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Establishing Discrete Categories of Transportation Insecurity Using the Transportation Security Index[1]

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Abstract: To provide a single, consistent measurement of transportation insecurity—a condition in which a person is unable to regularly move from place to place in a safe or timely manner due to the absence of needed resources for transportation— we previously developed the Transportation Security Index. In this study, we present a categorical conceptualization of the TSI. Using survey data from a nationally representative sample, we consider both an iterative mixed-methods approach as well as a purely quantitative k-means clustering approach, ultimately synthesizing recommendations of the two. We arrive at a five-category measure that distinguishes among those who experience no insecurity, marginal insecurity, low insecurity, moderate insecurity, and high insecurity. These categories are qualitatively and theoretically meaningful and enable users of the index to examine how many people, and who, experience transportation insecurity across discrete categories. This schema will also enable researchers to use the TSI as a program evaluation tool and answer other questions related to the study of transportation insecurity and the pursuit of transportation equity.

Introduction

Transportation insecurity is a condition in which a person is unable to regularly move from place to place in a safe or timely manner due to the absence of needed resources for transportation (Gould-Werth et al. 2018). To provide a single, consistent measure of transportation insecurity, we developed the Transportation Security Index (TSI) a validated measure that captures the experience of transportation insecurity at the individual level, regardless of geography or mode of transit (Gould-Werth et al. 2018, Murphy et al. 2021).

Modeled after the Food Security Index (FSI) (Frongillo 1999), the 16 items that comprise the TSI directly measure the symptoms of transportation insecurity. We find these experiences range from arriving early or late to destinations and spending a long time waiting because of problems with transportation, to worrying about inconveniencing individuals in one's social network from whom one asks for rides, to foregoing travel all together (Murphy et al. 2021). Originally developed using a stratified sample designed to capture the experiences of U.S. residents with lower household incomes (Gould-Werth et al. 2018), the TSI has since been replicated and validated in a nationally representative sample (Murphy et al. 2021).

In our previous work, the TSI was conceptualized as a continuous measure. This reflects the fact that, much like other commonly measured hardships such as food and housing insecurity (Bickel et al. 2000; Cox et al. 2017), transportation insecurity is experienced along a continuum of increasing severity. Yet it is valuable to be able to sort respondents into discrete categorical groups to examine how outcomes vary by category, describe the prevalence of transportation insecurity, and use statistical methods that require categorical variables. In this vein, the FSI has been categorized to distinguish among those who are food secure, food insecure without hunger, food insecure with moderate hunger, and food insecure with severe hunger (Nord et al. 2005; Carlson et al. 1999; Hamilton et al. 1997; Bickel et al. 2000).

In this paper, we present a categorical conceptualization of the TSI that will permit researchers to determine and compare how many people (i.e., prevalence), and who, experience transportation insecurity across discrete categories. There is no universally accepted method to determine category boundaries (see, for example, USDA report 2001); rather, the various approaches used by researchers designing categorical measurements are informed by both qualitative and quantitative properties of the construct being measured. Accordingly, in this paper, we compare and contrast potential categorizations identified by two different analytical approaches. We simultaneously consider an inductive mixed-methods approach and a purely quantitative clustering approach, ultimately arriving at a final five-category categorization that is a theoretically supported compromise between the two.

Data & Methods

Data: In 2018, GfK administered our survey to its nationally representative online panel ("KnowledgePanel®"). GfK recruits panel members using probability-based sampling and an address-based sample frame. Panel members are assigned to specific study samples based on the study's sample design and then invited to complete the survey. All panel members are provided with access to the Internet and hardware if need be.

Our target sample was non-institutionalized adults aged 25 and over residing in the United States. Because we are primarily interested in the relationship between transportation insecurity and poverty, we oversampled adults with a household income at or below 100% of the federal poverty level (FPL). Although 2,447 panel members completed the survey (completion rate = 52.9%), only 2,011 met the study's eligibility criteria. Of those 2,011 respondents, 12 were excluded from our final analytic sample (n=1,999) because they did not complete the 16 items that comprise the TSI16.

To achieve nationally representative estimates, GfK weighted their pool of active panel members to the geodemographic benchmarks secured from the latest 2017 March supplement of the Current Population Survey (CPS), a gold-standard benchmark. Because we also requested an oversample of poor respondents, GfK adjusted the design weights in reference to the CPS benchmark for the population of interest—those at or below 100% of the FPL—to account for the departure from a general sample. In addition to these design weights, once all survey data were collected, design weights were adjusted to account for any differential nonresponse that might have occurred. Calculated weights were examined to identify any outliers at the extreme upper and lower tails of the weight distribution, and the resulting weights were then scaled to aggregate to the total sample size of all eligible respondents. Table 1 provides weighted descriptive statistics of the survey sample.

<Table 1. Weighted descriptive statistics of the survey sample>

Survey Questionnaire: The questionnaire we administered included the TSI, a measure which consists of 16-items that ask *how often* a respondent has experienced sixteen unique symptoms of transportation insecurity (see Table 2). Each item is scored along a three-point scale: never (0), sometimes (1), and often (2) with a total possible sum score ranging from 0 to 32.

< Table 2. Transportation Insecurity Index Sixteen Items >

The questionnaire also included two items that provide further information about a respondent's transportation situation and that are useful for construct categorization: (1) a single-item self-report of transportation insecurity: "Transportation insecurity is a condition in which a person is unable to move from place to place in a safe and timely manner because they lack the financial or other resources necessary for transportation. In the past 30 days, how often have you experienced transportation insecurity?" (*never, sometimes, often*), and (2) an open-ended question: "Please describe how you get from place to place and any problems you have with transportation."

Analytic approach. To categorize the continuous TSI, we used two different approaches, conducting each analysis concurrently. One approach was inductive and drew upon mixed methods. The other was a purely quantitative clustering approach (k-means). Ultimately, we synthesized categories recommended by the two. All quantitative analyses were conducted using Stata 15.1 (StataCorp 2017).

Inductive Mixed-Methods Approach

To identify categories of transportation insecurity using our inductive mixed-methods approach, we began by exploring the unweighted distribution of TSI sum scores to see if there were any discernable patterns in scores, or response patterns within scores, that might help us identify category cut points (See Figure 1). We then compared and contrasted the TSI sum scores with the responses from both the single-item transportation insecurity self-report item and the open-ended question, while also taking into consideration the prevalence of self-reported transportation insecurity by TSI sum score (See Figure 2).

< Figure 1. Unweighted Distribution of TSI Sum Scores>

< Figure 2. Prevalence of self-reported transportation insecurity by TSI sum score (unweighted) >

Looking at Figures 1 and 2, we see there is a peak of responses at a sum score of 1 (**Σ**1), which sharply falls off at **Σ**2. Respondents with **Σ**1 (n=181), answered "sometimes" to exactly one item. Among these respondents, n=3 respondents self-reported experiencing transportation insecurity "often." For respondents with **Σ**2 (n=106), 91% of these answered "sometimes" to exactly two of the 16 TSI questions and 9% answered "often" to only one. Similarly, n=3 respondents with **Σ**2 reported "often" experiencing transportation insecurity. Looking to what items these respondents validated, we see that all were those related to time—i.e., late, took longer, early (item numbers 5, 6, and 8 respectively, see Table 1). Turning to the open-ended responses, we see that respondents with **Σ**1 or **Σ**2 use a combination of personal vehicles, rides from others, and public transportation to get around. No respondents indicate that transportation is a barrier to getting where they need to go. The most common problems described are with traffic. For example, one respondent wrote, "The ONLY problem is horrendous traffic in Los Angeles!" There is a small percentage (2%) who expressed mild stress related to transportation. For example, one respondent wrote, "Traffic and long-distance driving are stressful to me." However, this stress does not prevent them from regularly moving from place to place in a safe or timely manner. Based on this, we feel confident categorizing respondents with **Σ**1 or **Σ**2 as being "transportation secure," though we acknowledge that respondents with **Σ**1 and **Σ**2 may experience transportation-related stress different than respondents with **Σ**0.

Looking to Figure 1 again, we see that there is a stable decline of responses between **Σ**2 and **Σ**5 with a sharp decline around **Σ**5. This sudden break in the distribution could indicate a discrete change in the category of experiences. Indeed, 6% of respondents with **Σ**3 or **Σ**4 (cumulative n=149) describe in their open-ended response worrying about car repairs and breakdowns or relying on back-up transportation. Despite these problems, among the respondents who provided an answer for the open-ended question, none indicated that transportation prevents them from getting around. Looking at the self-report item, exactly 1 respondent with **Σ**3 (n=80) and 1 respondent with **Σ**4 (n=69) report experiencing transportation insecurity "often," and 11 and 15, respectively (17% of total) report experiencing transportation insecurity "sometimes." Yet both respondents who answered "often" indicate in their open-ended responses that they can get where they need to go and are satisfied with their ability to get around.

In contrast, among respondents with **Σ**5 (n=61), 13% self-report "often" experiencing transportation insecurity and 25% self-report "sometimes." This is an increase from respondents

with **Σ**3 and **Σ**4, yet the open-ended responses indicate similar experiences with transportation: worry about their car breaking down but still being able to access essential destinations—i.e., work or medical appointments. Respondents with **Σ**6 (n=37), on the other hand, are markedly different: they describe not always being able to get places they want to go. For example, one respondent wrote, "I don't go out very much to save money, so I usually go to places close to me by walking. I only take public transportation a few times a month by depositing $20 to my half fare Metro Card."

Given that the experiences of respondents with **Σ**3 through **Σ**5 are qualitatively different from those we categorized as "transportation secure," we recommend differentiating among these groups in our categorization schema. The data suggest respondents with **Σ**3 through **Σ**5 experience marginal insecurity because they describe being inconvenienced by transportation and experiencing transportation-related worry; however, as described above, they do not experience transportation insecurity to the extent that those with **Σ**6 do. Accordingly, we recommend differentiating between those with **Σ**5 and those with **Σ**6. Taken all together, these results support categorizing respondents with **Σ**3 through **Σ**5 as experiencing "marginal insecurity."

Returning to Figure 1, we see observations of Σ6 through Σ10 plateau with another small peak of observations around Σ10. Looking to how respondents endorsed the single-item self-report question, we see a significant difference in what those with Σ10 report compared to those with Σ11. Specifically, whereas only 1.7% of respondents with **Σ**1 through Σ10 (n=650) report that they "often" experience transportation insecurity, 27% of respondents with Σ11 or greater (cumulative n=289) report that they "often" do. Examining the types of items that respondents endorsed, we find that at Σ11 or greater, in addition to validating items that suggest constrained travel, respondents were more likely to validate items that relate to having negative feelings regarding their transportation situations, i.e., feeling bad or feeling embarrassed. For instance, whereas less than 1% (n=9) of respondents Σ6 through Σ10 report "often" feeling bad because of transportation, 17% of respondents Σ11 through Σ16 do. As much was conveyed in their open-ended responses. One respondent (Σ11) described feeling embarrassed because they drive a vehicle in need of repairs which they cannot afford, writing, "I traveled less, felt embarrassed because of the noise and safety concern. I can't afford a car payment plus full coverage insurance. Life is hard."

The differences between those with Σ6 through Σ10 and those with Σ11 or greater in terms of how often they self-report experiencing transportation insecurity and their likelihood of expressing having experienced negative feelings related to transportation insecurity suggests that those with Σ10 should be differentiated from those with Σ11. Given that those with Σ6 through Σ10, unlike those with **Σ**3 through **Σ**5, *do* experience constrained travel, but so few self-report experiencing transportation insecurity "often," we recommend categorizing respondents with Σ6 through Σ10 as experiencing "low insecurity."

Again, looking to Figure 1, we see observations of Σ11 through Σ15 plateau with a sizeable peak at Σ16, which sharply falls off at Σ17 and continues to decline thereafter. Examining Σ16 (n=38) we see that 58% (n=22) of respondents answered "sometimes" to all sixteen questions. However, based on their self-reports, it does not appear that all of these respondents experience transportation insecurity. Indeed, 18% report "never" experiencing transportation insecurity despite answering "sometimes" to all 16 items. This is confirmed in the open-ended responses. One respondent (Σ16)

wrote that they get around, “with my car and no problems” despite, again, affirming all 16 items. This leads us to believe that some of these respondents were straightlining, answering “sometimes” for each question to complete the survey quickly without much consideration of the items. Yet, it is also clear that respondents with Σ16, some of whom answer “sometimes” to all sixteen questions, experience transportation insecurity. For example, eighteen percent (n=38) self-report that they “often” experience transportation insecurity. One such respondent (Σ16 who self-reported “often”) wrote, “My car has serious problems, and I cannot afford to pay for them. I have no friends who drive. I use Medicaid provided transportation for doctors visits.”

To determine whether discrete categories exist within the Σ11 through Σ32 beyond the straightlining at Σ16, we examined the response patterns of respondents in this group. Doing so, we find that all respondents with Σ11 and higher are similar in that they describe limiting their travel behavior, traveling with difficulty, and experiencing negative feelings related to their transportation situations, but that important distinctions exist between those with Σ17 and higher and those Σ16 and below, suggesting a categorical break at Σ17.

Whereas 17% (n=26) of those with Σ11 through Σ16 self-report “often” experiencing transportation insecurity, more than twice as many (44%, n=61) of those Σ17 and greater do. Further, whereas those with Σ11 through Σ16 report having constrained travel behavior, respondents with scores Σ17 and higher are more likely to describe in their open-ended responses either not being able to go places at all or being severely limited in the places they can go. For example, one respondent (Σ24) wrote, “we have no vehicle here, so we all have to walk or ride the bus everywhere it has really made getting a job difficult.” Another (Σ17) wrote, “There are many restrictions on when, where, and for how long I can get out.” Another respondent described using a paratransit system that only allows for trips to medical appointments, but not to the grocery store or laundromat. Such difficulty getting to places is also evident in how this group endorsed two items on the TSI that tap into constrained travel behavior (“skipping going places,” “not able to leave the house”) compared to those with lower scores. Whereas 18% of respondents with Σ11 through Σ16 report that they "never” skip going places because of problems with transportation, less than 1% (n=3) of respondents with Σ17 and greater do. And while only 8% (n=12) of respondents with Σ11 through Σ16 report that they are “often” not able to leave the house, nearly half (49%) of respondents with Σ17 (n=67) and higher report “often” having this experience. Given the high degree of constrained travel – some of which is quite severe - among those with scores of Σ17 and above, we consider these respondents to be experiencing “high insecurity” and would distinguish them from those with Σ11 through Σ16 who we consider to be experiencing “moderate insecurity.”

In sum, this approach suggests the following five-category categorization of TSI sum scores: no insecurity/secure = 0 to 2, marginal insecurity = 3 to 5, low insecurity = 6 to 10, moderate insecurity = 11 to 16, and high insecurity = 17 to 32.

K-Means Clustering Approach

The second approach that we took to identify categories of transportation insecurity was to examine the data using a purely quantitative approach to empirically cluster categories together. We did so using a *k*-means clustering method, a non-deterministic partitional clustering method

that clusters observations into *k* mutually exclusive and exhaustive groups. Using each observation's TSI sum score as input, the initial *k* group means are defined as the TSI sum score of *k* randomly selected observations. Each observation is then assigned to the group whose mean TSI16 sum score is closest to its TSI16 sum score. Here, closest is defined using the Euclidean (or Minkowski) distance for observations *i* and *j* which is generally defined as:

$$\left\{\sum_{a=1}^{p}\left(x_{ia}-x_{ja}\right)^{2}\right\}^{1/2}$$

Because we are using each observation's TSI sum score as the only input to the model, the equation simplifies to $\left(x_i - x_j\right)$ because *p*, the number of inputs per observation, equals 1. Once all observations have been assigned to a group, each group's mean is recalculated. The process repeats until group assignment does not change between iterations. Cut points are then identified by observing the range of TSI sum scores within each of the *k* groups.

To determine the number of groups into which observations are classified, we took into consideration properties of the model. Generally, lesser values of *k* will result in solutions that are more reproducible; however, meaningful substantive differences between observations might be missed. Therefore, we desired to identify a *k* which provided as much description of the population that could be generally reproduced. We determined that between three and six distinct categories of transportation insecurity could be theoretically and empirically justified (i.e., low, moderate, high vs secure, low, marginal, moderate, high, severe). Accordingly, we estimated *k*=3, *k*=4, *k*=5, and *k*=6 means clustering models. Further, because the method is nondeterministic (i.e., results could differ each time the model is estimated), we re-estimated each model 10 times.

Table 3 illustrates the range of TSI sum scores observed for each of the three, four, five, or six groups identified across each of the ten estimations of the two models. Across ten estimations of both the *k*=6 and *k*=5 models, there were five unique solutions, none of which accounted for the majority of solutions. Although there were also five unique solutions across ten estimations of the *k*=4 model, one was replicated six times. Across ten estimations of the *k*=3 model, there were two unique solutions, with one solution accounting for eight of the ten solutions. These results suggest that, as expected, three groups can be more reliably reproduced than four groups, that four groups can be more reliably reproduced than five groups, and that five groups can be more reliably reproduced than six groups.

< Table 3. TSI16 sum scores by cluster solution>

An examination of substantive differences among the model categorizations reveals that the difference between the *k*=3 and *k*=4 solutions is the greater discrimination of those at the highest end of the transportation insecurity continuum (i.e., the most insecure). Conversely, the difference between the *k*=4 and *k*=5 solutions is the greater discrimination of those at the lowest end of the transportation insecurity continuum (i.e., the least insecure). With the addition of a sixth category, the model further differentiates among those in the middle of the transportation insecurity continuum.

As mentioned previously, we desired a solution that provided as much description of the population that is generally reproducible (i.e., as many categories or groupings that can be reproduced across iterations of the *k*-means algorithm). Because none of the *k*=6 or *k*=5 solutions replicated a majority of the iterations, we ruled them out. Although one *k*=3 solution replicated 8 times, by definition, that solution is less descriptive than the *k*=4 solution that replicated 6 times. Therefore, in using the *k*-means clustering approach to identify categories of transportation insecurity, the following *k*=4 solution is preferred: no insecurity/secure = 0 to 2, low insecurity = 3 to 7, moderate insecurity = 8 to 15, and high insecurity = 16 to 32.

Synthesizing Between Approaches: Selecting the Final Categorization

The two approaches that we used to identify categories of transportation insecurity differed both in the number of categories identified (5 vs. 4) and in the distribution of sum scores across those categories (See Table 4).

< Table 4. Proposed categorization by method >

Despite these differences, there were some similarities between the two, especially in how they categorized the most extreme points (highest and lowest sum scores). Both approaches identified the most secure respondents as those with scores between 0 and 2, leading us to retain the category of "secure/no insecurity" for those with these scores.

While one approach identified the least secure ("high insecurity") respondents as those with scores greater than 16 (k-means clustering approach), the other identified the least secure respondents as those with scores great than 17 (mixed-methods approach). As described in the section detailing our mixed methods approach, in our analysis of item response patterns by sum score, we discovered that some scores of 16 might be the result of straightlining—i.e., respondents selecting "sometimes" for each question because they were trying to complete the survey quickly and without careful thought. Because, qualitatively, there was a marked difference between those with scores of 16 and those with scores of 17 in the extent to which their travel is constrained, we decided to follow the recommendation of the mixed-methods approach to reserve the definition of "high insecurity" for those with sum scores of 17 and above.

Looking at Table 3, the key difference between the two solutions suggested by our two approaches, then, is the categorization of the intermediate points. Specifically, our mixed-methods approach categorizes those with scores between 3 and 16 into three groups (3 to 5, 6 to 10, 11 to 16) whereas the *k*-means clustering approach separates those with scores between 3 and 15 into two groups (3 to 7, 8 to 15). The mixed-methods approach provided compelling evidence that those with scores of 3 through 5 were qualitatively different from those with scores of 6 through 10 in that while they worried about transportation, unlike those with scores of 6 through 10, they were able to regularly get to their destinations. This approach provided similarly compelling evidence that those with scores of 6 through 10 were qualitatively different than those with scores of 11 through 16 in that while they report having constrained travel behavior, unlike those with scores of 11 through 16, they are much less likely to self-report "often" experiencing transportation insecurity and are less likely to endorse items suggesting they experience negative feelings because of their transportation insecurity, a finding supported by their open-ended responses as well. Given the strength of the evidence that suggests that that the "marginal," "low," and "moderate" insecurity

categories hold not only meaningful qualitative distinctions – but potentially theoretical ones as well – we retained these three categories in our final TSI categorization. This leads us to recommend as our final categorization for the TSI the following five categories:

Transportation Secure = 0 to 2, Marginal Insecurity = 3 to 5, Low Insecurity = 6 to 10, Moderate Insecurity = 11 to 16, and High Insecurity = 17 to 32.

Though, ultimately, our final categorization aligned with the five categories suggested by the mixed-methods approach, we wish to emphasize that this final categorization schema was the result of weighing the two approaches equally and considering their recommendations in unison. Moreover, although our final categorization is that recommended by the mixed-methods approach, importantly, the *k*-means clustering approach *does* provides evidence that supports this decision. That is, an examination of the cluster solutions (see Table 3) reveals that each cut point suggested by the mixed-methods approach is also within the bounds of the cluster solutions. For example, the mixed-methods approach recommends a category of summed scores 3 through 5. Looking at the estimations using the *k*=4 solution, 7 of the 10 iterations find 3 to be an appropriate cut point. Similarly, if we examine the *k*=5 solution, 6 of the 10 iterations find an appropriate cut point to be between 4 and 7. In short, while our final categorization is that suggested by the mixed-methods approach, the information from both approaches supports our final categorization schema.[3]

Conclusion

In this paper, using the previously validated TSI sum score as input, we deployed two distinct approaches to identify a categorical measure of transportation insecurity: an inductive mixed-methods approach and a *k*-means clustering quantitative approach. We integrated the qualitative and quantitative information from both approaches to arrive at a five-category TSI. Specifically, this categorical measure distinguishes among those who experience no insecurity/secure (sum scores ranging from 0 to 2), marginal insecurity (3 to 5), low insecurity (6 to 10), moderate insecurity (11 to 16), and high insecurity (17 to 32).

Having identified a categorization schema, scholars, policy makers and urban planners are now able to use the TSI to examine the prevalence of transportation insecurity in the broad population and by demographic group as well as whether (and how) membership in these categories predicts a wide range of outcomes of interest, from employment status to health. Additionally, this categorization schema will also enable researchers to use the TSI to evaluate policies and programs aimed at ameliorating transportation insecurity by, for example, assessing what interventions are effective in moving individuals from experiencing more to less severe categories of insecurity. These are all important – but not yet examined – questions related to the study of transportation insecurity and the pursuit of transportation equity.

[3] Arguably, much of the power of having categorical variables comes from different categories being able to predict different outcomes of interest. Accordingly, our first step in adjudicating between the recommendations of our two approaches was to compare how each categorization predicts four outcomes that we hypothesize are associated with transportation insecurity: not working, self-rated health, self-rated depression, and loneliness (details and results available upon request). In doing so, we did not find a meaningful difference in the predictive power of our two categorizations that suggested a "best" categorization schema. Thus, this analysis was not useful for informing our decision making.

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Table 1. Weighted descriptive statistics of the survey sample

	Proportion	Frequency
Race		
White	0.65	1,351
Black	0.12	246
Hispanic	0.15	249
Other	0.08	153
Age		
25-39	0.29	585
40-64	0.50	987
65+	0.21	427
Gender		
Male	0.48	971
Female	0.52	1028
Education		
Less than HS	0.10	208
High school	0.29	623
Some college	0.27	638
Bachelor	0.34	530
Income		
>15,000	0.08	732
15,000-29,999	0.10	209
30,000-49,999	0.16	199
50,000-74,999	0.17	235
75,000+	0.48	624
FPL		
at or below 100%	0.09	837
Between 100-200%	0.19	223
above 200%	0.72	939
Urbanicity		
Urban	0.25	566
Suburban	0.55	1,004
Rural	0.20	427
Children		
No	0.70	1,414
Yes	0.30	585

	N	Mean/Proportion	SD	Min	Max
TSI16sum*	1,999	3.823	6.488	0	32

**Because we analyze the raw, unweighted data, this distribution is presented as unweighted*

Table 2. Transportation Insecurity Index Sixteen Items

Item Label	Question Wording
Late	To get to the places they need to go, people might walk, bike, take a bus, train or taxi, drive a car, or get a ride. In the past 30 days, how often were you late getting somewhere because of a problem with transportation?
Took longer	In the past 30 days, how often did it take you longer to get somewhere than it would have taken you if you had different transportation?
Waiting	There are times when we need to wait for transportation to pick us up. In the past 30 days, how often did you spend a long time waiting because you did not have the transportation that would allow you to come and go when you wanted?
Early	In the past 30 days, how often did you have to arrive somewhere early and wait because of the schedule of the bus, train, or person giving you a ride?
Reschedule	In the past 30 days, how often did you have to reschedule an appointment because of a problem with transportation?
Skipped	In the past 30 days, how often did you skip going somewhere because of a problem with transportation?
Not able to leave	In the past 30 days, how often were you **not** able to leave the house when you wanted to because of a problem with transportation?
Worried	In the past 30 days, how often did you worry about whether or not you would be able to get somewhere because of a problem with transportation?
Stuck	In the past 30 days, how often did you feel stuck at home because of a problem with transportation?
Not invited	In the past 30 days, how often do you think that someone did not invite you to something because of problems with transportation?
Avoiding	In the past 30 days, how often did you feel like friends, family, or neighbors were avoiding you because you needed help with transportation?
Left out	In the past 30 days, how often did you feel left out because you did not have the transportation you needed?
Felt bad	In the past 30 days, how often did you feel bad because you did not have the transportation you needed?
Inconvenience	In the past 30 days, how often did you worry about inconveniencing your friends, family, or neighbors because you needed help with transportation?
Relationship effects	In the past 30 days, how often did problems with transportation affect your relationships with others?
Embarrassed	In the past 30 days, how often did you feel embarrassed because you did not have the transportation you needed?

Table 3. TSI16 sum scores by cluster solution*

	k = 6						*k* = 5					*k* = 4				*k* = 3		
	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	1	2	3
1	0-1	2-3	4-7	8-13	14-20	21+	0	1-2	3-7	8-15	16+	0-2	3-7	8-15	16+	0-3	4-12	13+
2	0-1	2-3	4-7	8-13	14-20	21+	0	1-2	3-7	8-15	16+	0-2	3-7	8-15	16+	0-3	4-12	13+
3	0-1	2-3	4-7	8-13	14-20	21+	0	1-2	3-7	8-15	16+	0-2	3-7	8-15	16+	0-3	4-12	13+
4	0	1-2	3-6	7-12	13-20	21+	0	1-2	3-7	8-15	16+	0-2	3-7	8-15	16+	0-3	4-12	13+
5	0	1-2	3-6	7-12	13-20	21+	0-1	2-4	5-10	11-19	20+	0-2	3-7	8-15	16+	0-3	4-12	13+
6	0	1-2	3-6	7-12	13-20	21+	0-1	2-4	5-10	11-19	20+	0-2	3-7	8-15	16+	0-3	4-12	13+
7	0	1	2-4	5-10	11-19	20+	0-1	2-4	5-10	11-19	20+	0-2	3-9	10-18	19+	0-3	4-12	13+
8	0	1	2-4	5-10	11-19	20+	0-1	2-6	7-13	14-22	23+	0-3	4-10	11-19	20+	0-3	4-12	13+
9	0	1-2	3-6	7-12	13-21	22+	0-2	3-6	7-12	13-20	21+	0-4	5-11	12-20	21+	0-4	5-13	14+
10	0-1	2-4	5-10	11-17	18-23	24+	0-2	3-7	8-13	14-20	21+	0-4	5-12	13-21	22+	0-4	5-13	14+

** For ease of interpretation, cluster solutions have been rearranged so that identical solutions are adjacent.*

Table 4. Proposed categorizations by method

	Mixed Methods Approach		K-Means Clustering Approach		**Final Categorization**	
1	Secure	0-2	Secure	0-2	**Secure**	**0-2**
2	Marginal insecurity	3-5			**Marginal insecurity**	**3-5**
3	Low insecurity	6-10	Low insecurity	3-7	**Low insecurity**	**6-10**
4	Moderate insecurity	11-16	Moderate insecurity	8-15	**Moderate insecurity**	**11-16**
5	High insecurity	17+	High insecurity	16+	**High insecurity**	**17+**

Figure 1. Unweighted distribution of TSI sum scores

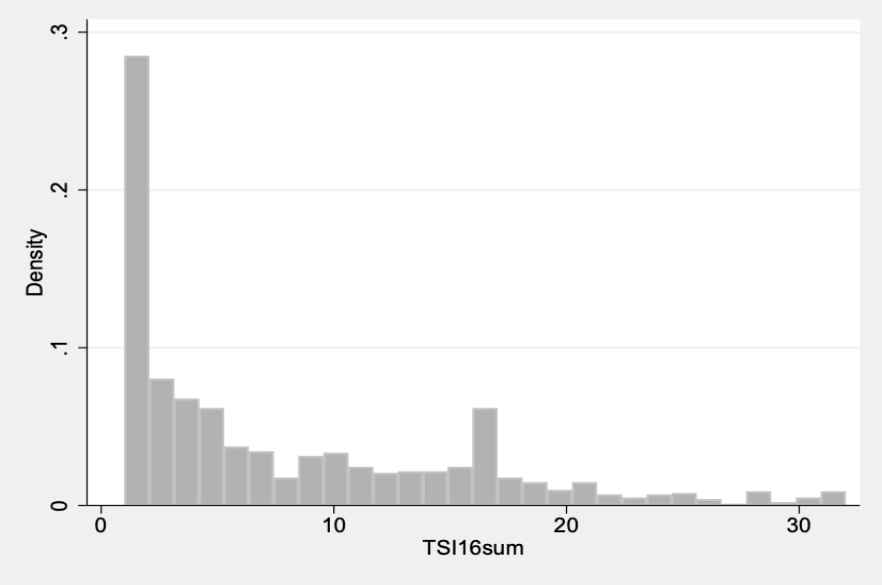
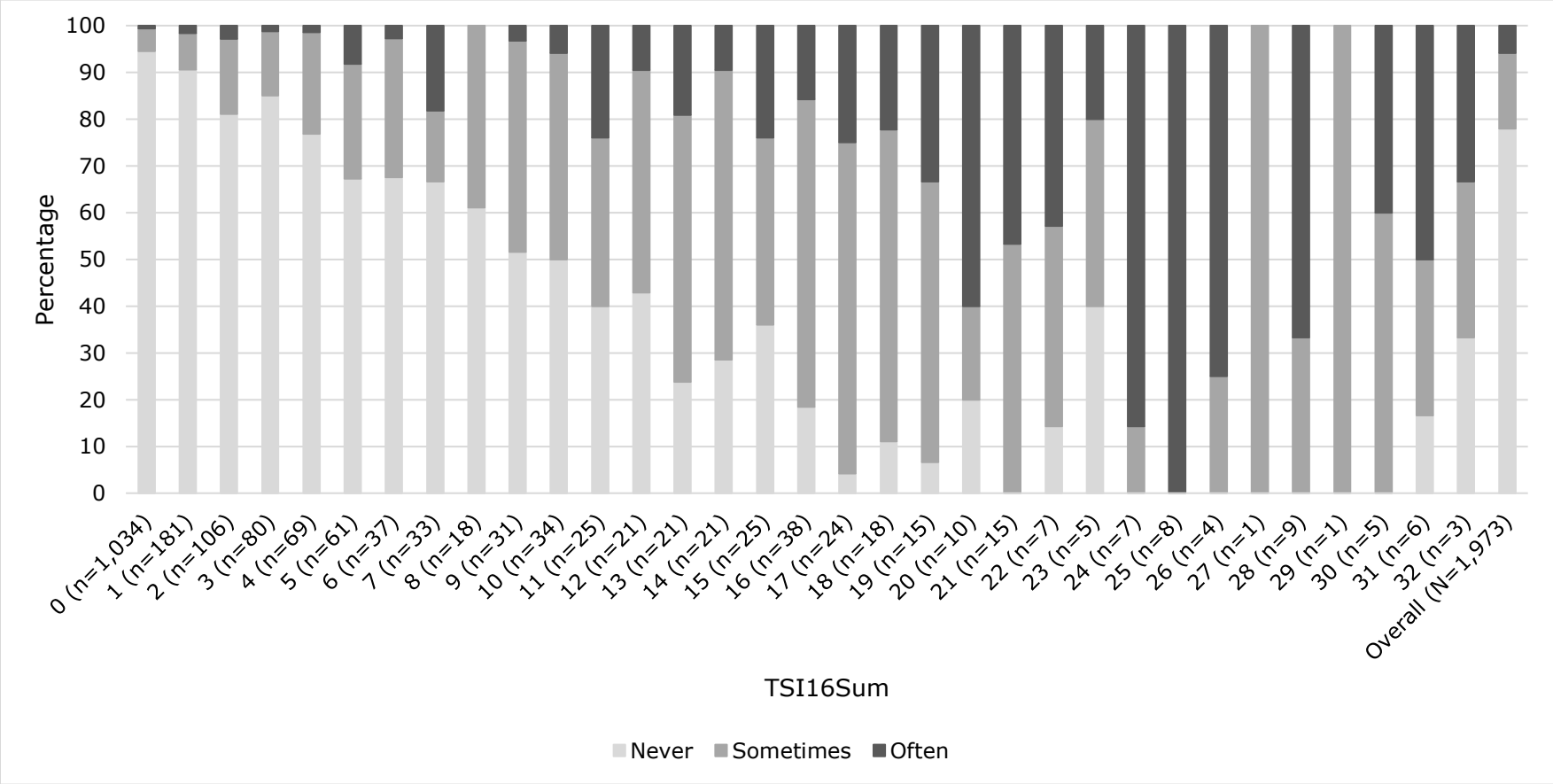


Figure 2. Prevalence of self-reported transportation insecurity by TSI sum score (unweighted)[4]



[4] This figure includes only those respondents in our sample (n=1,999) who completed the transportation insecurity self-report item (n=1,1973).