Measuring Transport Poverty in Canada: Validating Conceptual Dimensions and Identifying Central Indicators

Evidence from the Mobilizing Justice National Survey on Transport Poverty

Amir Forouhar, Steven Farber, and Ignacio Tiznado Aitken

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MOBILIZING JUSTICE

Towards Evidence-Based Transportation Equity Policy

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The Mobilizing Justice Partnership is funded by the Social Sciences and Humanities Research Council (SSHRC). Based at the University of Toronto Scarborough, the national intersectoral research partnership aims to understand and address transportation poverty in Canada and to improve the well-being of Canadians at risk of transport poverty. Learn more at www.mobilizingjustice.ca.

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Introduction

Transport poverty has emerged as a critical lens for understanding how insufficient access to transportation perpetuates social exclusion and limits participation in essential aspects of daily life (Currie & Delbosc, 2010; Lucas, 2012; Martens, 2016). Unlike traditional accessibility metrics, which primarily gauge proximity to transit or destinations, transport poverty is conceptualized as a multidimensional and experiential condition shaped by the interplay of affordability pressures, accessibility deficits, mobility constraints, and exposure to environmental and personal safety risks (Lucas et al., 2016; Singer & Martens, 2023; Verhorst et al., 2023).

Despite the growing adoption of multidimensional transport poverty frameworks in policy and research (Jeekel & Martens, 2017; Lucas et al., 2016; Mattioli et al., 2017), rigorous psychometric validation of measurement instruments in this domain remains sparse (Kong et al., 2021; Pérez-Peña et al., 2021). Many surveys incorporate multiple indicators without testing whether those indicators theoretically cohere as intended, whether the dimensional structure holds empirically, or which survey items best represent each construct for practical use. These gaps create poorly validated instruments, which may misclassify populations, obscure heterogeneity, or fail to support robust policy inference. Comparative work shows that the chosen definition and measurement scale for transport poverty shapes which predictors and contexts the concept applies to (Verhorst et al., 2023), underscoring the need for rigorous validation before adoption.

The Mobilizing Justice partnership, a nationally coordinated Canadian research and policy initiative, designed and administered a large-scale national survey expressly to measure transport poverty in its multi-dimensional complexity. The survey captures both objective conditions and subjective perceptions of mobility adequacy, aspiration gaps, and relative deprivation. Its perception-based measurement block is grounded in the four-dimensional framework of transport poverty introduced by Lucas et al. (2016) and extended here with a general mobility perception block.

This report addresses these gaps by providing a systematic empirical validation of the perception-based transport poverty section used in the Mobilizing Justice national survey of transport poverty (NSTP). It tests whether the proposed dimensions are supported by the data, evaluates the internal consistency of measurement blocks, and identifies divergences between theoretical constructs and observed patterns.

The analysis further introduces an item-level centrality approach to identify the most representative indicators within each dimension. This enables both refinement of the measurement structure and the development of more parsimonious, policy-relevant indicators. This is especially important for two groups of practitioners: municipalities and community organizations that lack the capacity to administer a full survey instrument and instead need a small number of validated stand-alone questions; and agencies operating larger, established instruments (such as provincial or regional travel surveys, time-use surveys, or origin-destination surveys) that have limited room to add new content and therefore need evidence on which one or two items per dimension carry the most diagnostic value before committing to instrument revisions, a process that is typically slow and difficult to reverse. By identifying the most central and representative items within each dimension, this study supports the development of shorter, modular survey components that can be more readily integrated into existing instruments such as national travel surveys, time-use

surveys, or origin–destination surveys. This approach provides a practical pathway for embedding transport poverty indicators into established statistical systems without increasing respondent burden or compromising existing survey objectives, thereby enabling more systematic monitoring across jurisdictions while remaining compatible with institutional constraints. This process culminates in a concise, five-item diagnostic tool comprising the single most representative indicator from each of the five validated dimensions.

Specifically, this research addresses the following objectives:

1. **Validate the dimensional structure of transport poverty using survey data** by examining whether the proposed dimensions emerge empirically as distinct latent constructs.
2. **Evaluate the internal consistency of survey-based measurement blocks** to determine whether the indicators within each dimension reliably measure the same underlying construct and to identify items that weaken conceptual coherence or statistical reliability.
3. **Assess alignment between theoretical constructs and empirical patterns** by evaluating the extent to which the survey results correspond with the multidimensional framework proposed by Lucas et al. (2016) and identifying areas where lived experiences diverge from the original conceptual structure.
4. **Identify the most representative indicators within each dimension** in order to support the development of shorter and more practical transport poverty survey modules that can be used by governments, community organizations, and policy partners
5. **Develop and validate a concise, five-item diagnostic tool** that governments, community organizations, and larger survey programs can adopt directly, with minimal administrative burden

Conceptual Framework

Transport Poverty and Social Exclusion

Interest in transport poverty emerged from the broader social exclusion literature of the late 1990s and early 2000s, when transport began to be understood not merely as a sectoral policy issue but as a structural factor shaping access to economic and social participation (Church et al., 2000; Social Exclusion Unit [SEU], 2003). Early UK work linked transport disadvantage with exclusion from services, employment, and everyday activities, showing that transport barriers can reinforce wider patterns of deprivation (Church et al., 2000; Lucas, 2012; Lucas et al., 2001). This line of research helped establish transport as a key mechanism through which social exclusion is produced and experienced (Lucas, 2012; Rajé, 2017).

A central contribution of this literature was the argument that transport disadvantage is not simply a by-product of income poverty but a distinct and structural form of exclusion (Lucas, 2004; 2012). Lucas (2012) synthesizes international evidence to show that transport-related social exclusion operates through interconnected constraints on mobility, accessibility, affordability, and safety. Related work also shows that transport barriers can create involuntary immobility and restrict access to daily necessities, especially for people in low-income or geographically isolated communities (Hine & Mitchell, 2001; Lucas et al., 2001).

Preston and Rajé (2007) further clarified the relationship between transport, accessibility, and exclusion by distinguishing between transport disadvantage as a structural condition and transport-related social exclusion as its social consequence. Their analysis, grounded in Sen's entitlement perspective, also highlighted the limitations of policy approaches that rely only on aggregate accessibility planning (Preston & Rajé, 2007). Together, these studies support the view that transport policy must address both the supply of transport and the social circumstances that shape who can use it effectively (Church et al., 2000; Preston & Rajé, 2007).

A further theoretical advance came from justice-based and capability-oriented approaches to transport. Martens (2016) explicitly places transport decision-making within the capability approach developed by Sen (2001) and Nussbaum (2013), shifting attention from transport provision alone to the freedoms that transport enables. From this perspective, transport poverty is best understood as a failure to convert transport resources into real opportunities to participate in valued activities (Martens, 2016; Singer & Martens, 2023). This capability-based framing has since been extended in reviews connecting accessibility measurement more directly to the capability approach (Vecchio & Martens, 2021) and to transport-related social exclusion specifically (Luz & Portugal, 2022).

Research on subjective well-being has extended this literature by showing that perceived mobility deprivation predicts life satisfaction and related well-being outcomes independently of what calculated accessibility metrics alone would predict (Delbosc & Currie, 2011). This is consistent with broader evidence emphasizing the importance of perceived accessibility and its divergence from calculated measures (De Vos et al., 2013; Pot et al., 2021; Singer & Martens, 2023). Transport disadvantage is also linked to subjective well-being through social exclusion pathways (Awaworyi Churchill & Smyth, 2019; Pot et al., 2025; Stanley et al., 2011). More recent work highlights that perceptions of transport disadvantage are relational and shaped by social comparison processes (Schwanen et al., 2015), reinforcing the view that perceived accessibility is socially constructed and context dependent (Pot et al., 2021; Singer & Martens, 2023).

Transport Poverty Multidimensional Framework

Despite growing interest in the social dimensions of transport, there is a recognized need for robust, context-sensitive tools to measure transport poverty, a multidimensional issue that remains under-researched and poorly articulated across academic and policy circles (Kong et al., 2021; Pérez-Peña et al., 2021). Titheridge et al. (2014) distinguish spatial mismatch/entrapment, mobility/time-geography, and social exclusion approaches, while Jeekel and Martens (2017) situate transport poverty within a broader accessibility-planning lens. Drawing on the fuel poverty literature, Mattioli and colleagues (2017) model transport poverty on energy vulnerability frameworks, highlighting compounding "double vulnerability" across energy and transport domains (Martiskainen et al., 2021; Simcock et al., 2021), while other work operationalizes transport cost burden using household budget survey data.

Despite these complementary lenses, the framework proposed by Lucas et al. (2016) remains the most widely cited multidimensional conceptualization of transport poverty and is adopted as the primary organizing structure for this report. Drawing on systematic review evidence from multiple national contexts, they conceptualize transport poverty as a multicausal and multidimensional constraint on individuals' ability to participate in everyday activities, rather than a single, uniform condition. They argue that an individual is

transport poor if, in order to satisfy their daily basic activity needs, at least one the following conditions apply:

- There is no transport option available that is suited to the individual's physical condition and capabilities.
- The existing transport options do not reach destinations where the individual can fulfil his/her daily activity needs, in order to maintain a reasonable quality of life.
- The necessary weekly amount spent on transport leaves the household with a residual income below the official poverty line.
- The individual needs to spend an excessive amount of time travelling, leading to time poverty or social isolation.
- The prevailing travel conditions are dangerous, unsafe or unhealthy for the individual.

Lucas et al. (2016) emphasizes that these dimensions often overlap, creating a "mutually reinforcing cycle" of disadvantage that restricts people's capability to participate in society, often termed Transport Related Social Exclusion (TRSE).

Extension: General Mobility Perceptions as a Reflective Construct

Consistent with the framework proposed by Lucas et al. (2016), the Mobilizing Justice National Survey on Transport Poverty (NSTP) incorporates the core dimensions into four categories alongside an additional *general perceptions* block that captures overall subjective evaluations of transport conditions (overall mobility satisfaction, perceived transport quality relative to others in the population, and a direct self-assessment of mobility). This block aligns with recent work that conceptualizes mobility status as a distinct perceptual construct, including the scale developed by Martens and Singer (2024), which operationalizes people's mobility status through self-reported ease or difficulty in reaching needed or desired destinations. In this sense, *general mobility perceptions* may function as an integrating or higher-order reflective construct, summarizing overall experienced mobility quality while remaining analytically distinct from the deprivation-based dimensions.

It is worth noting that Lucas et al. (2016) also identify transport-related time poverty as a related condition, and subsequent work has shown time poverty to be closely interrelated with the four core dimensions (Tiznado Aitken et al., 2024; see also Verhorst et al., 2023). The present instrument does not include a standalone time-poverty construct. Instead, as described in *Data and Measures* section, desired travel time is treated as an indicator of the mobility construct to enable reliability testing, as Cronbach's alpha requires at least two items per construct. This report assesses empirically whether these items behave as a mobility subdimension or cohere as a separate construct.

Data and Measures

The Mobilizing Justice National Survey on Transport Poverty

The empirical foundation of this report is the Mobilizing Justice National Survey on Transport Poverty, a large-scale, nationally representative survey administered across Canada. The survey was designed under the Mobilizing Justice partnership, a Social Sciences and Humanities Research Council (SSHRC) of Canada–funded initiative bringing together researchers, community organizations, and policy practitioners to advance the understanding and reduction of transport poverty across Canadian communities.

The survey captures a broad range of household and individual transport characteristics from 27,216 respondents, organized into three main sections: (A) Household dynamics and transport resources, (B) Perceptions, and (C) Respondent sociodemographic profile (Fig 1). Transport Poverty subsection (B1) -- the analytical focus of this report -- employs an aspiration-gap measurement approach in which perception-based items are measured on a continuous 0–100 scale designed to capture respondents' evaluations of their travel conditions relative to their needs, preferences, or desired situations. This continuous aspiration-gap format was chosen over a conventional Likert scale for two reasons. First, a slider format is generally easier for respondents to complete, particularly when scale endpoints are anchored with plain-language descriptions rather than abstract agreement categories. Second, the continuous scale preserves analytic flexibility: it can be collapsed into a 5-category Likert-equivalent scale post hoc if needed for comparability with other instruments, whereas the reverse conversion is not possible.

For many items, a value of 50 represents a neutral, adequate, or desired condition; however, the interpretation of the scale varies depending on the wording and orientation of each question. In some cases, higher values reflect more positive outcomes (e.g., satisfaction or perceived safety), while in others they indicate greater burden or deprivation (e.g., spending more on transport than one can afford). As a result, several variables were reverse-coded during analysis to ensure consistent interpretation across constructs. This flexible scaling approach allows the survey to capture both subjective evaluations and perceived aspiration gaps across multiple dimensions of transport poverty.

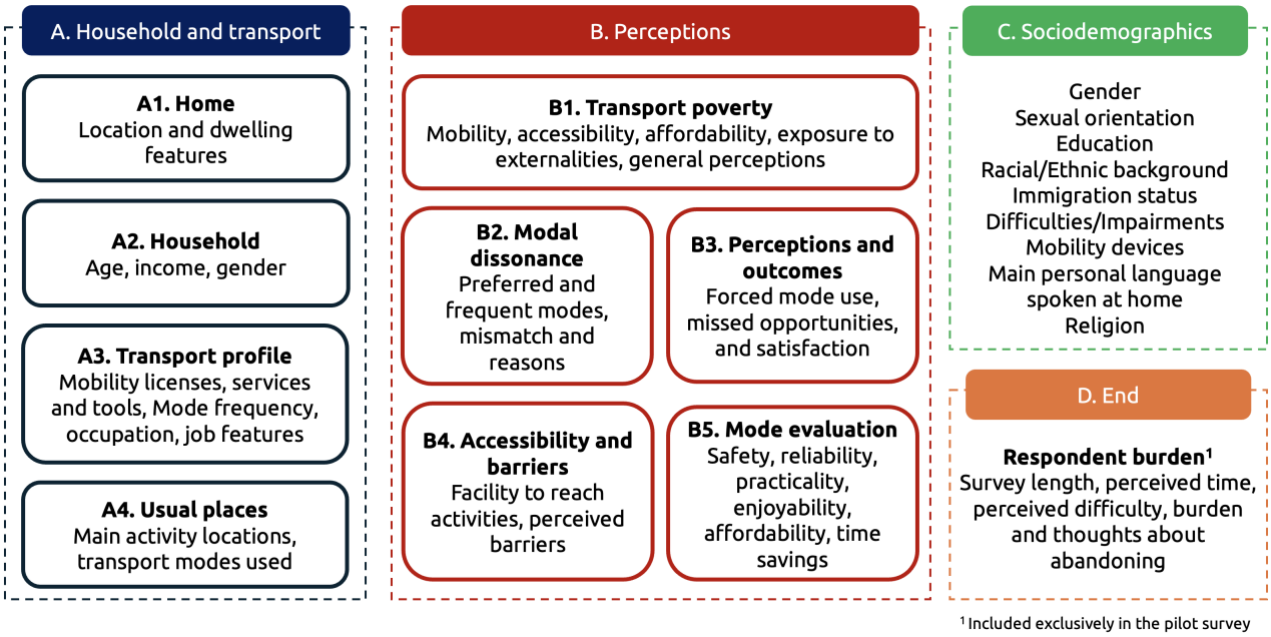

Figure 1. Survey content of the Mobilizing Justice National Survey on Transport Poverty (Tiznado-Aitken et al., 2025).

Transport Poverty: Perception-Based Measures

Table 1 presents the 16 perception items included in the validation analysis, organized by conceptual block. All items were administered using a 0-100 aspiration gap scale. However, the interpretation of the scale differs across items, as the meaning of higher and lower scores depends on the wording and orientation of each question.

Table 1. Perception-Based Survey Items by Conceptual Block

Dimension	Variable Name	Survey Question	Interpretation
Mobility	**Transport options suited to abilities**	I have (fewer/more) transport options, suited to my physical condition and abilities, than I would like	<50 = fewer options than needed; 50 = just right; >50 = more options
	Desired trips	I make (fewer/more) trips than I would like	<50 = suppressed trips; 50 = just right; >50 = excess trips

	Desired distance	I travel (fewer/more) kilometres than I would like	<50 = suppressed distance; 50 = just right; >50 = excess distance
	Desired travel time	I spend (less/more) time travelling than I would like	Below 50 = time-constrained/less than desired; 50 = just right; >50 = excess time burden
Accessibility	**Public transport allows reaching destinations**	The public transport options in my neighbourhood allow me to reach (fewer/more) of the destinations that I need	<50 = destination accessibility deficit by transit; 50 = just right; >50 = better access
	Access to transport options	I have access to (fewer/more) transport options than I would like	<50 = access deficit; 50 = just right; >50 = better access
	Ability to reach needed destinations	With the transport options I have available, I can reach (less/more) destinations than I need	<50 = general destination accessibility deficit; 50 = just right; >50 = better access
Affordability	**Desired car ownership**	I own (fewer/more) car(s) than I would like to	<50 = owns less relative to preference; 50 = just right; >50 = owns more
	Transport cost affordability	I spend (less/more) money on transportation than I can afford	Higher = more financial strain
	Housing cost affordability	I spend (less/more) money on housing than I can afford	Higher = more financial strain
Exposure to Externalities	**Pollution exposure**	I feel the environment in which I travel is (not polluted at all / very polluted)	Higher = more polluted (greater burden)
	Safety from crime/harassment	I feel (not safe at all / very safe) from crime and harassment while travelling	Higher = safer (less burden)
	Safety from road accidents	I feel (not safe at all / very safe) from road accidents while travelling	Higher = safer (less burden)
General Perceptions	**Overall mobility assessment**	How would you assess your mobility (how easy and quickly can you reach the destinations you want to reach) on a scale from 0 to 100	Higher = better perceived mobility
	Satisfaction with travel conditions	I am (very dissatisfied/very satisfied) with my current travel conditions	Higher = more satisfied
	Relative travel conditions vs others	Compared to the rest of the population, I feel that my overall travel conditions are (worse/better) than others	Higher = better relative standing

Methodological Strategy

The measurement validation strategy follows a five-step sequential psychometric framework, consistent with established scale validation practice in transportation and social science research (e.g., Boateng et al., 2018; DeVellis & Thorpe, 2021; Ettema et al., 2011; Gould-Werth et al., 2018). All analyses were conducted in R using several specialized packages, including the *psych* package for exploratory factor analysis and reliability testing, the *lavaan* package for confirmatory factor analysis, and the *GPArotation* package for oblique factor rotations. Data preparation and descriptive analyses were conducted using packages within the *tidyverse* ecosystem. Each step addresses a specific aspect of the validity and reliability of the transport poverty measurement instrument.

Step 1: Factor Analysis Diagnostics

Before extracting factors, data suitability for factor analysis was assessed using four tests. First, the inter-item correlation matrix was inspected for evidence of sufficient shared variance (correlations predominantly > 0.30) without extreme multicollinearity (r > 0.90). Second, Bartlett's test of sphericity tested whether the correlation matrix is significantly different from an identity matrix. Third, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was computed; values above 0.70 indicate adequate factorability. Fourth, the determinant of the correlation matrix was examined to confirm the absence of perfect multicollinearity.

Step 2: Exploratory Factor Analysis (EFA)

EFA was conducted using principal axis factoring (PAF). This method is recommended when the analytical goal is to identify latent constructs underlying observed variables, particularly when variables may depart from multivariate normality. Orthogonal rotation was rejected in favour of oblique rotation (oblimin) because transport poverty dimensions are theoretically interrelated and imposing orthogonality would impose an unrealistic independence constraint. The number of factors was determined using parallel analysis, which compares the observed eigenvalues from the survey data against eigenvalues generated from randomly simulated datasets of the same size and dimensional structure. Factors were retained only when their observed eigenvalues exceeded the corresponding eigenvalues derived from the random data, indicating that the factor explained more variance than would be expected by chance alone.

Step 3: Internal Consistency Reliability

Cronbach's alpha (α) was computed for each conceptual block to assess internal consistency reliability (Cronbach, 1951; Tavakol & Dennick, 2011). Alpha is a function of the number of items in a scale and the average inter-item covariance, so higher values generally indicate greater internal consistency (Cronbach, 1951; UCLA Office of Advanced Research Computing [OARC] Statistical Consulting Group., n.d.). Following common conventions in the social sciences, values of α≥.70 were treated as acceptable and values of α≥.80 as good. (Nunnally & Bernstein, 1994; UCLA OARC Statistical Consulting Group., n.d.). Item-level diagnostics, including corrected item-total correlations (r.drop) and alpha-if-item-deleted statistics were examined to identify items that weaken block coherence. Items that showed poor alignment with their theoretical block were flagged for removal and the scale was re-estimated.

Step 4: Confirmatory Factor Analysis (CFA)

Following the EFA-driven refinement of item composition, a CFA was estimated, implementing full information maximum likelihood (FIML) to use all available data under missing-at-random assumptions. Model fit was evaluated using the comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) (Kline, 2023; Xia & Yang, 2019). The model fit was considered good when: CFI > 0.95 (acceptable at > 0.90), TLI > 0.90, RMSEA < 0.06 (acceptable at < 0.08), and SRMR < 0.08 (Browne & Cudeck, 1993; Hair et al., 2019; Hu & Bentler, 1999).

Step 5: Item Centrality Analysis

The analysis further introduces an item-level centrality approach to identify the most representative indicators within each dimension using three complementary metrics:

- **Standardized CFA loading (λ):** The magnitude of the item's direct relationship to its latent factor, representing item–factor strength (Brown, 2015; Kline, 2023).
- **Corrected item–total correlation (r.drop):** The correlation between an item and the sum of all other items in its block, with the item itself removed from the total to avoid artificial inflation, also known as item discrimination. This represents internal consistency contribution (Cristobal et al., 2007; Nunnally & Bernstein, 1994).
- **Item–factor score correlation:** The correlation between each item and the latent factor score derived from the CFA model, representing the item's capacity to serve as a proxy for the full factor (DiStefano et al., 2009). Factor scores were extracted using lavPredict() and correlated with individual items using pairwise complete observations.

The central item in each block is that which ranks highest across all three metrics. Convergence across metrics provides strong evidence that the selected item is not merely reliable in isolation but genuinely representative of the broader latent construct.

Results

Step 1 - Factor Analysis Diagnostics

Table 2 presents the results of the four diagnostic tests. All tests confirm that factor analysis is appropriate for the dataset. The inter-item correlation matrix revealed predominantly moderate correlations (r = 0.20–0.70) across the 16 items, with no pair exceeding r = 0.90, confirming the absence of multicollinearity while demonstrating sufficient shared variance to justify factor extraction. Bartlett's test of sphericity was highly significant ($p < .001$), rejecting the null hypothesis that variables are uncorrelated. The overall KMO measure of sampling adequacy was 0.80, indicating very good factorability, with individual item MSA values all exceeding 0.63. The determinant of the correlation matrix (0.01309155) was well above the acceptable threshold of 0.00001. Collectively, these diagnostics confirm that the data fully meet the assumptions required for factor analysis.

Table 2. Factor Analysis Diagnostic Tests

Diagnostic Test	Result	Threshold	Verdict
Correlation Matrix Inspection	Most r > 0.30; maximum r < 0.90 across 16 items	r > 0.30 (adequate shared variance)	**Passed**
Bartlett's Test of Sphericity	$\chi^2(120)$ = significant, p < .001	p < .05 (reject H_0)	**Passed**
Kaiser-Meyer-Olkin (KMO)	Overall MSA = 0.80; all individual KMOs > 0.63	MSA ≥ 0.70 (overall)	**Passed**
Determinant of Correlation Matrix	0.01309155	> 0.00001 (no multicollinearity)	**Passed**

Step 2 - Exploratory Factor Analysis

Parallel analysis indicated retention of five factors, confirming both the four dimensions from Lucas et al. (2016) and validating that the *General Perceived Mobility* items form a fifth, empirically distinct factor rather than collapsing into the original four. Table 3 presents the resulting factor structure from the first round of principal axis factoring model with oblimin rotation.

Table 3. EFA Factor Structure

Empirical Label	Items Loading (≥ 0.30)	Lucas Dimension Correspondence
General Perceived Mobility	Satisfaction with travel conditions (0.854); Overall mobility assessment (0.701); Relative travel conditions vs others (0.680)	General Perceptions (extended framework)
Mobility Intensity	Desired distance (0.847); Desired trips (0.615); Desired travel time (0.661)	Mobility/ time-poverty (Lucas)
Accessibility Constraints	Access to transport options (0.786); Public transport allows reaching destinations (0.765); Transport options suited to abilities (0.533); Ability to reach needed destinations (0.483)	Accessibility (Lucas)
Affordability Pressures	Housing cost affordability (0.700); Transport cost affordability (0.686); **Desired car ownership (no significant loading)**	Affordability (Lucas) — partial
Safety Exposure	Safety from crime/harassment (0.749); Safety from road accidents (0.694); **Pollution exposure (no significant loading)**	Externalities (Lucas) — safety sub-domain only

Note. Loadings below 0.30 are suppressed. Cumulative variance explained = 45.7%.

The factor structure exhibits the following key features:

- **General Perceived Mobility:** The three general perception items (*transport satisfaction*, *mobility self-assessment*, and *relative transport comparison*) load exclusively and strongly on this factor, confirming the empirical distinctiveness of the general perception block.
- **Mobility Intensity:** Three items capturing activity level (*trips*, *kilometres*, and *time travelling*) cohere as a distinct mobility factor, consistent with the Lucas et al. (2016) mobility dimension.
- **Accessibility Constraints**: The three *accessibility* items plus the *transport options* item from the original mobility block converge on a clear accessibility factor.
- **Affordability Pressures:** *Transport cost affordability* and *housing cost affordability* load jointly, consistent with the economic constraint dimension of Lucas et al. (2016).
- **Safety Exposure:** The two safety items (*crime/harassment* and *road accidents*) form a coherent safety sub-dimension of the Lucas et al. (2016) externalities block.

The EFA results reveal a meaningful divergence between the theoretically specified dimensions and how transport poverty is structured in respondents' lived experiences. While the framework proposed by Lucas et al. (2016) treats mobility, accessibility, affordability, and externalities as distinct but internally coherent constructs, the empirical findings indicate a more differentiated structure. In particular, the "*Mobility*" dimension separates into two dimensions: a perceptual component reflecting overall evaluations of mobility adequacy, and a behavioral component capturing mobility intensity (trips, distance, and time). Similarly, the "*Exposure to Externalities*" dimension does not emerge as a single construct. Instead, safety-related factors (exposure to crime or traffic risk) form a distinct factor, while pollution fails to cohere with these items or load meaningfully. This indicates that respondents do not perceive environmental pollution as part of the same latent construct as personal safety risks, suggesting that environmental and safety concerns constitute separate perceptual domains.

In addition, *Desired car ownership* did not correlate meaningfully with affordability-related items. Respondents appear to frame car ownership aspiration as reflecting lifestyle preference, autonomy, or social status rather than financial strain; a conceptually important distinction suggesting that the affordability block should be operationalized through cost-burden items only.

Step 3 - Reliability Analysis

Table 4 presents Cronbach's alpha for each conceptual block, item-level diagnostics, and the actions taken based on those diagnostics.

- **Mobility intensity:** The initial alpha of 0.66 reflected the inclusion of *Transport options suited to abilities*, whose corrected item-total correlation (r.drop = 0.19) indicated weak alignment with the activity-intensity items. Removing this item and refining the block to the three activity items (*trips*, *kilometres*, *time*) increases internal consistency to 0.75.
- **Accessibility constraints:** Alpha = 0.74 with all r.drop values exceeding 0.50, indicating strong and coherent internal structure. No items were removed.
- **Affordability pressures:** The initial alpha of 0.45 was substantially below acceptable thresholds. The *car ownership* item (r.drop = 0.052) demonstrated near-zero correlation with the affordability sub-

scale, and its removal raised alpha to 0.645. The two cost-burden items (*transport* and *housing affordability*) form a coherent two-item sub-scale, consistent with EFA findings.

- **Safety exposure:** Alpha = 0.60, with the *pollution* item weakening block coherence (removing it raises alpha to 0.70). Convergent with EFA findings, this confirms that pollution perception constitutes a distinct perceptual dimension not captured by the safety sub-scale.
- **General Perceived Mobility:** Alpha = 0.80, the strongest across all blocks, with all items exhibiting high r.drop values (> 0.60). This block is internally coherent and requires no modification.

Table 4. Reliability Analysis Results by Dimension Block - Initial and Refined

Dimension	Initial α	Diagnostic Findings	Action Taken	Refined α
Mobility Intensity	0.66	*Transport options suited to abilities* had r.drop = 0.19; removing it raises α to 0.75	Item removed; block refined to 3 activity items	0.75
Accessibility Constraints	0.74	All items strong (r.drop > 0.50); coherent block	Block retained as-is	0.74
Affordability Pressures	0.45	*Desired car ownership* had r.drop = 0.052; removing raises α to 0.645	Car ownership item removed	0.645
Safety Exposure	0.60	Pollution item weakens block; removing raises α to 0.70; EFA also showed non-loading	Pollution item removed from block	0.70
General Perceived Mobility	0.80	All items strong and coherent; no action needed	Block retained as-is	0.80

Step 4 - Confirmatory Factor Analysis

Following reliability-driven item refinement (removing *Transport options suited to abilities* from *Mobility*, *Desired car ownership from Affordability*, and *Pollution exposure* from *Externalities*) the refined five-factor CFA model was estimated. Table 5 presents standardized factor loadings.

The CFA results support the hypothesized five-factor structure. The model demonstrates good fit across all primary indices. Incremental fit indices are within acceptable ranges, with CFI = 0.950 and TLI = 0.929, suggesting that the model adequately reproduces the observed covariance structure. Absolute fit measures further support this conclusion, with RMSEA = 0.056 (90% CI: 0.055–0.058) and SRMR = 0.044, both within commonly accepted thresholds for good fit.

The standardized factor loadings indicate that all indicators load significantly and meaningfully on their respective latent constructs, with values ranging from 0.587 to 0.857. Most loadings exceed 0.65, reflecting moderate to strong relationships between observed variables and their underlying factors. In particular, several indicators demonstrate strong representation of their constructs, including *Distance traveled vs desired* within mobility intensity (0.857), *transport cost affordability* (0.812), *safety from accidents* (0.755), and *satisfaction with travel conditions* within the general perception factor (0.851). Correspondingly, these items exhibit the lowest residual variances and highest R^2 values, indicating that the factor model explains a

large proportion of their variance. Overall, these results support the convergent validity of the measurement model while also indicating variation in the strength of individual indicators across dimensions.

Table 5. Standardized Factor Loadings, Residual Variance, and Item R^2 from CFA

Factor	Item	Std. Loading	Residual Var.	R^2
Mobility Intensity	Desired trips	0.634	0.598	0.402
	Desired distance	0.857	0.266	0.734
	Desired travel time	0.653	0.574	0.426
Accessibility Constraints	Public transport allows reaching destinations	0.717	0.486	0.514
	Access to transport options	0.736	0.458	0.542
	Ability to reach needed destinations	0.655	0.571	0.429
Affordability Pressures	Transport cost affordability	0.812	0.341	0.659
	Housing cost affordability	0.587	0.655	0.345
Safety Exposure	Safety from crime/harassment	0.709	0.497	0.503
	Safety from road accidents	0.755	0.43	0.57
General Perceived Mobility	Overall mobility assessment	0.725	0.474	0.526
	Satisfaction with travel conditions	0.851	0.276	0.724
	Relative travel conditions vs others	0.701	0.509	0.491

Note: All loadings significant at $p < .001$. CFI = 0.950; TLI = 0.929; RMSEA = 0.056 (90% CI: 0.055–0.058); and SRMR = 0.044.

Step 5 — Item Centrality Analysis

Table 6 presents the full item centrality results across all five validated dimensions. Item centrality was assessed by triangulating three metrics: standardized CFA loading, corrected item–total correlation (CITC), and item–factor score correlation. Highlighted rows indicate the central item identified within each dimension.

Table 6. Item Centrality Analysis Across Five Dimensions

Dimension	Item	Std. Loading	CITC	Item–Factor r
Mobility Intensity	**Desired distance**	**0.857**	**0.665**	**0.951**
	Desired travel time	0.653	0.549	0.725
	Desired trips	0.634	0.528	0.704
Accessibility Constraints	**Access to transport options**	**0.736**	**0.604**	**0.850**
	Public transport allows reaching destinations	0.717	0.598	0.813
	Ability to reach needed destinations	0.655	0.514	0.756
Affordability Pressures	**Transport cost affordability**	**0.812**	**0.477**	**0.957**
	Housing cost affordability	0.587	0.477	0.699
Safety Exposure	**Safety from road accidents**	**0.755**	**0.534**	**0.889**
	Safety from crime/harassment	0.709	0.534	0.834
General Perceived Mobility	**Satisfaction with travel conditions**	**0.851**	**0.706**	**0.928**
	Overall mobility assessment	0.725	0.627	0.790
	Relative travel conditions vs others	0.701	0.609	0.764

Note: Highlighted rows indicate central items; CITC = Corrected Item–Total Correlation (r.drop); Item–Factor r computed using pairwise complete observations.

For two dimensions, the top two items are closely matched across metrics. Within *Accessibility Constraints*, *Access to transport options* (item-factor r = 0.850) and *Public transport allows reaching destinations* (r = 0.813) differ only modestly, suggesting either may serve as the central item depending on whether the research or policy focus is on general transport option availability or specifically on public transit reach. Similarly, in *Safety Exposure*, *Safety from road accidents* (r = 0.889) and *Safety from crime/harassment* (r = 0.834) are both strong single-item proxies, capturing traffic-related and personal-security dimensions of safety respectively. Table 7 therefore lists both items for these two dimensions, with selection guided by study focus rather than a single dominant statistical criterion."

Table 7. Recommended Central Items by Dimension - Practical Diagnostic Tool

Dimension	Central Item	Recommended Survey Question
Mobility Intensity	**Desired distance**	Thinking about your typical weekly travel activities: I travel (fewer/more) kilometers than I would like
Accessibility Constraints	**(1) Access to transport options** OR	I have access to (fewer/more) transport options than I would like.
	(2) Public transport allows reaching destinations	The public transport options in my neighbourhood allow me to reach (fewer/more) of the destinations that I need
Affordability Pressures	**Transport cost affordability**	I spend (less/more) money on transportation than I can afford.
Safety Exposure	**(1) Safety from road accidents** OR	I feel (not safe at all / very safe) from road accidents while travelling.
	(2) Safety from crime/harassment	I feel (not safe at all / very safe) from crime and harassment while travelling
General Perceived Mobility	**Satisfaction with travel conditions**	I am (very dissatisfied/very satisfied) with my current travel conditions.

Discussion

The Five-Factor Solution and Partial Validation of the Lucas Framework: What the Data Confirm and Where They Diverge

The results of this study provide substantial empirical support for the theoretical structure proposed by Lucas et al. (2016) while simultaneously revealing important perceptual restructurings that carry implications for how transport poverty is conceptualized and measured in practice. Three of the four dimensions suggested by Lucas et al. (2016), *Mobility*, *Accessibility*, and *Affordability*, emerge with good internal coherence and meaningful factor loadings, confirming that Canadian respondents perceive these as experientially distinct and measurable domains of transport disadvantage. The *General Perceptions* block, while not part of the original Lucas framework, constitutes the most internally coherent construct in the instrument ($\alpha = 0.80$), suggesting that it captures something real and important that sits alongside the four theoretical dimensions. Taken together, the findings support a revised five-factor structure for perception-based transport poverty measurement consisting of *Mobility Intensity*, *Accessibility Constraints*, *Affordability Pressures*, *Safety Exposure*, and *General Perceived Mobility*. This structure retains the core strengths of the framework proposed by Lucas et al. (2016) while reflecting how transport disadvantage is actually experienced and perceived by respondents in the Canadian context.

The most substantively important divergence from the theoretical model concerns the internal structure of two dimensions. First, the *Exposure to externalities* dimension does not hold together as a single construct in the data. Instead, safety-related perceptions, fear of crime/harassment, and traffic accidents, group together as one factor. *Pollution exposure*, however, does not align with any of the measured dimensions. This shows that people do not experience environmental pollution and personal safety as part of the same type of problem. Safety is immediate and personal, based on direct experience, while pollution is more indirect and less noticeable in day-to-day travel (Bickerstaff & Walker, 2001). This finding suggests that the Lucas et al. (2016) externalities dimension may require disaggregation in future perception-based instruments, separating a Safety sub-dimension from an Environmental Exposure sub-dimension, which might include not only emissions and air quality but also sub-dimensions such as noise, climate and landscape.

Second, attitudes toward car ownership do not behave like a financial measure of affordability. The very weak relationship of *Desired car ownership* with the *Affordability* scale (r.drop= 0.052) shows that this item is not capturing the same concept. Instead, *Desired car ownership* reflects deeper social and cultural meanings, including independence, freedom, and identity, as discussed in the automobility literature (Sheller & Urry, 2000; Urry, 2004; Walks, 2014). Because of this, people's desire to own a car is not mainly driven by cost considerations. For measurement purposes, this means that affordability should focus on actual financial burden rather than aspirations or preferences related to car ownership.

These divergences point to a broader lesson: the specific operationalization of transport poverty materially shapes what is measured, for whom, and which policy levers appear relevant. Singer and Martens (2023) develop a broader travel-problems taxonomy that, like the present study, moves beyond single-indicator transport poverty measures toward multi-item validated tools. Verhorst et al. (2023) similarly show that different transport poverty definitions and measurement scales identify different predictors and, by extension, different at-risk populations. Together, these studies confirm that measurement choices are not a neutral technical detail but a substantive determinant of how transport poverty is understood and addressed in policy.

Item Centrality and Its Practical Value for Policy Applications

One of the distinctive contributions of this study is the identification of a validated five-item diagnostic instrument for rapid transport poverty assessment. The item centrality analysis reveals that the five central items, one per dimension, achieve extraordinary levels of factor representation, with item-factor score correlations ranging from 0.850 to 0.957. The central *Affordability Pressures* item (*Transport cost affordability*, r = 0.957) and the central *Mobility intensity* item (*Desired distance*, r = 0.951) essentially capture the full variance of their respective latent constructs, meaning that a single well-chosen question can substitute for the full multi-item block with minimal information loss.

In addition to the single most central items identified for each dimension, the results also suggest that some dimensions may be adequately represented by more than one item, depending on the purpose of the analysis. For *Accessibility Constraints*, either of the following items performs strongly and may be used depending on the focus of the study: *Access to transport options* or *Public transport allows reaching destinations*. Both items show high factor loadings and strong item-total correlations, indicating that they capture slightly different but equally important aspects of accessibility. A similar pattern appears in the

Safety Exposure dimension. Here, either *Safety from road accidents* or *Safety from crime/harassment* may be selected depending on the policy or research focus. One emphasizes traffic-related safety, while the other captures personal security in public space. Both are strong indicators of the same underlying safety construct, but they highlight different dimensions of lived experience.

This has direct practical implications for governments, community organizations, and transport planning agencies across Canada. A key barrier to routine monitoring of transport disadvantage is the lack of short, validated instruments that can be embedded directly into existing statistical systems including community needs assessments, service surveys, and larger established instruments where the capacity to add entirely new content is limited and revisions are slow to implement. The five-item diagnostic tool in Table 7 addresses this gap by combining theoretical grounding in the framework proposed by Lucas et al. (2016) with strong empirical validation on a national sample. This is particularly valuable for local agencies with limited survey capacity, as it enables reliable monitoring of transport poverty in a much shorter format while maintaining conceptual integrity, and still allows flexibility in selecting alternative high-performing items depending on local priorities.

Limitations

Several limitations of this study should be acknowledged when interpreting and applying the findings.

- **First**, the validation is based on a single cross-sectional administration of the survey. The factor structure identified here, the five-dimensional perceptual model, may not be stable across time, particularly in response to significant disruptions such as the COVID-19 pandemic, fuel price shocks, or major transit infrastructure changes. Future research should test measurement invariance longitudinally to establish whether the dimensional structure of transport poverty perceptions is consistent across survey rounds.
- **Second**, although the Mobilizing Justice National Survey includes respondents' geographic location, this report analyzes the data at an aggregated national level, combining respondents from highly diverse contexts, including major metropolitan centres, mid-sized cities, small towns, and rural and remote communities. The factor structure has been validated at the national level, but there is no guarantee that it holds equally within each context. Urban respondents may have a more detailed understanding of accessibility than rural respondents for whom transit may not exist at all. Future work should use multi-group CFA or alignment methods to test whether the structure is consistent across urban-rural areas and across provinces and regions.
- **Third**, the Mobilizing Justice survey was conducted online, which introduces a known bias against populations with limited digital access, including individuals experiencing homelessness, people without fixed internet access, remote Indigenous communities, and individuals with severe mobility impairments. These groups are likely among the most transport-deprived in Canada, so their underrepresentation may lead to underestimation of both the prevalence and severity of transport poverty.
- **Fourth**, the refinements made to the *Exposure to externalities* and *Affordability* blocks (removing *Pollution exposure* and *Desired car ownership* items) were empirically justified but entail the loss of

theoretically motivated indicators from the Lucas et al. (2016) framework. Rather than discarding these items, we recommend two complementary paths: expanding the exposure dimension with additional items (e.g., noise, climate-related exposure) to avoid relying on pollution as a single indicator, and testing alternative phrasings of both items to determine whether their weak performance reflects a conceptual mismatch or simply poor wording. In the interim, both items should be retained as standalone indicators and tested against transport poverty outcomes via correlation and regression analyses, rather than embedded within composite scales.

- **Fifth**, the analysis uses Cronbach's alpha as the primary reliability metric. While alpha is the most widely used reliability measure, it can be inflated by high inter-item correlations even when items do not actually reflect the same latent construct. Future analyses should additionally report more accurate estimates of reliability when items have varying factor loadings. For the current study, the convergence of alpha with CFA-based evidence provides confidence in the reliability conclusions.
- **Sixth**, while the five-factor solution fits the data well, the theoretical status of the *General Perceived Mobility* block remains ambiguous. As discussed, it may function as a higher-order outcome rather than a co-equal dimension. Bifactor and second-order model specifications should be tested in future work to clarify its structural role.

Conclusion and Key Takeaways

This paper has presented a comprehensive psychometric validation of the perception-based transport poverty instrument administered in the Mobilizing Justice National Survey on Transport Poverty. Drawing on a national Canadian sample of N = 27,216, the study subjected 16 perception items to a five-step sequential validation protocol to assess empirical alignment with the multidimensional framework of Lucas et al. (2016). The main takeaways are as follows:

The Lucas et al. (2016) framework is substantially but not fully supported in the Canadian context. Three of the four core dimensions (*Mobility*, *Accessibility*, and *Affordability*) emerge as internally coherent and empirically distinct perceptual constructs, confirming that Canadians perceive transport disadvantage through the multidimensional lens the framework proposes rather than as a single undifferentiated condition. The *Exposure to externalities* dimension, however, does not function as a unitary construct: personal safety risks and environmental pollution are perceived as experientially distinct domains and do not cohere within a shared latent factor. This finding refines rather than invalidates the Lucas framework, suggesting that perception-based applications require the *Exposure to externalities* dimension to be disaggregated into *Safety Exposure* and *Environmental Exposure* sub-dimensions.

Two theoretically specified items do not function as intended within their assigned blocks. *The Desired car ownership* item (r.drop = 0.052) measures something closer to autonomy aspirations and social identity than financial constraint, while the *pollution exposure* item consistently weakens the *Exposure to externalities* block reliability and fails to load on any factor. Neither finding reflects an instrument deficiency; both reflect genuine limits in the direct portability of the Lucas framework to a perception-based national measurement context. Both items should be retained in future survey administrations as standalone indicators examined through complementary analyses rather than embedded within composite scales.

A revised five-factor structure best represents how Canadians experience transport poverty. The findings support a perception-based transport poverty framework consisting of *Mobility Intensity*, *Accessibility*, *Affordability*, *Safety Exposure*, and *General Perceived Mobility*. Three of these dimensions correspond directly to the original Lucas et al. (2016) framework, while *Safety Exposure* emerges from the refinement of the *Exposure to externalities* dimension and *General Perceived Mobility* emerges as an additional construct capturing overall evaluations of transport conditions. Together, these five dimensions provide the most empirically supported representation of transport poverty perceptions in the Canadian context.

The refined CFA model demonstrates good fit across all primary indices. Following EFA- and reliability-guided item refinements, the five-factor model retaining 13 items achieves CFI = 0.950, RMSEA = 0.056 (90% CI: 0.055–0.058), and SRMR = 0.044, with robust estimates confirming the stability of these results. All items load significantly on their respective factors (all $p < .001$), with standardized loadings ranging from 0.587 to 0.857, confirming the structural validity of the measurement model.

Item centrality analysis yields a validated five-item diagnostic instrument for applied use. The central item per dimension achieves item–factor score correlations between 0.850 and 0.957, making each a near-complete proxy for its latent construct. *Transport cost affordability* (r = 0.957) and *distance travelled versus desired* (r = 0.951) are particularly strong single-item proxies. *Access to transport options, Safety from road accidents* and *Satisfaction with travel conditions* are also identified as central items for their corresponding dimensions. For municipalities, transit authorities, and community organizations that cannot administer a full survey, this five-item instrument offers a theoretically grounded, nationally validated screening tool that preserves the multidimensional structure of transport poverty while minimizing respondent burden. It is suited to needs assessments, programme evaluation, and longitudinal monitoring, though the full 13-item instrument remains necessary for research applications requiring fine-grained characterization of transport poverty profiles.

"Taken together, transport poverty is not a single, uniform condition. It reflects different combinations of *mobility intensity*, *accessibility constraints*, *affordability pressures*, *safety exposure*, and *general perceived mobility* that vary across populations and places. The validated five-factor structure developed in this report makes it possible to measure this complexity at a national scale and provides a practical foundation for future research, monitoring, and policy action aimed at reducing transport poverty in Canada."

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