? (check the one response that BEST describes you)
O Not a student O Yes – College/University/Community College O Yes – K - 12th grade
O Yes – Vocational / Technical / Trade school O Other________________________

25. Do you have a valid driver's license? OYes ONo

26. What is your AGE? O Under 16 O 16-18 O 19-24 O 25-34
O 35-49 O 50-64 O 65 and over

27. What is your race / ethnicity? *(check all that apply)*
O American Indian/Alaska Native O Asian O Black/African/African American O Hispanic/Latino
O Native Hawaiian/Pacific Islander O White O Other: __________________

28. What is your gender? O Male O Female

29. Which of the following BEST describes your TOTAL ANNUAL HOUSEHOLD INCOME in 2015 before taxes?
O Less than $15,000 O $25,000 - $34,999 O $60,000 - $99,999 O $150,000 - $199,999
O $15,000 - $24,999 O $35,000 - $59,999 O $100,000 – $149,999 O $200,000 or more

30. Do you speak a language other than English at home? O No OYes - **Which language?** ____________
30a. [If #30 is Yes] How well do you speak English? O Very Well O Well O Less than well O Not at all

31. Do you have any of the following: *(check all that apply)*
O Smart phone O Checking account O Debit card O Credit card

REGISTER TO WIN 1 of 3 31-Day passes

Please provide your name and phone number so you can be sent your prize if selected.

Your Name: _________________________________
Phone Number: (_____) _______________________

Thank you for your help!

APPENDIX B
INDYGO TRAINING OD SURVEY

Introductions

MPO Indianapolis Metropolitan Planning Organization

IndyGo Indianapolis Public Transportation Corporation

- Ryan McCuchan (ETC)
- Brad Carlson (ETC)
- Fred G'sell (ETC)
- Lochmueller Group

2

Agenda

- Overview of the project
- What you will be doing
- Expectations for conduct
- How to use the equipment
- How to conduct the survey
- Practical exercise for conducting the survey
- Adjourn

3

Overview of the Survey

The overall purpose of the survey is to collect information on the travel patterns of bus passengers to inform transportation planning and forecasting, leading to a better transit system.

4

Overview of the Survey

Most importantly, the data you will be collecting is important and will benefit the Indianapolis and the surrounding areas for years to come.

Each individual passenger you collect information on from the interview, is being counted. It is very important to capture each individual so that each particular passenger may be represented in planning.

Interviewer Position

As a Interviewer, your job will consist of riding on board IndyGo bus routes conducting in-person interviews with passengers.

You will approach passengers using a random selection method (to be described later in training), politely explain who you are and what IndyGo is doing, ask for participation, and conduct the survey using a personal tablet loaded with the survey.

6

Expectations for Conduct: General

- Be On-time
- **Drivers and Transit employees are ALWAYS right!!!!!**
- Business Casual Attire – Jeans are okay but make sure jeans are appropriate (no tears, excessively baggy). No saggy pants.
- Be polite and courteous to everyone (Employees/Passengers).
- Good hygiene is important.
- No headphones on the bus. If you want to listen to headphones, keep them hidden and use them only on break.
- Do not use the internet on the tablets for personal use!!

7

Expectations for Conduct: Continued

- Cell phone calls from the bus should be to supervisors or other survey staff for work purposes only. Personal cell phone calls should be made on break and should not involve foul language if on any of the transit systems property including bus stop shelters.
- No disrespectful behavior of any kind will be tolerated.
- No Cheating…you will get caught

8

Conduct on Buses

- Do **NOT** hold up the line when people are getting on or off the bus.
- The survey is **ALWAYS** voluntary. There is never a good reason to argue with anyone who doesn't want to participate in the survey.
- No eating / drinking / chewing tobacco / smoking / E cigarettes / vaping on the bus. No tobacco products while in your vest/near transit facilities including shelters, because that is against the law.
- **Some one is always watching you**

9

Administrative Issues

- Driver / Customer Interaction
  - No arguments with drivers / riders **(remove yourself from the situation)**
  - Even though you do not work for the IMPO or IndyGo, your behavior reflects on them.
  - "Thank you for your suggestions and/or I understand your comments and concerns. I am a subcontractor for IndyGo and the IMPO and I am sure that if you call customer service, they will also value your thoughts and opinions".

10

Administrative Issues Continued

- Contact Information
  - Project cell phone ???????????????
  - No VM, texts encouraged
  - Identify yourself and your issues quickly
- DO NOT BRING VALUABLES THAT DON'T FIT IN YOUR POCKET OR CARRYABLE BAG!!!!

11

Safety

Your personal safety comes first.

- Always look both ways when crossing streets and parking lots
- Always wear your vest (identifies you as a interviewer to security)
- Always have your hand on the hand rail if you are standing/walking on a moving vehicle

If you ever feel that your safety is being threatened, please get off the vehicle.

Conduct Statement

QUESTIONS ABOUT CONDUCT or SAFETY?

13

Data We are Collecting

The main elements we will be collecting during the interview is the passenger's one-way trip. A **one-way** trip is shown in the example below and differs from a **round trip**. A one-way trip is getting from point A to point B such as traveling from work to home, home to work, school to shopping, etc.

14

Data We are Collecting

The one-way trip information we will collect includes:

- Each passengers Origin (where the passenger is coming from including type of place and location)
- All routes the passenger has taken and will take to make the current trip they are on (routes prior to the vehicle the survey is being conducted and the routes that will be used after the passenger exits the vehicle that they are surveyed on)

15

Data We are Collecting

- Destination (where the passenger is going including type of place and location
- Boarding and alighting locations for the vehicle the survey is being conducted (where the respondent got on the bus and is getting off the bus which they are surveyed on)
- How passengers get to their first transit stop from their origin and how they will get to their destination from their last transit stop
- Transfers before and after this bus

16

Data We are Collecting

We will also collect the passenger's home address. If a passenger is uncomfortable providing their precise home address, ask if they can provide the nearest cross streets or intersection. Other data we will collect includes:

- Fare information
- The time that the passenger boarded the bus that they are being surveyed on
- If the passenger will be making their return trip using the same exact routes (opposite direction)

17

Data We are Collecting Continued

- Frequency and length of time riding transit
- Residential Status – If the respondent is a Visitor
- Working Automobiles available to their household and availability for current trip
- Number of people living in household **(Specify Dorms etc.)**
- Household employees (persons over 15 that are living with them and employed)
- Employment status of the passenger and if employed, does employer pay any part of transit fare

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Data We are Collecting Continued

- Student status of the passenger
- Drivers license status of the passenger
- Age, Ethnicity, and Gender of passenger
- Household Income for 2015 (let passenger select this on the tablet)
- Other languages spoke in their household if any
- If they speak another language at home, how well do they speak English

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Interview Length

The interview should take no longer than 7 minutes. Depending on amount of transfers used and other items, it may take a minute or two more. Once familiarized with the survey and program, you may be able to complete a survey in 4-5 minutes. Our expectations for surveyor productivity are no less than 5 completed surveys per hour that are accurate.

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How to Approach Passengers

Approach passengers with a smile and introduce yourself as a surveyor for Metropolitan Council. Make sure to approach the passenger with enthusiasm and do not be afraid when asking questions relating to demographics. Be polite even if the passenger declines the interview. Always thank the passenger at the end of the survey or if the passenger refuses.

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Turning Refusals

If a passenger refuses to take the survey, quickly state the importance of the survey and how their individual input will contribute to transportation improvement. It is very important to capture that individuals trip and demographic information so that they may be counted in regional planning.

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Capturing Accurate Locational Data

It is of utmost importance that the correct address or cross streets are input into the survey. Address information must include:

- Complete address with correct city (you must verify city or zip code)
- If a passenger only gives an intersection (cross streets), we must have **two cross streets**. If the passenger only provides one cross street, you must ask for another intersecting street and then verify the city.
- If the passenger provides a place name, then you must verify the exact location of that place (streets and city).

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How to Use the Equipment

- **Two Types: Samsung Galaxies and/or iPads**
- **Review Basics**
  - How to turn the device on/off
  - How to log into the survey
  - How to adjust brightness and other settings
  - How to check you battery strength

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How to Conduct Survey

- **Selecting Participants**
  - Everyone who boards the bus/train is eligible participate
  - The tablet will select the rider to be interviewed
  - DO NOT skip children or persons with disabilities
  - If you encounter a child who is accompanied by an adult, ask the parent or adult with him/her for permission or have the parent answer on behalf of the child.
  - Always introduce the interview in English!
  - VERY IMPORTANT – the selection process must ALWAYS BE RANDOM

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How to Conduct Survey

- **Getting People to Do the Survey**
  - "Hi, I'm Brad, you were randomly selected to participate in a short interview to improve service on route XX."
  - "Would you mind answering a few questions?" or
  - "Please help us out"

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How to Conduct Survey

- **Four Response Options:**
  - YES – you will ask if they have at least five minutes to determine whether you will administer
    - Full Survey
    - Full Survey until passenger has to exit
  - NO – refusal, follow question
  - NO – language barrier, attempt call

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Break 10:20am

We will now be taking a short break. Please return to the meeting room in approximately 15 minutes.

Survey Assignments

For some assignments you will need to be cognizant of getting on and off your assigned route. You will need to ask the driver at the end of each trip, if that bus is remaining the same route. We will also be conducting some survey assignments by utilizing Bus Blocks.

A block is an series of trips made by a single bus and may includes multiple routes.

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Survey Assignments

The Block will always be represented on the front of the bus but always double check with the driver. On occasions you will have to get off your vehicle and wait to catch another block so we can get you back to a starting location or back on track to get back to the starting location.

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Survey Assignments

The Most Important Thing is, when one trip ends, check your assignments sheet so you can either:

- Get off that bus to catch another block. When ever you see a black line in your assignment such as assignment 6 which has three block changes, you will have to get off each bus to wait for the next block.
- **Ensure the route and direction so you can enter each route and direction properly to associate each survey with the correct information.**

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Survey Assignments

Go through Example assignments 50 and 6

Asn = Assignment Number

Route= Route to enter (Important)

Direction=Route Direction to enter (important)

Block= Bus vehicle you will be riding on

Start Location= starting point/stop for trip

Start = starting point/stop for trip

End= ending point/stop for trip

End Location= ending point/stop for trip

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How to Conduct Survey

- **Let's Walk Thru the Survey**

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How to Conduct Survey

- Questions
- Breakout in Small Groups

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FINAL EXAM

- Test Questions

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