OBS 2008 Demographic Analysis

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In 2008, Metro Transit of Madison worked with Cambridge Systematics and the UW-Madison Transportation Operations and Safety Lab to complete an on-board survey (OBS) of riders to gain additional insight into demographic characteristics of riders and use patterns in the system. I expand on that report by utilizing the trip-weights calculated by Cambridge Systematics to address questions of equity.[1] Cambridge Systematics calculates trip-weights by matching survey responses within aggregated regions of the city with actual ridership data from fare boxes and other sources through a statistical process. These weights extend the survey responses to predict characteristics of the total ridership population.

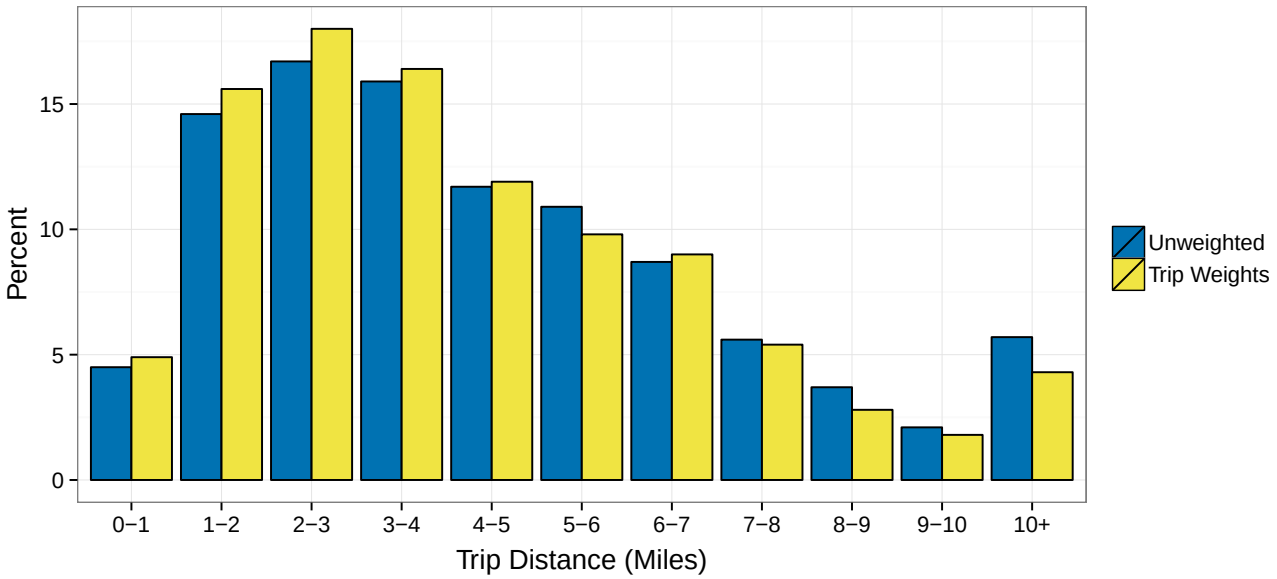
The 2008 survey team calculates trip-weights for each survey response in the final section of the report. The earlier sections of analysis use unweighted survey response counts. There are some noteworthy differences between weighted and unweighted results. For example, cash payments account for a two percent greater share of rides in a trip-weighted sample, which is nearly a 20 percent increase. Trips to and from the university are overrepresented in the unweighted sample by almost 10 percent. Trip-weighting suggests fewer long trips than were reported in the original sample, as can be seen in Figure 1. This report uses trip-weighted values throughout when discussing equity concerns.

Major Equity Findings

- Black and African American riders, as well as riders reporting multiple races, are significantly more likely to use cash to pay for their trips. See Figure 7.
- Users of 10-ride passes fall disproportionately in the 45-65 age group and also are wealthier than those using other payment methods. Riders of age 65 are very likely to use cash to pay, but this age group accounts for a very small portion of ridership. See Figure 9 for age and Figure 4 for income.
- Based on reported availability of a vehicle during the time of their trip, riders paying with cash are significantly more likely to be transit-dependent than other riders. See Figure 12.
- As riders' income rises, they are less likely to take trips involving transfers. See Figure 13.
- Blacks and African American's share of one-seat rides is only 60 percent of their share of total ridership. Over 50 percent of Blacks and African Americans transfer at least once, compared to about 15 percent of White riders. And Black riders account for 40 percent of all multiple transfer rides, even though they make up only 11.2 percent of total ridership. See Figure 15, Figure 16, and Table 7.

[1] Trip-weights are drawn from the consultants report, which does not provied information regarding the statistical validity of different weights when used for aggregate analysis. I assume large differences between groups with large sample populations are valid and avoid comment on smaller samples or small variation.

Figure 1: Percent of Respondents by Trip Distance - Weighted and Unweighted



Limitations of 2008 OBS Report Results for Equity Analysis

The timing and sampling patterns of the survey affect the strength of equity findings in both the original report and this follow-up report. The 2008 survey collected responses Tuesday through Thursday between the hours of 6:00am and 2:00pm. It oversampled high-volume commuter routes relative to low-ridership routes. This design provided good information on commuting patterns on the Metro system but does not provide optimal information on Title VI issues, if the populations of concern exhibit different ridership patterns than general commuters.

Morning and midday responses cannot be extrapolated to evening or nighttime ridership with a high degree of certainty. This means there is little information on use of the system by service workers whose shifts do not align with standard morning commute hours. It also likely affects the type of trip purposes that people reported in surveys.

If Title VI populations live in service areas where routes were undersampled, unweighted samples do not accurately portray their use of the system. Weighting survey responses can partially correct for this sampling bias, but undersampled routes and populations have higher margins of error than oversampled routes. It is not possible to report this margin or error in the following analysis because the weighting methodology is not reproducible from the report nor are margins of error reported.

Different income characteristics of the survey respondents in 2000 than 2008 also indicates that the sampling technique may significantly undersample low-income riders. Unweighted responses from riders indicating less than $25,000 of income decreased by 12 percentage points from 55 percent of riders to 43 percent of riders. Change in community-wide income from 2000-2008 is insufficient to explain the whole change, because only 4 percent fewer households reporting incomes less than $25,000.[2] An alternative explanation is that system ridership patterns changed significantly, with significantly more higher-income riders, or fewer low-income riders.

[2]Author's calculations based on U.S. Census Bureau income data for the urbanized area in the Madison MSA from the 2000 Census and 2008 American Community Survey.

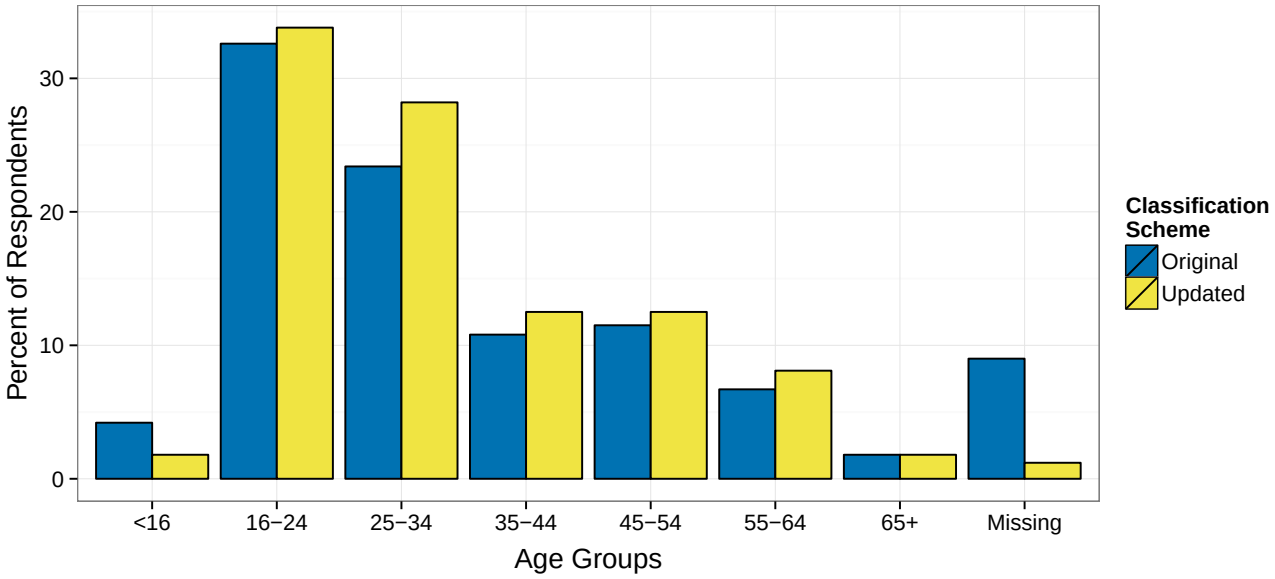
Update to Age Groups

This report uses different age groups than the 2008 report. A error codes respondents of ages 16, 25, 35, 45, and 55 as missing data and respondents who did not report their age as "less than 16". The total number of age group classifications changed by reallocating these responses is 646 respondents (14 percent of the total sample.) Table1 and Figure 2 show the difference between classification schemes.

Table 1: Percent of Respondents by Age Group

	<16	16-24	25-34	35-44	45-54	55-64	65+	Missing
Original	4.2	32.6	23.4	10.8	11.5	6.7	1.8	9.0
Updated	1.8	33.8	28.2	12.5	12.5	8.1	1.8	1.2

Figure 2: Percent of Respondents by Age Group following Reclassification



Utilization of Payment Methods

The the on-board survey data show the use of payment methods across riders. Fares are set independently across the different types of payment methods available to Metro Transit riders. Consequently, if payment method use varies across demographic groups, changing fare levels has disparate effects on different groups.

The number of payment methods and corresponding fare categories is more diverse than the three categories available in the 2008 on-board survey. The following analysis uses the three payment methods reported: "Pass," "10-Ride," and "Cash." "Pass" refers to a number of pass programs that allow unlimited rides within a time period, ranging from yearly institutional programs such as the University of Wisconsin's program to 31-day unlimited passes that can be purchased by the public.[3] "10-Ride" passes are a book of ten tickets, which are each good for one ride and do not expire. "Cash" fares are paid upon boarding a bus. "Cash" and "10-ride" payments both allow unlimited transfers within two hours of the first boarding using a "transfer ticket."

[3]In many institutional programs a per ride fare is paid by the organization, but there is no marginal cost to a pass user or limit on their monthly rides

Differences Across Income Groups

The 2008 OBS survey collected income data in six categories.[4] The salary bins are not the same size in terms of income range or number of respondents. The first bin is households earning less than $10,000 per year, the next bin includes incomes from $10,000 to $25,000 per year, the following three bins increase in increments of $25,000, and the final bin is incomes greater than $100,000 dollars. The original OBS report provides some analysis of how ridership share between income groups compares to Census data on population shares in Madison belonging to these income groups.

Figure 3 displays the number of trips taken by income bracket in absolute amounts. Each income bracket is further divided into different colors based on their payment method. The largest absolute count of trips taken based on trip-weighting of response are individuals with $25,000 to $50,000 in annual household income. The variation in bracket width limits comparability as the next lower bracket has nearly as many riders but only has an income range 60 percent as wide.

Figure 3: Trip-Weighted Counts of Payment Method Use by Income Group

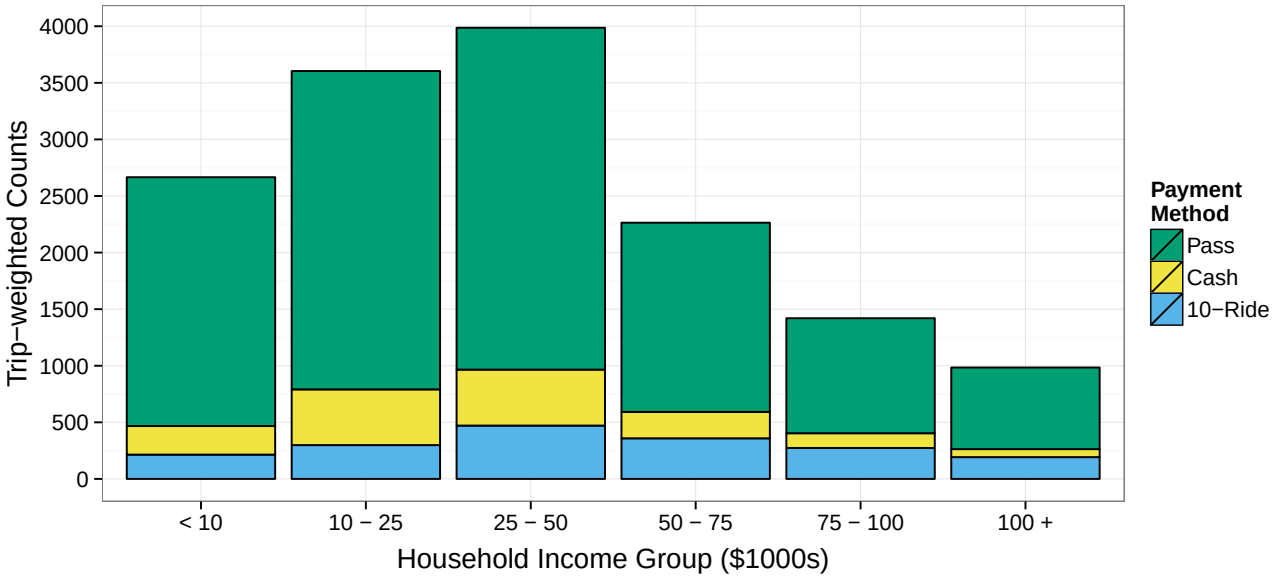


Figure 3 is also not very useful in understanding how payment methods vary across income groups since the variations in bar height distorts changes in payment method use. Figure 4 solves that problem by showing payment method use as a share of all rides within an income category.

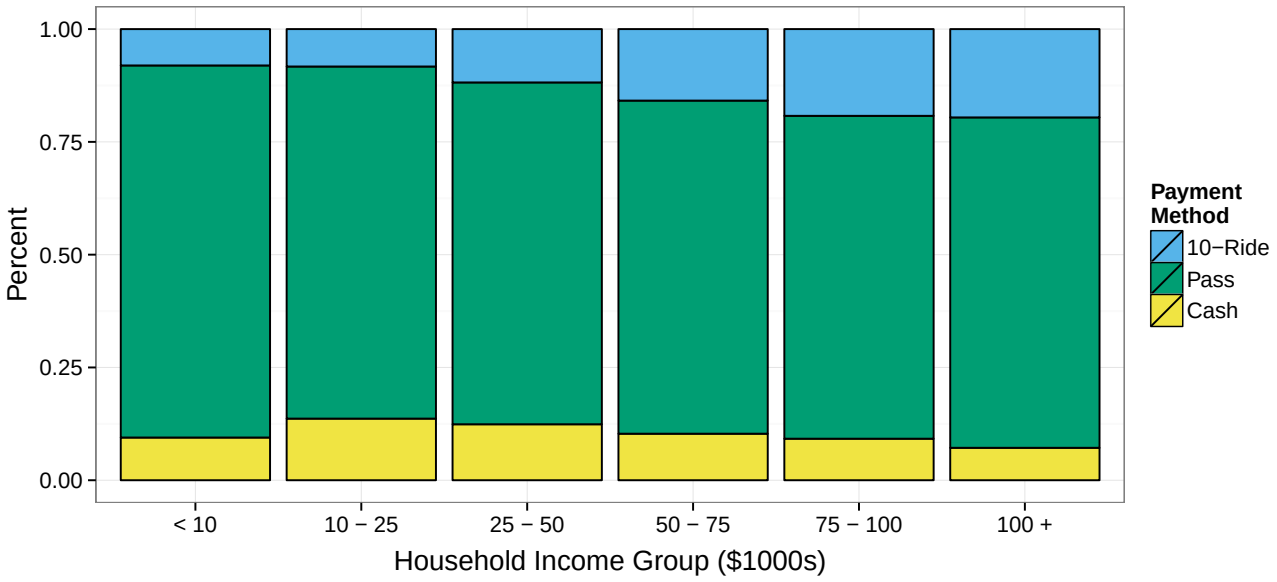
In Figure 4, cash is a more common payment method those with incomes in the $10,000 to $50,000 range than other income groups. Cash payment may be less common in the lowest income category because that group is likely to contain a large number of college students. [5] 10-ride pass use grows as a share of trips as income increases. A possible explanation is that wealthier riders are less consistent riders, and infrequent riders gain more benefit from a 10-ride pass, since the tickets do not expire, than from purchasing an unlimited rides pass.

Figure 5 groups trips using a single payment method together to show the income groups that use that payment type. The use of cash fares and unlimited rides passes skew to the left, while 10-ride pass use has a much more balanced distribution. There may be some distortion due to the varying width of income brackets. Continuous data would tell a more interesting story but is very hard to collect in surveys.

[4] All data is self-reported at a household level.

[5] The 2008 OBS does not provide the data necessary to exclude students from analysis and check whether in the rest of the Madison population cash payment utilization and income are inversely correlated.

Figure 4: Payment Method Use Within Income Groups

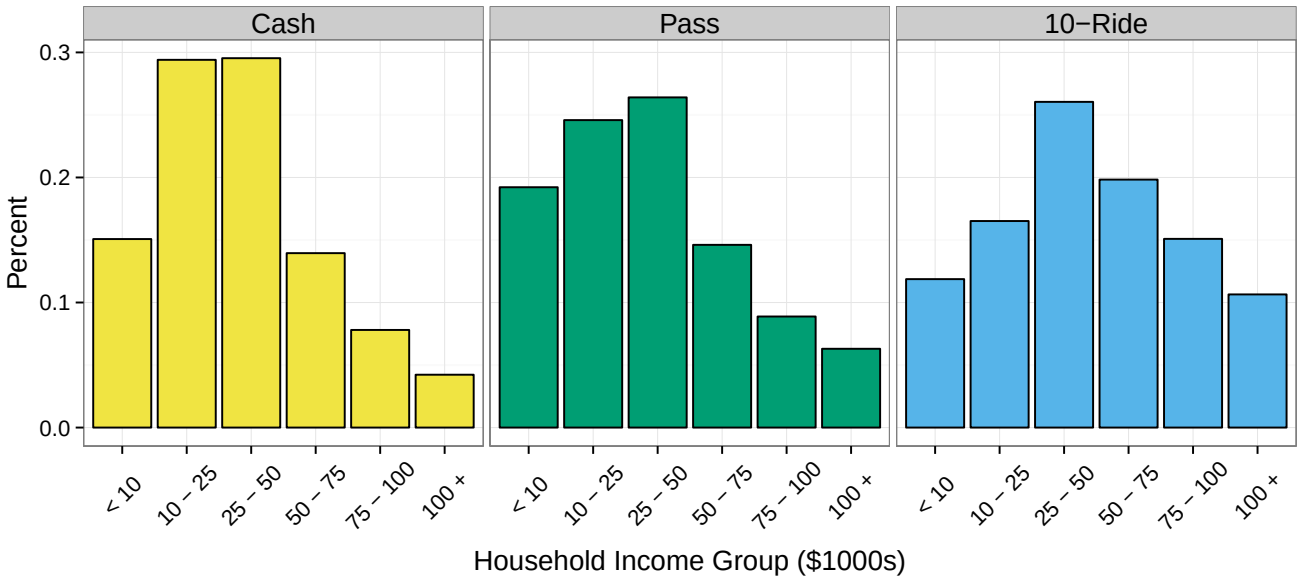


The preceding three figures contain different ways to examine payment method use across income groups. Table 2 provides a numerical representation of the data in a format that is most similar to Figure 5. It uses a ratio calculation to help identify which income-payment method groups differ most from the use level that could be expected if there was no variation in use across income. Values less than one reveal an income-payment combination this is less frequent than would be expected if payment method consistent across groups.

Table 2: Payment Method and Income

	<10	10-25	25-50	50-75	75-100	100+
% Total Ridership	17.9	24.1	26.7	15.2	9.5	6.6
% Cash Ridership	15.1	29.4	29.5	13.9	7.8	4.2
% Pass Ridership	19.2	24.6	26.4	14.6	8.9	6.3
% 10-Ride Ridership	11.9	16.5	26.0	19.8	15.1	10.6
Cash Ratio	0.8	1.2	1.1	0.9	0.8	0.6
Pass Ratio	1.1	1.0	1.0	1.0	0.9	1.0
10-Ride Ratio	0.7	0.7	1.0	1.3	1.6	1.6

Figure 5: Income Profile for Payment Method Groups



Differences Across Racial Groups

Just as important for equity concerns, and possibly more so in terms of Title VI obligations, is the variation in use of payment methods across racial groups. The absolute counts in Figure 6 obscure differences as the ridership of Metro Transit is predominately white, which hides almost all variation in payment method use between racial/ethnic groups.

Figure 6: Trip-Weighted Counts of Payment Method Use by Racial/Ethnic Group

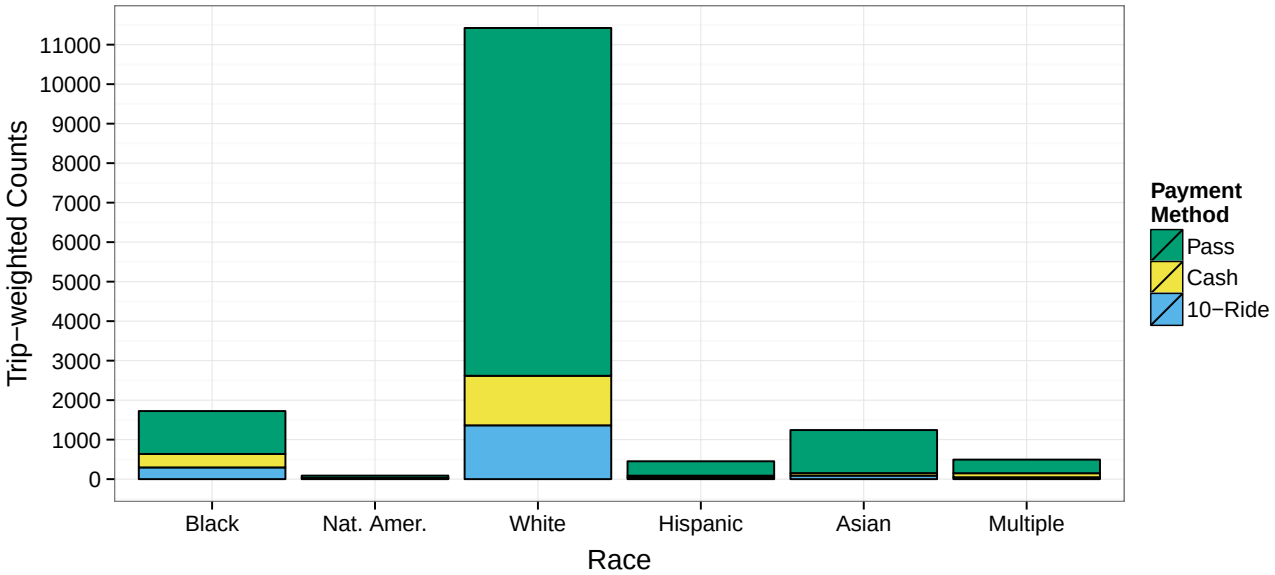
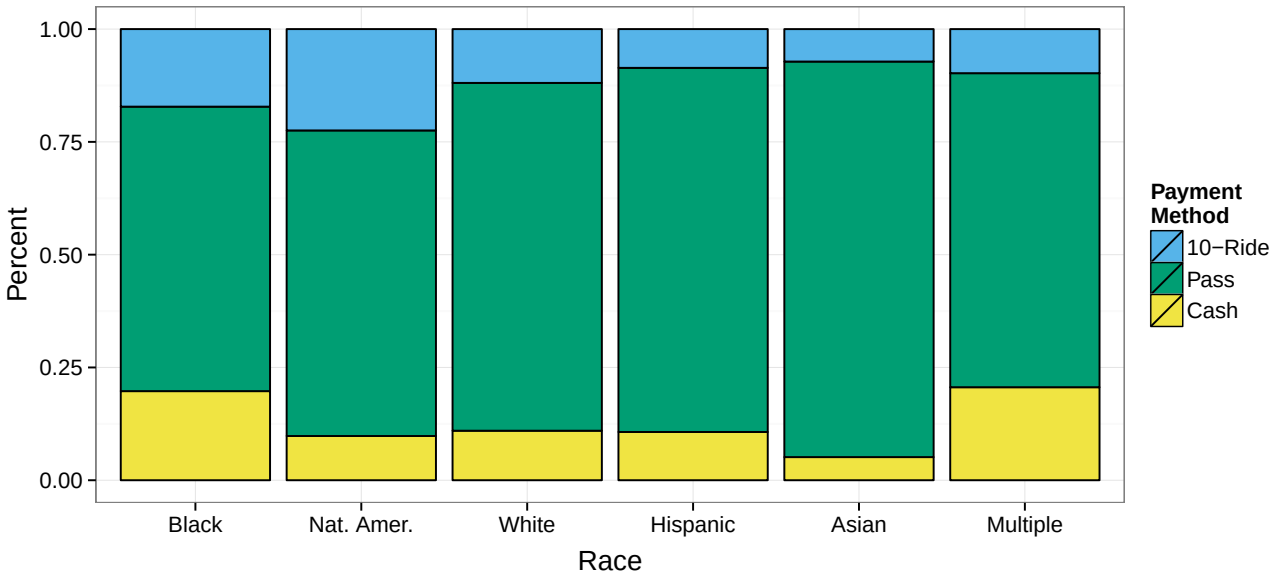


Figure 7 shows payment method use as shares of a racial groups total ridership. Cash fares and 10-ride passes account for an unusually high portion of Black riders payments. Those identifying as multiple races also use cash for a large portion of their fare payments. 10-ride pass utilization is high for Native American riders, but it is important to recognize that responses from those identifying as Native American accounted for less than 10 of the 4600 survey responses and may not be statistically reliable.

Table 3 follows the same format as Table 2, using a ratio calculation to highlight unusual payment method patterns along racial categories. The ratio for cash fare use among black and multiple race respondents

Figure 7: Payment Methods Use Within Racial Groups



is especially noteworthy as it is much larger than one. Asian respondents are much less likely to utilize payment methods other than unlimited rides passes than their share of total ridership would predict.

Table 3: Payment Method and Race

	Black	Nat. Amer.	White	Hispanic	Asian	Multiple
% Total Ridership	11.2	0.6	74.1	2.9	8.1	3.2
% Cash Ridership	18.7	0.5	69.0	2.7	3.5	5.6
% Pass Ridership	9.3	0.5	74.9	3.1	9.3	2.9
% 10-Ride Ridership	16.0	1.1	73.4	2.1	4.8	2.6
Cash Ratio	1.7	0.8	0.9	0.9	0.4	1.8
Pass Ratio	0.8	0.9	1.0	1.1	1.2	0.9
10-Ride Ratio	1.4	1.9	1.0	0.7	0.6	0.8

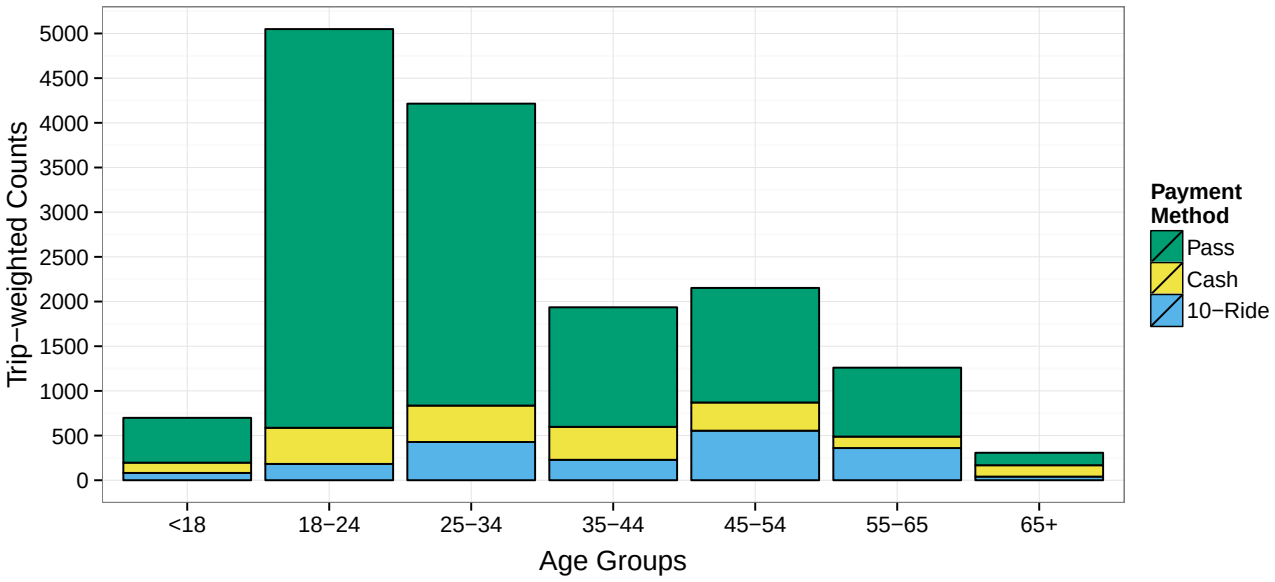
Differences Across Age Groups

Age differences are an important equity consideration, although slightly less so from the perspective of Title VI. Figure 8 shows that the ridership of Metro Transit is predominantly young. This is likely driven by the unlimited rides programs for area colleges. As is the case with the income and race variables, using count data, it is difficult to tell how use of the payment methods differs across age groups.

Figure 9 reveals cash use is very high for those over 65.[6] 10-ride passes are most popular among the middle-aged population, with over 25 percent of those from 45-65 using 10-ride passes. Very few 18-24 year old riders travel using payment methods other than unlimited rides passes, suggesting that a very large portion of this ridership category is composed of students receiving passes from their academic institutions. Figure 10 reinforces how skewed that distribution is for unlimited rides passes. Cash fare payments also skew to the left, although in a much less extreme manner. The 10-ride payment category does not exhibit this pattern at all.

[6]Over-65 ridership is low compared to other age categories, so there are fewer equity implications than this finding may imply. Additionally, a change in the fair structure makes cash fares much lower relative to 10-ride passes for those over 65.

Figure 8: Trip-Weighted Counts of Payment Method Utilization by Different Age Groups



The notable values in Table 4 are the low ratio calculation for 10-ride pass use by younger age groups, the high usage of 10-ride passes in the 45-55 and 55-65 groups, and the fact those over 65 account for a 3.5 times greater share of cash fare payments than their share of total estimated system ridership.

Table 4: Payment Method and Age

	< 16	16-24	25-34	35-44	45-54	55-65	65+
% Total Ridership	1.8	35.0	27.0	12.4	13.8	8.1	2.0
% Cash Ridership	2.0	25.8	21.8	19.7	16.9	6.9	6.8
% Pass Ridership	2.0	39.8	28.5	11.3	10.8	6.5	1.2
% 10-Ride Ridership	0.7	13.4	22.8	12.2	29.6	19.2	2.2
Cash Ratio	1.1	0.7	0.8	1.6	1.2	0.9	3.5
Pass Ratio	1.1	1.1	1.1	0.9	0.8	0.8	0.6
10-Ride Ratio	0.4	0.4	0.8	1.0	2.1	2.4	1.1

Figure 9: Payment Methods Use Within Age Groups

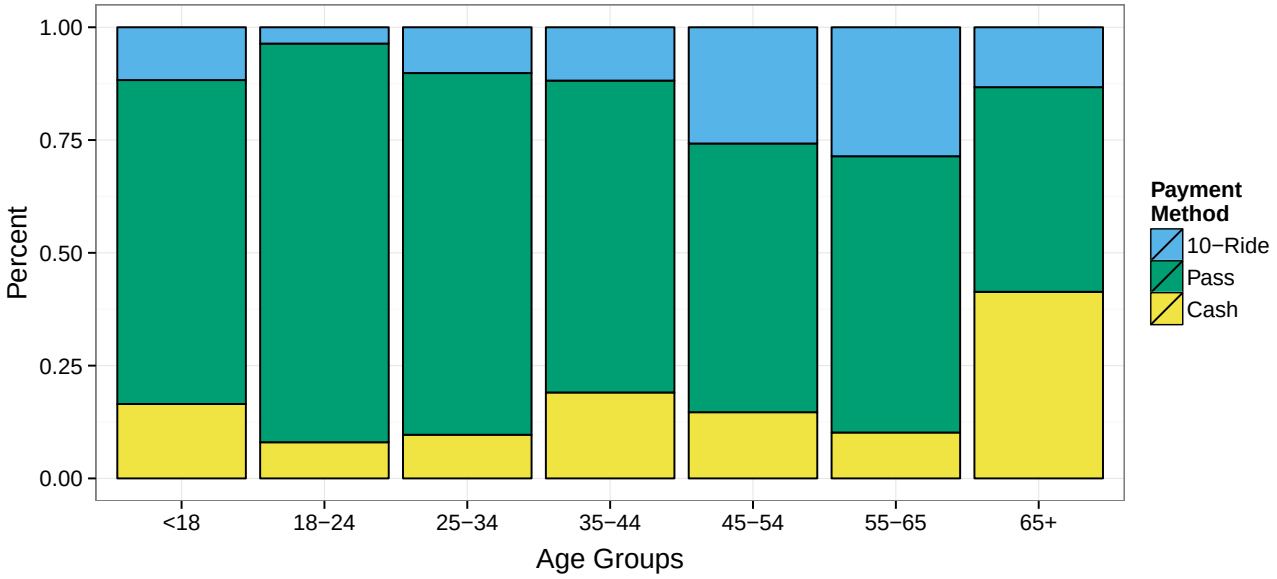
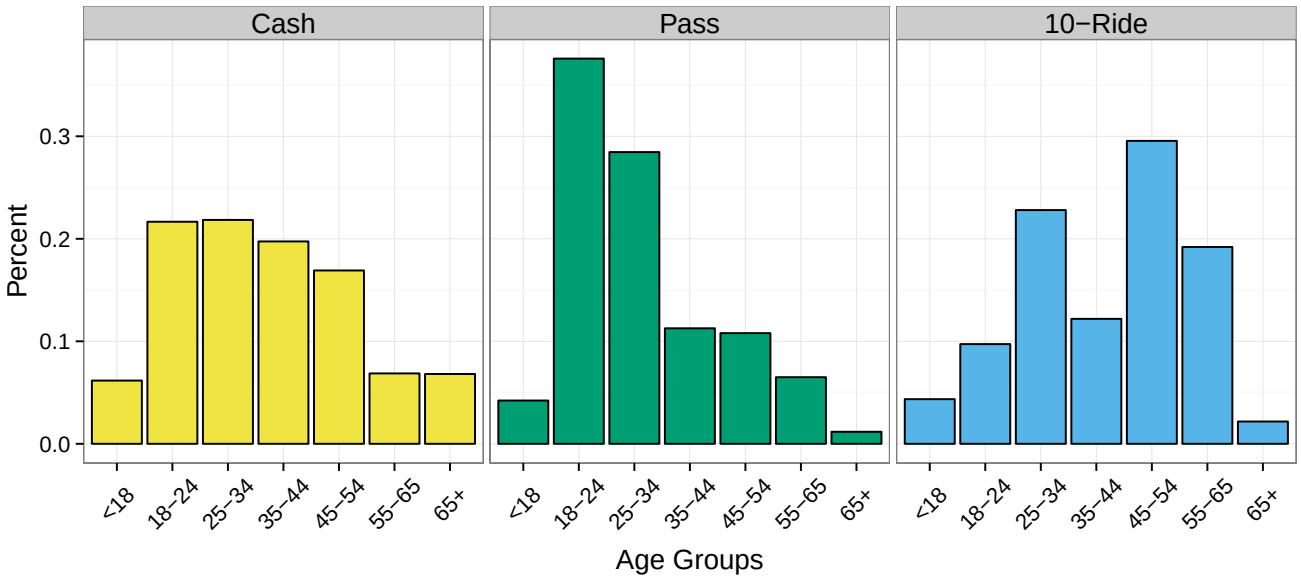


Figure 10: Age Profile for Payment Method Groups



Differences Across Vehicle Availability

Whether a vehicle was available to a respondent at the time of their trip provides one way to think about choice riders versus captive riders on the metro system. Figure 11 suggests that in total trips closely split between choice and captive riders. Looking to Figure 12, it is apparent that those using cash to pay their transit fares are considerably less likely to have access to a vehicle during their travel. This highlights an important correlation between transit dependence and cash fare use that could deserve more study. The disproportionate use of cash payments by transit dependent individuals is apparent in the ratios in Table 5. If college students could be removed from the samples the available/unavailable ratio for pass users could chance as well.

Figure 11: Trip-Weighted Counts of Payment Method Use by Vehicle Availability

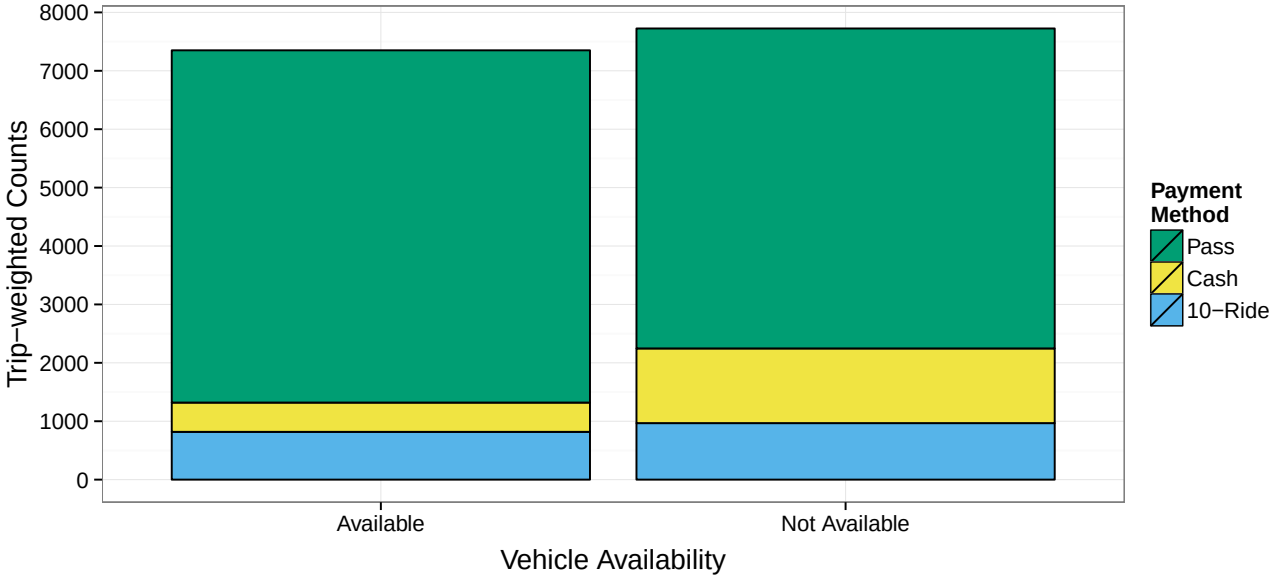


Figure 12: Vehicle Availability Split within Payment Method Groups

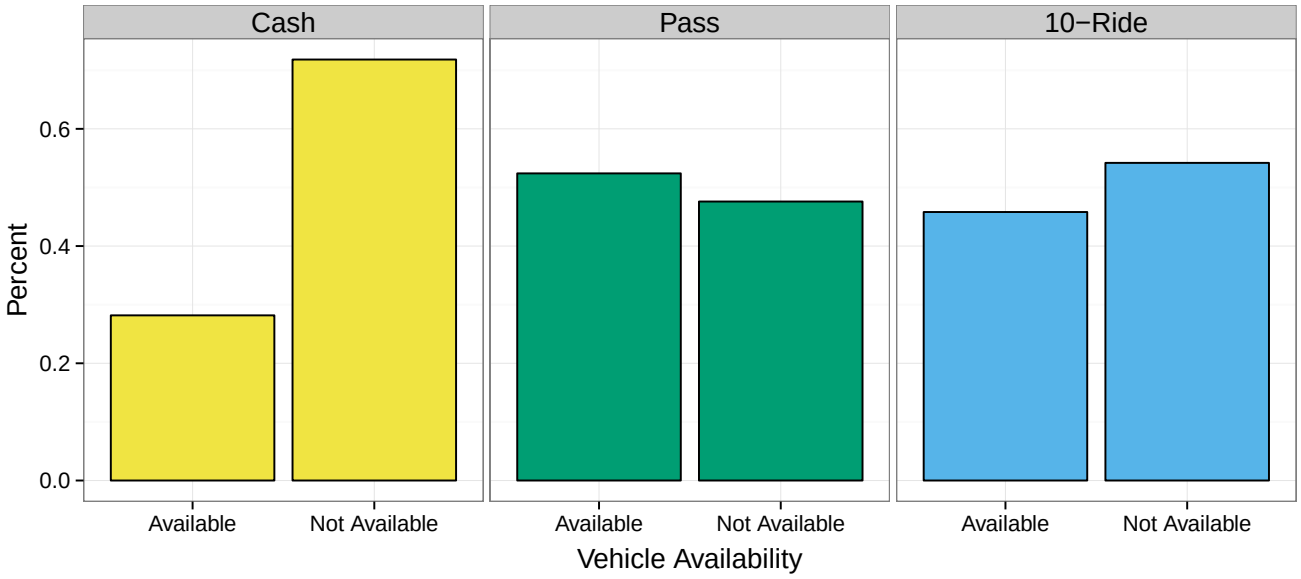


Table 5: Payment Method and Vehicle Availability

	Available	Not Available
% Total Ridership	48.8	51.2
% Cash Ridership	28.2	71.8
% Pass Ridership	52.4	47.6
% 10-Ride Ridership	45.8	54.2
Cash Ratio	0.6	1.4
Pass Ratio	1.1	0.9
10-Ride Ratio	0.9	1.1

Transfer Rates

This section moves from the discussion of payment methods to examining the data on transfer rates collected in the OBS. Transfer rates provide a useful insight as an indirect measurement of quality of service, rider experience, and total trip time. Studies show that the disutility associated with waiting for a bus is considerably greater than the disutility from time spent en route to your destination. Even if the trip times are the same for two riders, the one who spends time waiting at a transfer point feels like they have received worse service. The following section examines transfer rates across income groups, racial/ethnic groups, and vehicle availability.[7]

This transfer analysis considers three different ride profiles constructed from the survey data. One ride profile is a transfer-free one-seat ride. The second ride profile is a trip with only a single transfer. The final ride profile contains all trips with more than one transfer. The majority of multiple-transfer trips contain two transfers, while few respondents reported three or four transfers in the survey.

Differences Across Income Groups

The left panel of Figure 13 mirrors the total ridership counts by income group that were seen in Figure 3. Ridership skews towards the lower brackets defined by the survey. The differences within income brackets are more clear in the right panel of Figure 13. Very few trips taken by riders with higher incomes involve multiple transfers and barely 10 percent of riders transfer at all in the $100,000 plus income group. This is not surprising, as higher income riders likely have alternatives to transit and only choose to ride the bus if it's convenience is comparable to driving.

In Figure 14, the distribution of income among riders taking multiple transfers clearly skews to the left. The portion of one-seat riders with incomes above $75,000 is about 4 times higher than the portion of multiple seat riders in that income range. More precise numbers can be found in Table 6. The ratio calculations in the table also show the much smaller of a share of multiple-transfer riders for which high-income groups account, as well as the increased likelihood of low-income individuals to make multiple transfers during their trip.

[7] Age differences in transfer rates were examined but did not exhibit any interesting characteristics.

Figure 13: Transfer Rates by Income Group - Counts and Within-Group Ride Profile

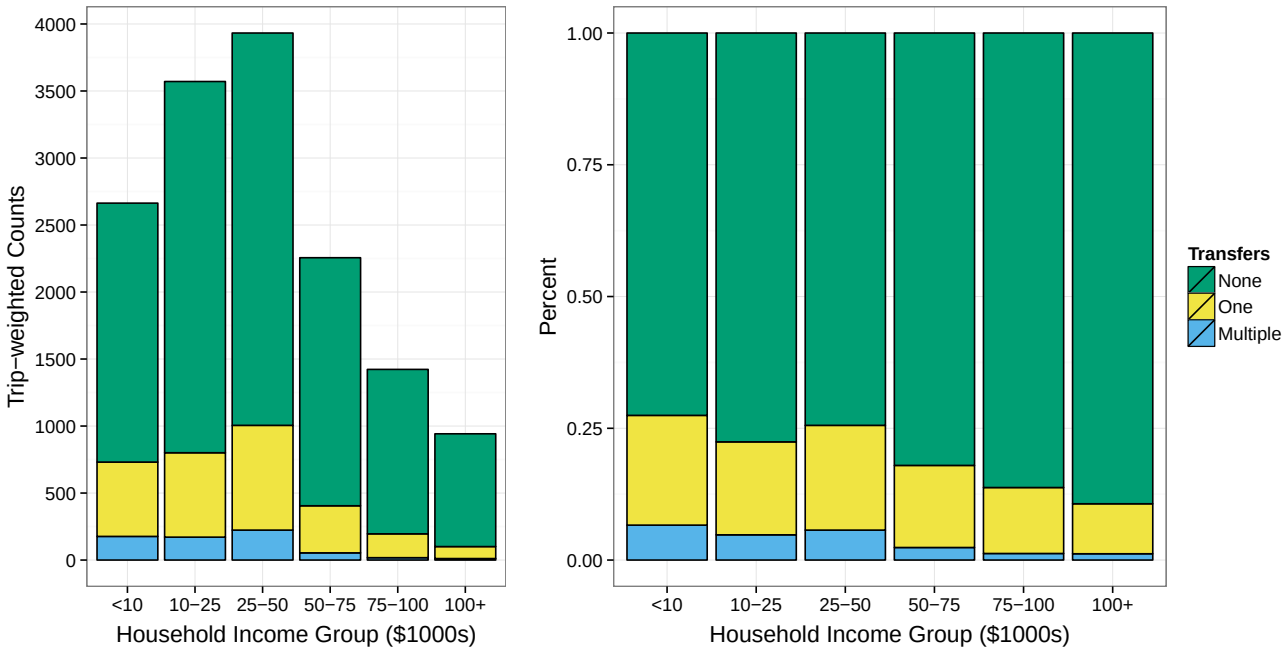


Figure 14: Income Distributions for Three Ride Profiles

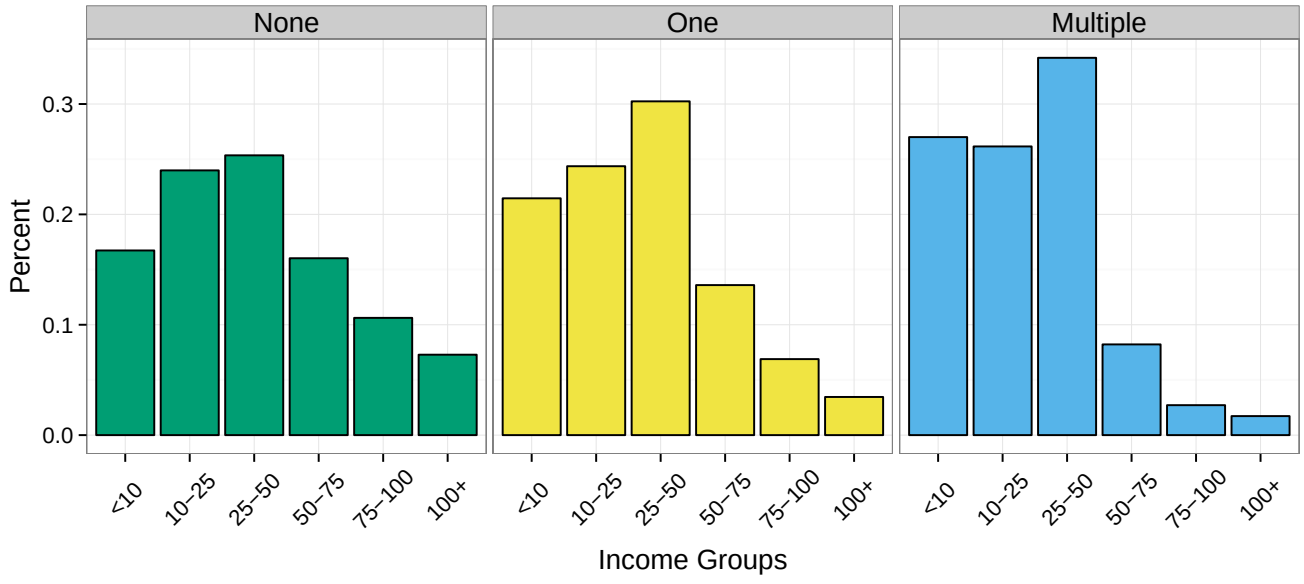


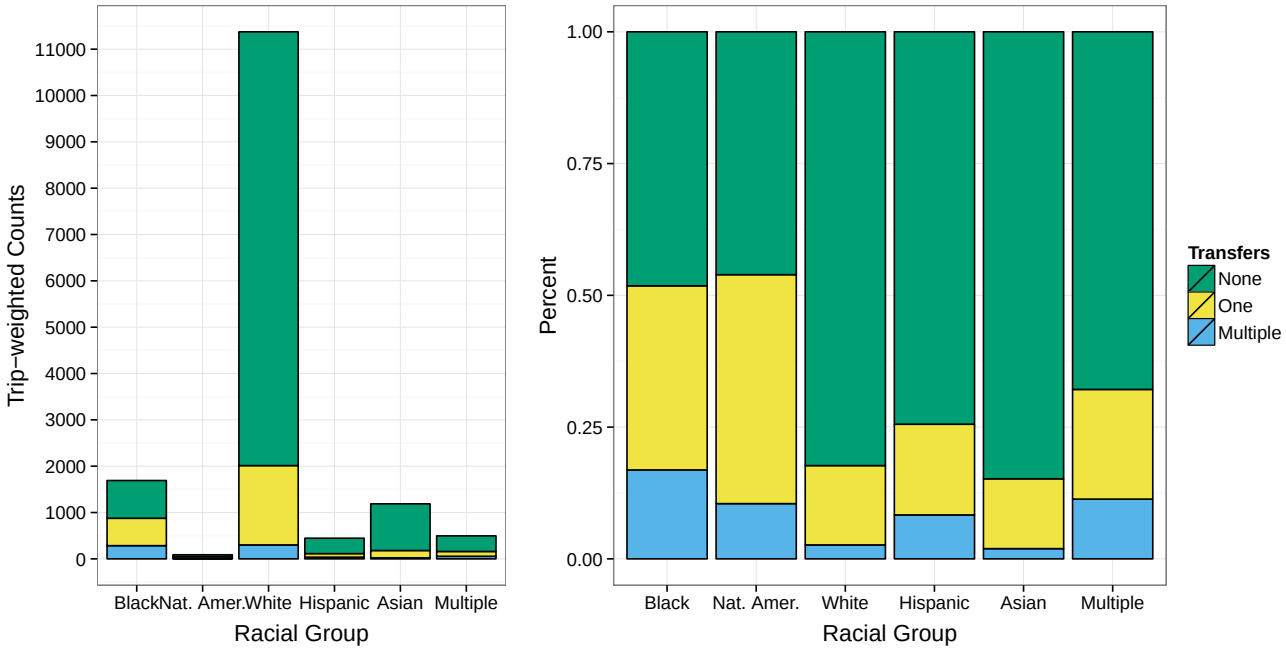
Table 6: Transfers and Income

	<10	10-25	25-50	50-75	75-100	100+
% Total Ridership	17.9	24.1	26.7	15.2	9.5	6.6
% One-seat Rides	16.7	24.0	25.3	16.0	10.6	7.3
% Single Transfer Rides	21.5	24.4	30.2	13.6	6.9	3.5
% Multiple Transfer Rides	27.0	26.2	34.2	8.2	2.7	1.7
One-Seat/Total	0.9	1.0	0.9	1.1	1.1	1.1
Single/Total	1.2	1.0	1.1	0.9	0.7	0.5
Multiple/Total	1.5	1.1	1.3	0.5	0.3	0.3

Differences Across Racial Groups

Of all of the insights provided by the 2008 on-board survey, the following disparity between black and white transfer rates is perhaps the most noteworthy finding for Metro to consider when planning to meet its Title VI obligations. The left panel of Figure 15 highlights the fact that, overall, riders are disproportionately white and experience one-seat rides. However, the right panel shows that over half Black or African American riders transfer during their trip. This number is less than 20 percent for white riders. The portion of Black riders who make more than one transfer is almost as high as the share of White riders who transfer a single time.[8]

Figure 15: Transfer Rates by Racial Group - Counts and Within-Group Ride Profile



In Figure 16 and Table 7, Black riders account for 40 percent of all multiple transfer trips even though they account for only 11.2 percent of total system ridership. They also account for an incredibly low portion of one-seat rides relative to their total ridership. Native Americans and those reporting multiple races, as well as Hispanics, to a lesser degree, all transfer more than would be expected based on their share of ridership.

[8]The evidence for disparity between Black riders and White riders is much stronger than for Native American riders because the sample of Native American Ridership provided by the survey was so small.

Figure 16: Racial Differences in Composition of Ride Profile Groups

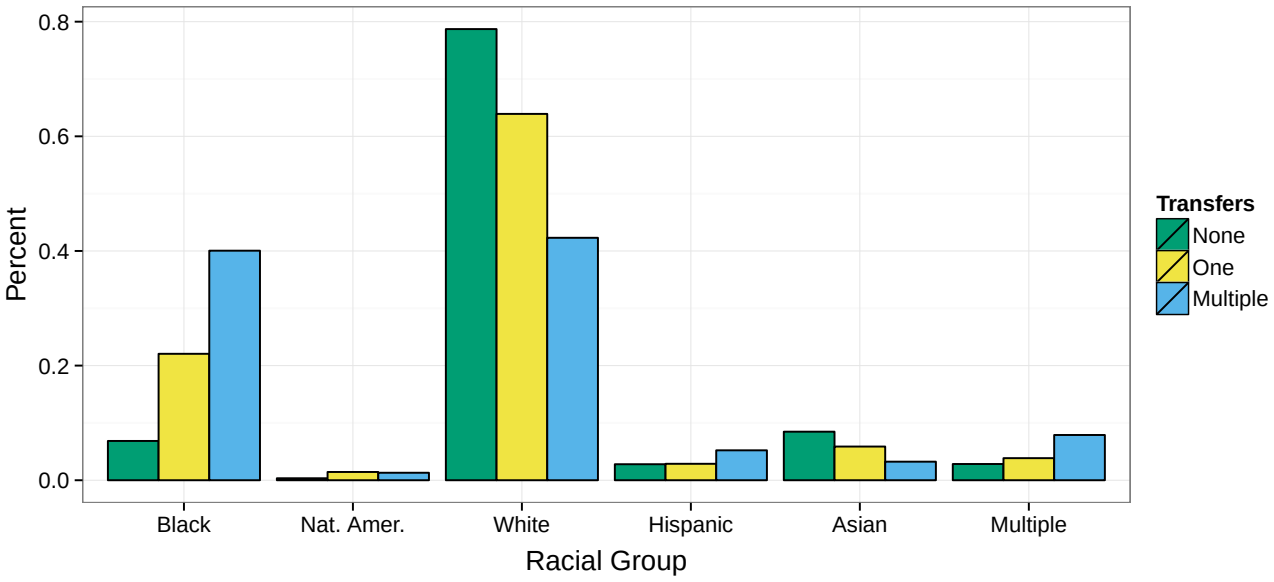


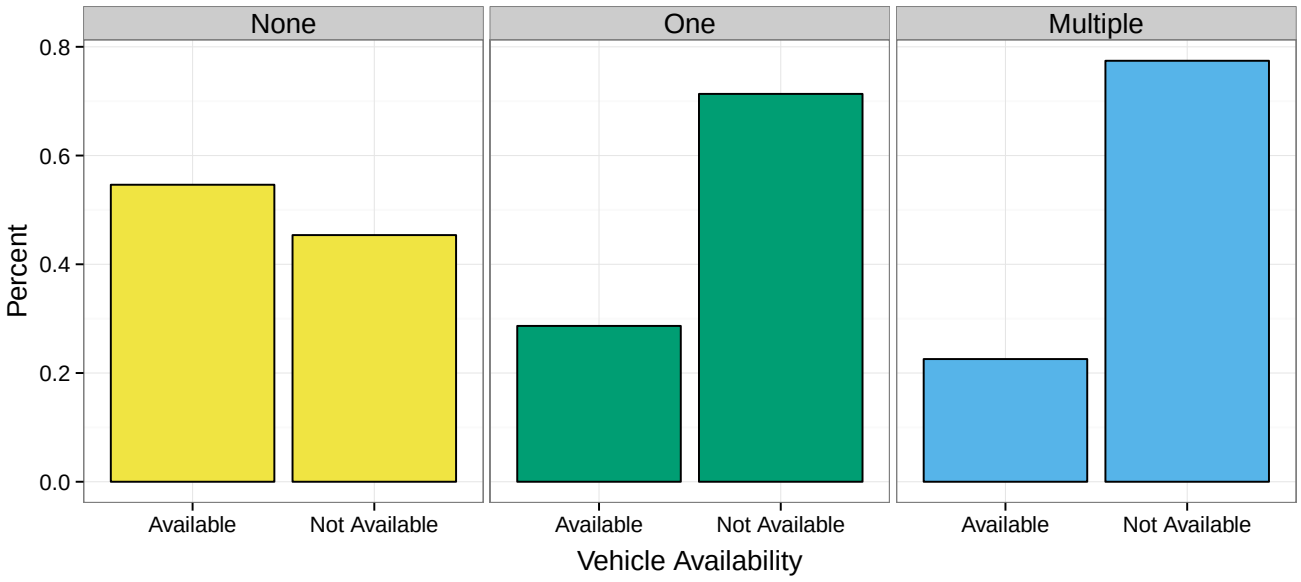
Table 7: Transfers and Race

	Black	Nat. Amer.	White	Hispanic	Asian	Multiple
% Total Ridership	11.2	0.6	74.1	2.9	8.1	3.2
% One-seat Rides	6.9	0.3	78.7	2.8	8.5	2.8
% Single Transfer Rides	22.1	1.4	63.9	2.9	5.9	3.9
% Multiple Transfer Rides	40.0	1.3	42.3	5.2	3.2	7.9
One-Seat/Total	0.6	0.6	1.1	1.0	1.1	0.9
Single/Total	2.0	2.5	0.9	1.0	0.7	1.2
Multiple/Total	3.6	2.3	0.6	1.8	0.4	2.5

Differences Across Vehicle Availability

In Figure 12 it was clear that transit-captive riders are much more likely to use cash to pay for their trips than choice riders based on the vehicle availability survey question. In Figure 17 there is an even more pronounced difference between choice and captive transit riders in terms of transfer rates. The majority of one-seat rides are taken by riders with a vehicle available. These riders are not very willing to take rides with transfers because these rides are likely to have greater disutility than driving. However, if a rider does not have a vehicle available for their trip, they accept transfers in order to reach their destination.

Figure 17: Vehicle Availability Split by Number of Transfers



Trip Purpose

The trip purpose data collected in the OBS provides additional insight into the ways the system is used. The following analysis shows how the system functions differently for people taking different types of trips and who is taking those different trip types.

The 2008 on-board survey analysis focuses on five trip purposes. Four trip purposes are "home-based," meaning that one end of the trip - origin or destination - is the respondent's home. The other possible endpoints of home-based trips in the survey analysis are "other," "school," "university," and "work." Home-based university trips may include school or work trips.[9] The fifth trip purpose is all "non-home-based" trips.

Trip Purpose and Trip Distance

In Figure 15, White and Asian riders have very low transfer rates. These demographics groups are strongly represented on the UW Campus. Figure 18 shows that home-bound university trips are relatively short. When people are traveling short distances it makes more sense that they have short trips. The number of medium-to-long trips is a much greater portion of trips to work. Figure 19 shows that both school and work trips are much less likely to be less than 3 miles in length.

[9]This is not a typical trip purpose in transportation demand models, but is clearly important to the Metro Transit system.

Figure 18: Trip-Weighted Counts by Trip Purpose and Trip Distance

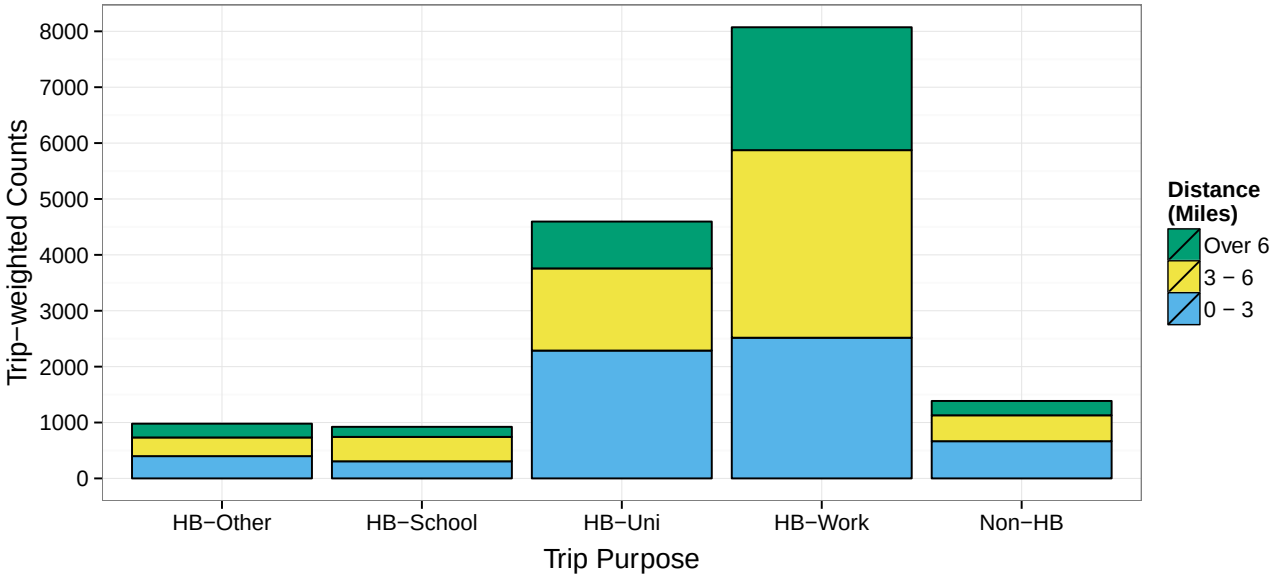
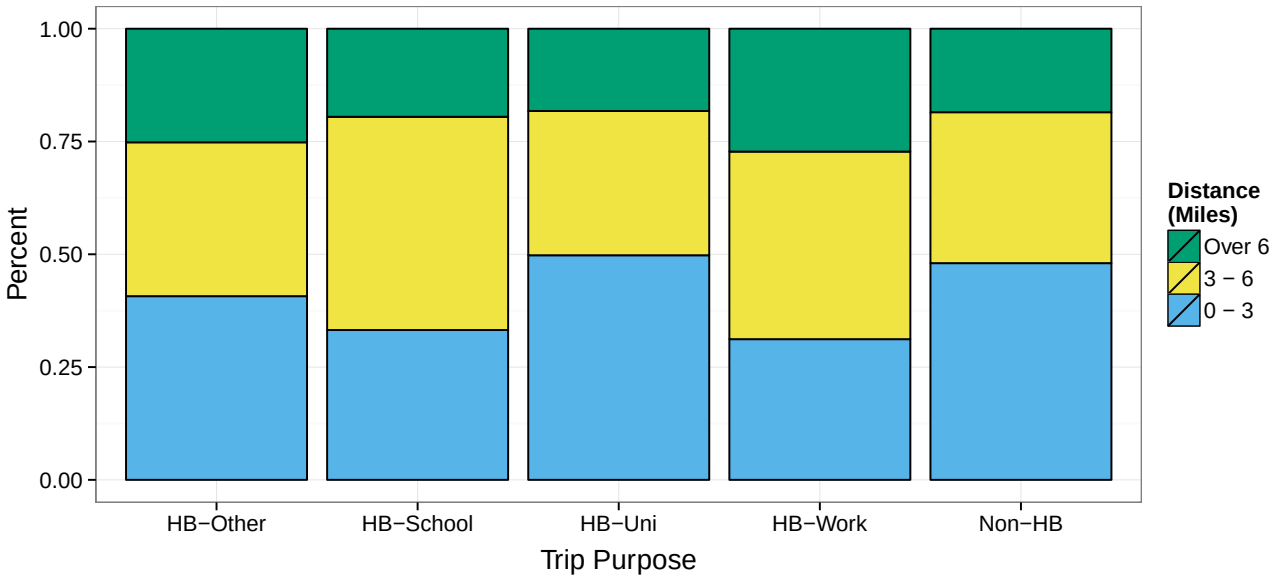


Figure 19: Travel Distance Within Trip Purposes



Transfer Rates Across Trip Purposes

In Figure 18, it is clear that based on the survey the most important function of the system is commuting between home and either work or the university. Some of this may be due to sampling bias in the time of day and routes where surveys were collected that was not corrected through trip-weighting. Using the 2008 trip-weights, around 20 percent of trips are unrelated to the university or workplace, as can be seen in Table 8.

Figure 20 shows that only about 60 percent of "home-bound other" and "home-bound school" trips are one-seat rides. Over 82 percent of "university" trips are one-seat rides. The higher efficiency of the system for university and work commutes is both intentional as Metro works to attract choice transit riders, and coincidental due to the geography of Madison and rider's residential choices. High route density near the university and the residential choices of individuals associated with the university leads to them having better transit service. However, Title VI populations may not have the same residential choices available to them, and Metro still has an obligation to provide them equitable service despite the complicated spatial structure of the city. The population using the bus system for school trips is also likely difficult to target through system design, as are other-purpose trips, which could be to an immense variety of locations for various purposes. The following section shows how trip purpose, Title VI, and system design are related.

Figure 20: Transfer Rates Across Trip Purposes

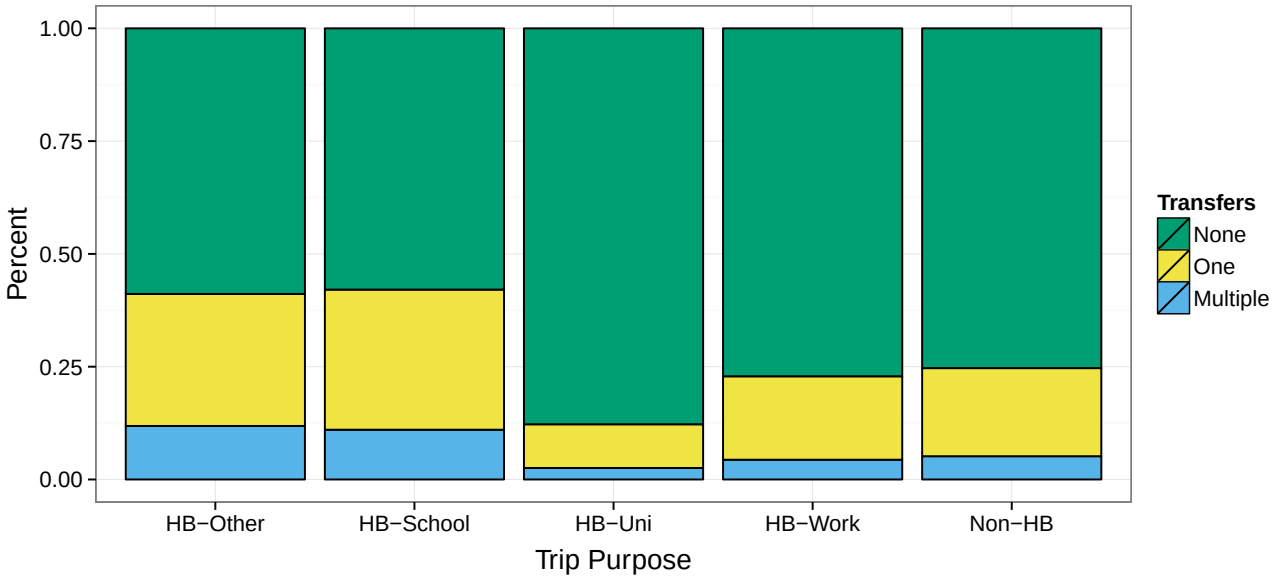
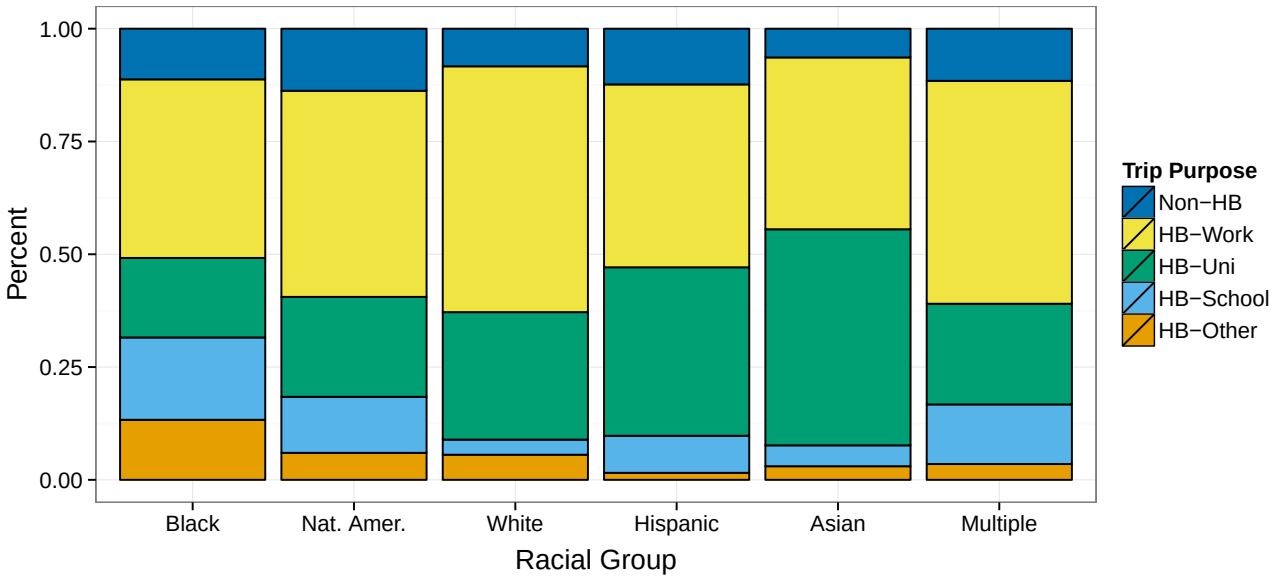


Table 8: Transfers and Trip Purpose

	HBO	HBS	HBU	HBW	NHB
% Total Ridership	6.1	5.8	28.8	50.6	8.7
% One-seat Rides	4.6	4.4	32.1	50.6	8.4
% Single Transfer Rides	10.3	10.4	15.7	53.9	9.7
% Multiple Transfer Rides	15.2	13.5	15.2	46.8	9.3
One-Seat/Total	0.8	0.8	1.1	1.0	1.0
Single/Total	1.7	1.8	0.5	1.1	1.1
Multiple/Total	2.5	2.3	0.5	0.9	1.1

Trip Purpose and Race

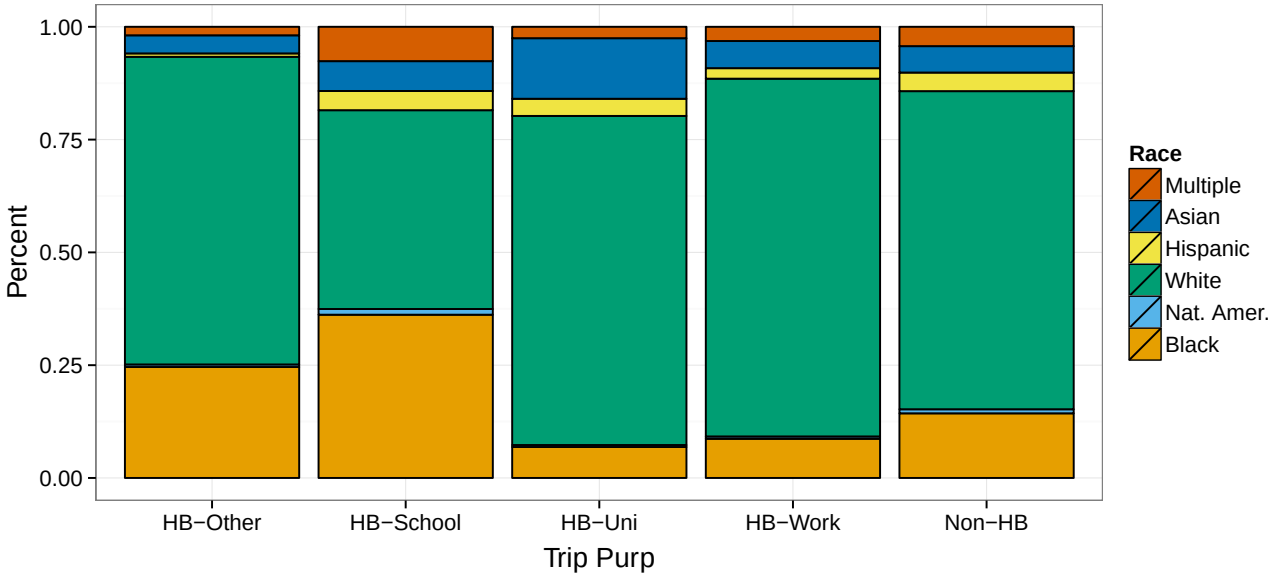
Figure 21: Travel Purposes Within Racial Groups



There are differences in system usage across racial and ethnic groups, as is clear from Figure 21. Trips to work are the major purpose for White riders, while Asian riders most frequently travel between home and the university. Blacks, Native Americans, and those of Multiple races rely much more heavily on the Metro system to get to school. Blacks use the system especially heavily for trips classified as "home-based-other."

Figure 22 simply reverses how the variables of interest are organized. This reveals just how disproportionately important Metro Transit is in helping Black students get to school. Blacks account for 35 percent of all home-based-school trips, even though they make up only 11.2 percent of total ridership (Recall row one of Table 3).

Figure 22: Racial Groups Within Trip Purposes

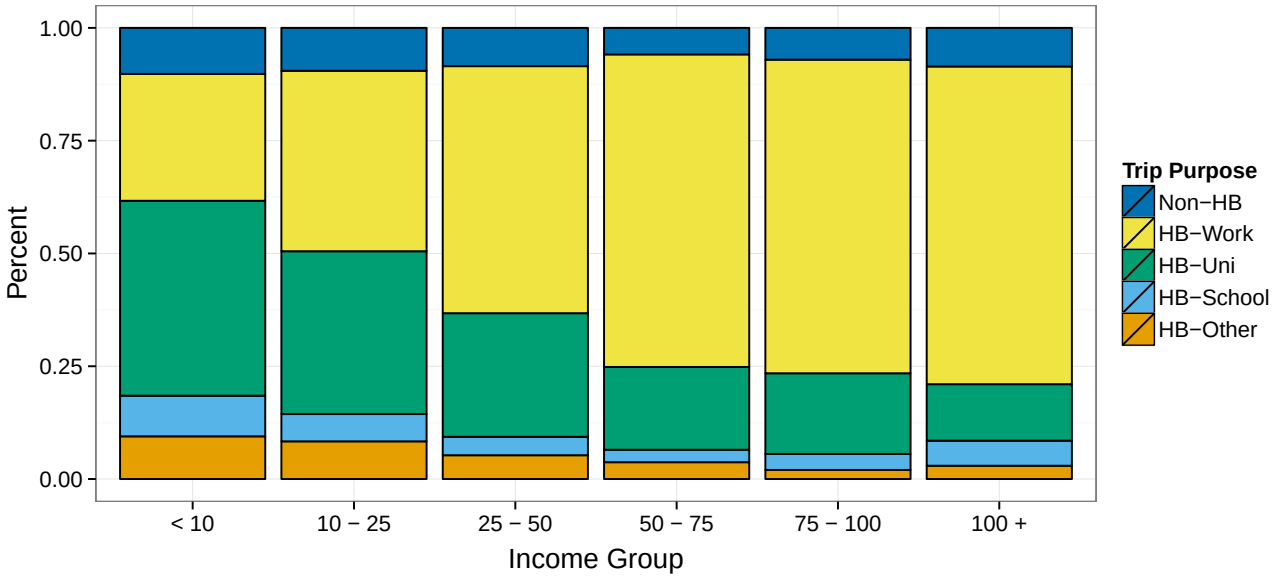


Trip Purpose and Income

There are also interesting stories revealed when trip purpose is compared to income level. It would again be useful if university students could be analyzed separately. With this group included, low-income groups

are much less likely to travel to work than higher income groups. They are much more likely to use Metro's system to take "school" or "other" trips.

Figure 23: Travel Purposes Within Income Groups



Policy Implications

This analysis provides insight into important considerations when changing Metro policies and in regards to future opportunities for data collection. The Metro Transit system is utilized differently by different populations, with variation across age, income, race, and vehicle availability. These variations are partly within the control of Metro Transit policies, although they are affected by structural characteristics of the city's spatial, social, geographic, and demographic makeup. Metro has little influence over why people travel and where they live, but Metro can affect how the system meets there needs.

The information available in the 2008 survey may be most useful to inform decisions about changes in fare categories. Survey results show that minority populations are more likely to use cash to pay fares, and that cash fare users are much more likely to be transit-captive than users of other payment methods. On the other hand, 10-ride passes are relatively more popular with higher income groups. This may suggest that cash fares should be raised as little as possible, while it is perhaps the case that the financial benefits of purchasing 10-ride passes are being captured by users that are not as likely to need them need them.

Future surveys should allow students at the city's main college campuses to be removed from the unlimited rides pass data to understand how passes provided by employers may differ from other fare categories. In general, the level of aggregation in the 2008 survey analysis from Cambridge Systematics restricts the ability to carry out some interesting lines of equity analysis. For example, the "home-bound-university" trip purpose combines students with staff and faculty at the university even though it is likely that these groups have significantly different travel patterns and demographic characteristics such as income, vehicle availability, household size and others.

Metro needs to explore its ability to insure equitable service for minority populations who do not use the system as frequently for commuting to work and university. It is important to recognize that the system serves many purposes for many people. When enhancements are made to commuter service, the risk that this further increases the relative disadvantage of Title VI groups must be considered. Metro should investigate why these populations are transferring for such a large portion of their trips and if it is possible to increase the number of one-seat rides that this portion of riders has available to them.

The origin-destination data provided by on-board surveys, including the 2008 survey and the in-progress update, could help understand the needs of these populations and identify opportunities for targeted service improvements. However, any analysis of data on the current system cannot provide accurate insight into optimal configurations because it is biased by the existing structure of the system. If Metro and the city are interested in understanding what changes could have the greatest impact on these groups, ongoing targeted interactions with these neighborhoods will be necessary.

The in-progress survey will greatly improve the ability to understand evening and night-time travel patterns. This service may be even more important for low-income and minority riders and differ significantly from morning commute patterns. Future surveys should continue to work to resolve the challenges posed by UW-Madison students composing such a significant portion of system ridership.