Verhorst *et al.*
*European Transport Research Review* (2023) 15:21
https://doi.org/10.1186/s12544-023-00596-z

European Transport Research Review

ORIGINAL PAPER

Open Access

# Definitions matter: investigating indicators for transport poverty using different measurement tools

Tom Verhorst[1], Xingxing Fu[1] and Dea van Lierop[1*]

## Abstract

**Background** An individual's inability to fully participate in social life due to limited means of transport options, in short, transport poverty, is a common theme in contemporary transport planning. However, due to the lack of a universal definition, identification and measurement of transport poverty can be challenging.

**Purpose** This paper aims to assess the implications of three widely used definitions and a newly developed measurement scale by comparing them in terms of scale levels, measurement dimensions and research contexts

**Methodology** This study first systematically reviews the literature on transport poverty and summarizes aspects of the transport poverty concept emphasized in previous studies. Using survey data from two Dutch cities, the study then measures transport poverty by means of a scoring system and an indicator derived from a new measurement scale by factor analysis. Finally, by performing a series of linear regression models on the generated scores, the predictors of each definition (measurement scale) are compared to identify which aspects of transport poverty are prioritized by each definition.

**Findings** Each transport poverty definition correlates with a different set of predictors, indicating that the used definition of transport poverty has an impact on how the concept is identified and implying in which contexts the definition (measurement scale) can be applied. The findings could help policymakers evaluate the applicability of different transport poverty definitions in specific contexts and help them select the optimal measurement tool for assessing the problem they are aiming to solve.

**Keywords** Transport poverty, Transport adequacy, Netherlands, Perceived accessibility

## 1 Introduction

Urban accessibility is often taken for granted and equity in transport planning is regularly overlooked [9]. For example, car-centric planning has resulted in the creation of land use patterns that are difficult to navigate for non-motorized transport users, confining them in their freedom of movement [13]. In addition, individuals with limited financial budgets, those who reside in secluded areas as well as individuals with a physical and/or cognitive disabilities often experience obstacles when it comes to reaching important destinations. The distribution of mobility and accessibility levels for certain population segments or areas may impact contemporary social processes, such as social inclusion, participation, and community cohesion [24]. Restricted accessibility in everyday travel has been found to have a negative impact on people's lives, and potentially results in social exclusion [8, 12]. As Preston and Rajé [30] state: '*social exclusion is not*

*Correspondence:
Dea van Lierop
d.s.vanlierop@uu.nl
[1] Department of Human Geography and Spatial Planning, Faculty of Geosciences, Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, the Netherlands

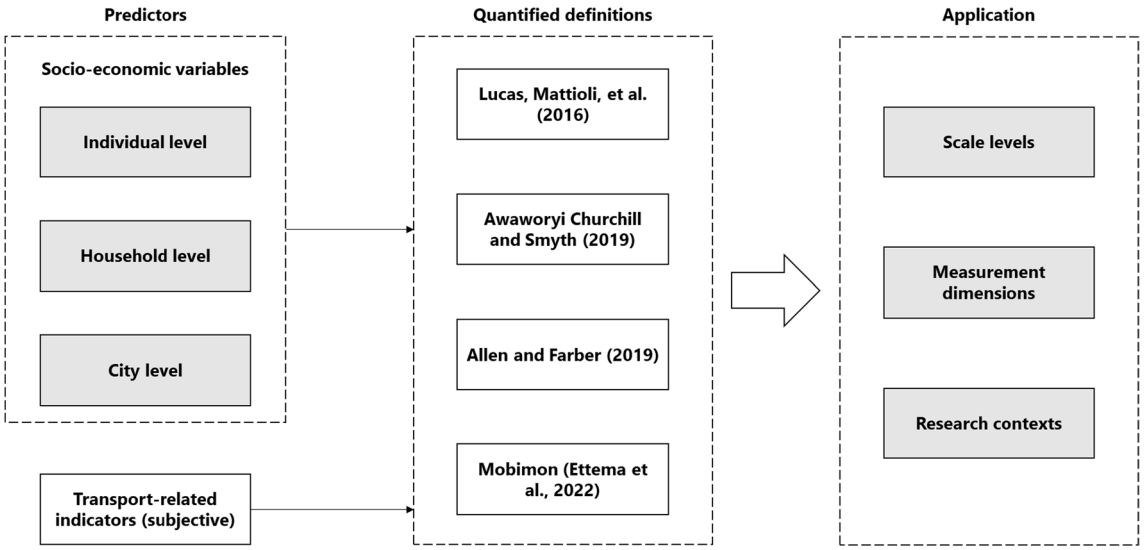


**Fig. 1** Research framework

*due to a lack of social opportunities, but a lack of access to opportunities.'*

The inequitable distribution of accessibility and the resulting lack of access to social opportunities for certain groups can lead to the occurrence of transport-related social exclusion, which is also known as transport poverty. Despite a growing interest in solving issues concerning social exclusion caused by a lack of accessibility, there is still a lack of a general understanding of transport poverty regarding its definition, measurement, and implications [19]. Moreover, most transport poverty definitions and studies have been developed in the Global North, while the situation is likely to be different, and also more challenging in the Global South. A basic definition of transport poverty is *an individual's inability to fully participate in social life due to limited means of transport* [14, 22, 24].

Identifying the presence of, or vulnerability towards, transport poverty in practice, however, remains to be challenging, since transport poverty is a very comprehensive subject, and has been used in many different contexts. Additionally, the term transport poverty has been used interchangeably with other concepts such as transport-related social exclusion, accessibility poverty and mobility poverty [3, 16, 26, 30]. While these concepts are remarkably similar, the definitions do not completely align. As a consequence, what transport poverty precisely entails, has not been fully articulated with the existing literature, making it difficult to measure and identify [22, 24, 34].

While there is no single clear definition of transport poverty, previous studies have used different definitions prioritizing multiple aspects of the concept of transport poverty, and creating frameworks that are applicable to different contexts. Thereby, this paper aims to assess the implications of different definitions of transport poverty by quantifying transport poverty using scoring systems transformed by three different definitions and a newly-developed measurement scale [27, 38]. Generating a deeper understanding of the identification of this phenomenon could help policymakers with the prevention of transport poverty, potentially resulting in a decrease in transport inequality while also contributing to the elimination of transport-based social exclusion. By performing a series of linear regression models on generated transport poverty scores, we compare the predictors of each transport poverty definition (measurement scale) to identify which aspects of the concept are prioritized by each definition (measurement scale) (Fig. 1). These analyses will contribute to answering the research question: What do the different definitions of transport poverty indicate and in which contexts can they be applied?

This paper is structured as follows. In the following section, we reviewed the definitions and measurements of transport poverty in the previous literature. In Sect. 3, we introduce the data and methods we use, including the development of scoring systems and the analysis of predictors of transport poverty scores. In Sect. 4, results of the analysis are presented. In Sect. 5, we discuss the implications of different transport poverty definitions and provide conclusions.

**Table 1** Mainstream definitions of transport poverty

| Author | Highlighted dimensions | Scale level | Definition |
|---|---|---|---|
| Lucas et al. [22, 24] | Affordability<br>Mobility<br>Accessibility<br>Exposure to transport externalities | Individual<br>Society | There is no transport option available that is suited to the individual's physical condition and capabilities<br>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<br>The necessary weekly amount spent on transport leaves the household with a residual income below the official poverty line<br>The individual needs to spend an excessive amount of time travelling, leading to time poverty or social isolation<br>The prevailing travel conditions are dangerous, unsafe, or unhealthy for the individuals |
| Awaworyi Churchill and Smyth [2] | Affordability<br>Accessibility | Household | The situation in which households find it difficult to meet the cost of transport<br>The situation in which household members have trouble getting a job because of transport problems or have not been looking for work due to lack of transport |
| Allen and Farber [1] | Accessibility | Household<br>Neighbourhood<br>City | The compounded lack of ability to travel to important destinations and activities |

## 2 Literature review

### 2.1 Defining transport poverty

The concept of transport poverty originated in the early 2000s, although studies have attempted to address transport poverty over the years, the terminologies and definitions used in the literature are varied and complex [1, 2, 14, 22, 24]. For example, transport-related social exclusion, mobility poverty and accessibility poverty are occasionally used as synonyms for transport poverty [3, 16, 26, 30]. Transport-related social exclusion is more relevant to definitions that highlight the social consequences of transport poverty [22, 24], whereas mobility poverty or accessibility poverty is more relevant to definitions that emphasize the causes of transport poverty [1, 2].

Other terms, including transport equality, transport equity, transport justice and mobility justice are also relevant to the concept of transport poverty. From a distributional point of view, transport equality and transport equity respectively look into the horizontal and vertical equity of transport systems. Transport equality looks into the extent to which transport resources are evenly distributed across the population, and transport equity looks into the extent to which people have equal access to opportunities through the disproportional allocation of transport resources [20, 36]. In the case of transport inequalities, the groups who have lower access to opportunities are potentially more vulnerable to experiencing transport poverty [1]. Distinguishing from transport equality and transport equity, transport justice and mobility justice encompass not only distributive components but also deliberative, procedural, restorative, and epistemic elements [15, 37]. Contrary to transport-related social exclusion, transport-related social inclusion is a result of a transport system with high equity or justice, in which all individuals and groups are considered in the planning and operations of a transport system with the goal of having all people experience the same potential access to social opportunities [11, 32].

Since there is no clear universal definition of transport poverty, it remains difficult to identify transport poverty and generate policies to counteract it. This leaves much to elaborate on, for example, the scale level (individual, household, area) at which the problem should be addressed remains questionable. Furthermore, it is also questioned whether the problem of transport poverty is even substantially different from poverty by itself [22, 24].

The most comprehensive and widely-cited definition of transport poverty was developed by Lucas et al. [22, 24]. These authors attempted to address the contention issues concerning transport poverty by generating a standard definition from existing academic and policy literature. Their definition highlights the negative social consequences caused by transport poverty for both individuals and society as a whole (see Table 1).They suggested that transport professionals need to better understand and communicate the severe social consequences that transport poverty can cause. Notably since the mobility behaviour of low-income groups differ from high-income populations, making recognition of these differences essential within transport planning.

Since Lucas et al.'s [22, 24] definition is so comprehensive, the complexity of this framework makes it exceedingly difficult as a standalone measurement tool in transport planning. Many studies that attempted to define transport poverty with a specific research question often adopted a sub-concept of the definition by

Lucas et al. [22, 24]. For example, Awaworyi Churchill and Smyth [2] used the term "transport poverty" in a more narrow sense to refer to the situation in which households find it difficult to meet the cost of transport, Allen and Farber [1], in their study on households suffering transport poverty at a national scale, defined transport poverty as the compounded lack of ability to travel to important destinations and activities. Often times, studies use succinct frameworks, reducing the burden of excessive data collection, which increases adoptability and makes research more convenient. However, the lack of a systemic approach and implementing limited dimensions may result in an insufficient amount of information needed to write fitting policies for specific contexts [39]. Therefore, in this study, we compare the three transport poverty definitions and a newly developed transport poverty scale from three dimensions, namely scale level, measurement dimension and research context, to imply how these definitions are applicable to practices and policies (see Fig. 1).

### 2.2 Measuring transport poverty

Lucas et al. [22, 24] summarised the indicators from the literature which they argue would be the most useful for measuring the different dimensions of transport poverty they defined, including measures of affordability, mobility, accessibility, and exposure to transport externalities. Affordability is the dimension that considers how difficult it is to meet transport costs, and is usually measured by actual transport expenditure as a share of income [2, 22, 24]. Mobility is the dimension which considers how difficult it is to move from location to location due to a systemic lack of transport and mobility options, and is usually measured by the lack of mobility services or infrastructure [22, 24, 28]. Accessibility is the major dimension used to measure transport poverty in previous studies. It is the dimension that considers an individual, group, or geographic location's ability to reach potential opportunities. Often, accessibility measures include assessments of being able to reach regular activities and destinations, such as employment, education, healthcare services, and other daily amenities. Accessibility can be measured from both objective and subjective perspectives. Objective accessibility is the extent to which land-use and transport systems enable individuals to reach activities or destinations [13], which has been of great significance to transport research and policies over the past decades. Lättman et al. [17, 18] argued that objective accessibility is limited in capturing accessibility for everyone since objective factors of travelling such as travel times and travel distances are perceived differently by individuals. Thus, the subjective perspective of accessibility, perceived accessibility, is complementary to objective accessibility and based primarily on individuals' opinions and experiences [17, 18, 35]. Lättman, et al. [17] also proposed Perceived Accessibility Scale (PAC) as a measurement tool of perceived accessibility. Exposure to transport externalities is the outcome of disproportionate exposure to the negative effects of the transport system, such as negative impacts of transport systems on safety and health, and it is usually measured by physical exposures such as pollution on the road and traffic volume [22, 24].

Discussion about different dimensions of transport poverty demonstrated that the partial aspects of transport poverty recorded would be the key determinant in understanding who is affected, and the shape of the policy solutions brought forward. Thus, the measurement depends on the given group or geographical area, and the issues under consideration. In recent years, several studies have attempted to assess transport poverty using quantitative measurement tools. These studies developed indices to measure specific dimensions of transport poverty at a specific scale level such as individual, household, area (community) or region under their consideration.

At the household level, Awaworyi Churchill and Smyth [2] measured transport poverty in the dimension of transport affordability in their study on the effect of transport poverty on subjective wellbeing among Australian households. Using an economic framework, the study measured transport poverty using variables related to whether a household needed to pay a disproportionate amount of income on transport costs in order to access essential services, travel to work and engage in social activities. Accordingly, they measured accessibility poverty based on whether the respondent of a household had trouble getting a job because of transport problems or whether they had not been looking for work due to lack of transport.

At the area level, Allen and Farber [1] assessed transport poverty and the lack of accessibility by measuring and analysing inequalities in access to employment opportunities across distinct groups of the population in Canadian cities. Using household demographic and employment data from the eight most populous urban regions in Canada, the study adopted area-specific measurements, assuming that areas were at risk of transport poverty when there was a high amount of people living under the regionally adjusted low-income cut-off and suffering from low public transport access to employment.

Investigating at the area or regional levels increases the scale of research. Since accessibility poverty is a main dimension of transport poverty, empirical studies widely use accessibility measures as a proxy of transport poverty. For example, the same measurement was used across different geographical scales [3, 33], with

less regard for local circumstances. This makes context specific policies difficult to create using these methods when individual characteristics are overlooked. An individual's needs, abilities and opportunities can strongly influence their level of access to transport modes and spatially distributed opportunities, and may strongly influence their overall accessibility [36]. To address these issues, several recent studies also took the socio-economic status of the areas into account to measure the socio-economic disparities of accessibility [6, 25].

Approaches to measuring transport poverty vary in terms of scale levels. While several studies focus on assessing individual characteristics [2, 14], others focus on population segments and geographical contexts [1]. Investigating groups and areas instead of individuals increases the scale of research, however, as mentioned before, using a more concise notion of transport poverty can make the accuracy of the fitting implications suffer [39]. Using the same measure for different areas without considering local circumstances makes context-specific policies difficult to develop. When comparing widespread rural Australia with more urbanised areas in Europe for example, different needs for accessibility and transport have to be taken into account. Moreover, most definitions and studies are based on the Global North, with limited empirical insight into BRICS countries [3, 31]. Therefore, not only different scale levels, but also different regional contexts ask for different measures and analyses. In this study, we use data from two Dutch cities to measure and analyse different definitions of transport poverty.

## 3 Data and methods

### 3.1 Data

Survey data was collected in Summer of 2021. This survey was conducted in order to provide insight into the determinants and consequences concerning transport poverty in the Netherlands (Mobimon project, developed by Ettema et al. [10]. The survey targeted two population segments: the first is a socially vulnerable segment with low incomes, and the second is a general population segment as the control group. A total of 1203 people participated in the survey and the valid sample contains 1009 individuals.

Table 2 displays the summary statistics of the sample used for analysis. Of the sample, 51.0% live in Utrecht and 49.0% in Rotterdam. Most people in the sample live in extremely or highly urbanized areas, so the results may not be universally applicable to suburban and rural areas. Compared to Dutch demographic data [7], the sample is overrepresented by females, young adults, and high education people. Due to the aims of the survey, the sample is also overrepresented by low-income groups. When looking at car access, more than one third of the survey population does not have access to a car (36.1%), which is higher than the overall percentage of the Netherlands, where 26% of households did not have access to a car in 2020 [40].

### 3.2 Quantifying different definitions of transport poverty

To identify the implications of different definitions of transport poverty, we use quantitative methods to assess the aspects emphasized by each definition. To this end, we fist transfer the three definitions of transport poverty introduced in the literature review section into scoring systems and calculate the transport poverty scores using variables in the survey (Table 3). According to the statements of the definition of transport poverty by Lucas et al. [22, 24], Awaworyi Churchill and Smyth [2], Allen and Farber [1], we extract several components for each definition and select corresponding variables from the survey to represent the components. The extensive definition by Lucas et al. [22, 24] is divided into five different parts. Awaworyi Churchill and Smyth [2] and Allen and Farber [1] on the other hand, used more concise definitions of transport poverty within their research, resulting in the extraction of two different components for both their definitions.

For consistency, we used a similar form as the index system for assessing the adequacy of housing environments established by Mercader-Moyano et al. [27]. We quantify the components of each definition in the same way, and the scores of each definition are created range from 0 (no risk of transport poverty) to 1 (maximum risk of transport poverty). For each definition, a respondent's score increases by a certain number of points when the respondent meets certain component for certain degree. The number of points for each component depends on how many components the definition contains and the answer for each component. For example, the definition by Lucas et al. [22, 24] contains 5 components, so each component mostly contributes a maximum of 0.2 points, and for different answers to the component, the points can be 0–0.2 according to the degree the respondent meets that component.

### 3.3 Testing a new measurement scale: Mobimon score

We also test the measurement scale developed by the survey (Mobimon, developed by Ettema et al. [10] ) we used for the analysis. The measurement scale contains nine transport poverty-related statements. For each statement, respondents indicated their agreement on a 5-point Likert scale, ranging from 'completely disagree'

**Table 2** Summary statistics of the sample

| | Utrecht | Rotterdam | Total |
|---|---|---|---|
| Respondents | 51.0% (515) | 49.0% (494) | 100% (1009) |
| *Sex* | | | |
| Male | 39.0% (201) | 46.4% (229) | 42.6% (430) |
| Female | 61.0% (314) | 53.6% (265) | 57.4% (579) |
| *Age* | | | |
| 18–30 | 41.7% (215) | 35.4% (175) | 38.7% (390) |
| 31–50 | 35.3% (182) | 39.5% (195) | 37.4% (377) |
| 51 + | 22.9% (118) | 25.1% (124) | 24.0% (242) |
| *Household composition* | | | |
| Single, without children | 26.4% (136) | 30.2% (149) | 28.2% (285) |
| Single parent, with children | 8.9% (46) | 7.5% (37) | 8.2% (83) |
| Couple, without children | 28.3% (146) | 28.1% (139) | 28.2% (285) |
| Couple, with children | 12.2% (63) | 15.2% (75) | 13.7% (138) |
| Other | 24.1% (124) | 19.0% (94) | 21.6% (218) |
| *Education level* | | | |
| Low (primary education, vmbo, tertiary education mbo1) | 10.9% (57) | 16.8% (83) | 13.8% (139) |
| Medium (secondary education havo and vwo, tertiary education mbo 2–4) | 26.6% (137) | 39.7% (196) | 33.0% (333) |
| High (university of applied sciences, bachelor, master, PhD) | 62.3% (321) | 42.9% (212) | 52.8% (533) |
| *Estimated net household income* | | | |
| Low: < €1870 | 45.2% (197) | 44.4% (188) | 44.8% (385) |
| Medium: €1870–€3800 | 41.1% (179) | 43.5% (184) | 42.3% (363) |
| High: > €3800 | 13.8% (60) | 12.1% (51) | 12.9% (111) |
| *Employment status* | | | |
| Full time job | 32.2% (166) | 43.7% (216) | 37.9% (382) |
| Part time job | 36.9% (190) | 30.2% (149) | 33.6% (339) |
| Student, retired or unemployed | 30.9% (159) | 26.1% (129) | 28.5% (288) |
| *Use of mobility aid* | | | |
| Yes (walking cane, crutches, white cane, walker, mobility scooter or a wheelchair) | 6.4% (33) | 2.0% (10) | 4.3% (43) |
| No | 93.6% (482) | 98.0% (484) | 95.7% (966) |
| *Primary Language spoken at home* | | | |
| Dutch | 82.5% (425) | 90.7% (448) | 86.5% (873) |
| Other | 17.5% (90) | 9.3% (46) | 13.5% (136) |
| *Possession of a valid driver's License* | | | |
| Yes | 71.8% (370) | 71.1% (351) | 7.15% (721) |
| No | 28.2% (145) | 28.9% (143) | 28.5% (288) |
| *Access to a car* | | | |
| Yes, always | 37.3% (192) | 46.0% (227) | 41.5% (419) |
| Sometimes | 24.5% (126) | 20.2% (100) | 22.4% (226) |
| No | 38.3% (197) | 33.8% (167) | 36.1% (364) |

to 'completely agree'. To generate a score from the measurement scale, a principal component analysis was conducted with a varimax rotation. We extracted two components from the measurement scale. However, the item 'being concerned about road safety' had a weak loading (0.310), so we remove this item for the item set and rerun the principal component analysis. After removal, the model fits well and one component is extracted from the measurement scale. Table 4 displays the results of the final factor analysis and showcases that the eight remaining items all load into one latent factor which explains 61.7% of the variance. The components all carry a sufficient factor loading and internal consistency is fitting with a Cronbach's alpha of 0.830 (alpha > 0.7). Kaiser–Meyer–Olkin's (KMO) measure of

**Table 3** Measurement tools transferred from three existing definitions

| Definition component | Corresponding questions in the survey | Answer | Assigned score |
|---|---|---|---|
| *Lucas et al.* [22, 24] | | | |
| No transport option suited to an individual's conditions | With the transport options available to me I can travel in a way that is suited to my physical condition and abilities | Completely disagree | 0.2 |
| | | Disagree | 0.1 |
| | | Neutral | 0 |
| | | Agree | 0 |
| | | Completely agree | 0 |
| 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 public transport options in my neighbourhood reach destinations or activities that are important to me | Completely disagree | 0.1 |
| | | Disagree | 0.05 |
| | | Neutral | 0 |
| | | Agree | 0 |
| | | Completely agree | 0 |
| | With the transport options available I can reach all my regular destinations and activities | Completely disagree | 0.1 |
| | | Disagree | 0.05 |
| | | Neutral | 0 |
| | | Agree | 0 |
| | | Completely agree | 0 |
| The necessary weekly amount spent on transport leaves the household with a residual income below the official poverty line | With the transport options available to me I have to spend more on necessary travel in a week than I can afford | Completely disagree | 0 |
| | | Disagree | 0 |
| | | Neutral | 0 |
| | | Agree | 0.1 |
| | | Completely agree | 0.2 |
| The individual needs to spend an excessive amount of time travelling, leading to time poverty or social isolation | With the transport options available to me I spend much more time travelling than I would like | Completely disagree | 0 |
| | | Disagree | 0 |
| | | Neutral | 0 |
| | | Agree | 0.05 |
| | | Completely agree | 0.1 |
| | In the past year, have you been less/unable to reach your family or friends in the Netherlands due to problems with transport? | Yes, I was unable to reach my family or friends at all because of problems with transport | 0.1 |
| | | Yes, I could not reach my family or friends as well as I wanted to because of problems with transport | 0.05 |
| | | No | 0 |
| | | Other | 0 |

**Table 3** (continued)

| Definition component | Corresponding questions in the survey | Answer | Assigned score |
|---|---|---|---|
| The prevailing travel conditions are dangerous, unsafe, or unhealthy for the individual | With the transport options available to me: | | |
| | I feel safe while travelling to my regular destinations and activities | Completely disagree | 0.066 |
| | | Disagree | 0.033 |
| | | Neutral | 0 |
| | | Agree | 0 |
| | | Completely agree | 0 |
| | I am concerned about road safety while travelling to my regular destinations and activities | Completely disagree | 0 |
| | | Disagree | 0 |
| | | Neutral | 0 |
| | | Agree | 0.033 |
| | | Completely agree | 0.066 |
| | I can travel without negative consequences to my health | Completely disagree | 0.066 |
| | | Disagree | 0.033 |
| | | Neutral | 0 |
| | | Agree | 0 |
| | | Completely agree | 0 |
| Maximum total score | | | 1 |
| *Awaworyi Churchill and Smyth* [2] | | | |
| A disproportionate amount of household income is spent on transport | With the transport options available to me I have to spend more on necessary travel in a week than I can afford | Completely disagree | 0 |
| | | Disagree | 0 |
| | | Neutral | 0 |
| | | Agree | 0.25 |
| | | Completely agree | 0.5 |
| Having trouble getting a job or not having been looking for work because of a lack of transport | In the past year, have you turned down a job or decided not to apply to a job that you were interested in due to (potential) problems with transport? (Multiple choice) | Yes, I had to turn down a job for this reason | 0.25 |
| | | Yes, I decided not to apply for a job for this reason | 0.25 |
| | | No | 0 |
| | | Not applicable (not looking for a job) | 0 |
| | | Other | 0 |
| Maximum total score | | | 1 |

**Table 3** (continued)

| Definition component | Corresponding questions in the survey | Answer | Assigned score |
|---|---|---|---|
| *Allen and Farber* [1] | | | |
| People living under the regionally adjusted low-income cut-off | What best describes your living situation? and What is your estimated net monthly household income? | Single-person household with a monthly income less than 980 euros | 0.5 |
| | | Single-parent household with a monthly income less than 1870 euros | 0.5 |
| | | Couple household (with or without children) with a monthly income less than 1870 euros | 0.5 |
| | | Other household type with a monthly income less than 980 euros | 0.5 |
| | | All the other | 0 |
| Low transit access to employment | Which public transport options are available in your neighbourhood? (Multiple choice) | Bus | 0.0625 if not |
| | | Tram/metro | 0.0625 if not |
| | | Regiotaxi/belbus | 0.0625 if not |
| | | Train | 0.0625 if not |
| | With the transport options available to me I can easily reach my (volunteering) work or internship | Completely disagree | 0.125 for employed<br>0 for unemployed |
| | | Disagree | 0.125 for employed<br>0 for unemployed |
| | | Neutral | 0 |
| | | Agree | 0 |
| | | Completely agree | 0 |
| | In the past year, have you turned down a job or decided not to apply to a job that you were interested in due to (potential) problems with transport? (Multiple choice) | Yes, I had to turn down a job for this reason | 0.0625 for employed<br>0.125 for unemployed |
| | | Yes, I decided not to apply for a job for this reason | 0.0625 for employed<br>0.125 for unemployed |
| | | No/Not applicable (not looking for a job) | 0 |
| | | Other | 0 |
| Maximum total score | | | 1 |

**Table 4** Principal component analysis of the measurement scale

| **Mobimon score component matrix** | | |
|---|---|---|
| | | **Component 1** |
| To what extent do you agree with the following statements? With the transport options available to me | | |
| I can reach all my regular destinations and activities | | 0.808 |
| I feel safe while travelling to my regular destinations and activities | | 0.762 |
| I am able to live my life as I want to | | 0.741 |
| I can travel in a way that is suited to my physical condition and abilities | | 0.720 |
| There is always a transport option available to me at the times I need it | | 0.715 |
| I can travel without negative consequences to my health | | 0.641 |
| I spend much more time travelling than I would like | | 0.580 |
| I have to spend more on necessary travel in a week than I can afford | | 0.535 |
| Cronbach´s Alpha | | 0.830 |
| Kaiser–Meyer–Olkin measure of sampling adequacy: | | 0.864 |
| Bartlett's test of sphericity | Approx. Chi-Square | 2808.506 |
| | Df | 28 |
| | Sig | 0.000 |

sampling adequacy is valued at 0.864 and Bartlett's test of sphericity is significant at 0.000.

### 3.4 Regression analysis and predictors

To identify the aspects each definition and the measurement scale emphasize, we use multiple linear regression to assess the predictors for the generated scores. Such an approach has been used in a study comparing a number of poverty indicators by assessing their associations with welfare regimes and socioeconomic status to assess the relative merits of different indicators [38]. We choose two categories of variables from the survey as predictors.

The first category includes the socio-economic variables (sex, city of residence, household composition, education level, income, primary language, and mobility aid usage). Some of these represent multiple aspects of social disadvantage as identified in literature. Physical disability for instance could be a determinant for social disadvantage [22, 24]. In this study, we use the variable "using mobility aids" as a proxy of physical disability. Also, one-parent households could be an indicator for social disadvantage [23], so we include household composition in the analysis.

The second category is made up of the transport-related variables. We choose 13 transport-related survey-statements from the survey and conduct a principal component analysis to generate several components from them as subjective transport conditions (Table 5). Three components are generated from the item set and are named as *access to amenities*, *perception of public transport* and *ease of driving*. The three components respectively represent the condition of reaching daily activities and regular destinations, the condition of using public transport and the condition of driving.

With the socio-economic variables and transport-related variables as predictors and the generated transport poverty scores as dependent variables, we perform two multiple linear regression models for each quantified definition or measurement scale in a step-wise format. In the first model of each definition, only socio-economic variables are tested as predictors; then, in the second model, transport-related variables are additionally tested as predictors.

## 4 Results

The results of multiple regression analyses are presented in Table 6. Model 1.1 and 1.2 used the quantitative measure of definition by Lucas et al. [22, 24] as dependent variable. Model 1.1 show that this definition of transport poverty has associations with several socio-economic variables. Compared to people with low education level, having a medium education level are less likely to risk being transport poor while this does not seem to be the case for people with a high education level. Individuals using mobility aids are more likely to experience transport poverty. The results also suggest that couples without children are significantly less at risk of experiencing transport poverty. People with a high or medium household income are less likely to suffer transport poverty than low-income people. Those who primarily speak Dutch at home have a lower risk of experiencing transport poverty. Model 1.2 shows that all the three

**Table 5** Principal component analysis of transport-related predictor (independent) variables

| **Rotated component matrix for transport-related predictor variables** | | | |
|---|---|---|---|
| | **Component 1** | **Component 2** | **Component 3** |
| | **Access to amenities** | **Perception of public transport** | **Ease of driving** |
| With the transport options available to me | | | |
| I can easily reach my family doctor (GP), pharmacy or health centre | 0.876 | | |
| I can easily reach the supermarket or local shopping areas | 0.857 | | |
| I can easily reach a hospital | 0.812 | | |
| I can easily reach my friends or relatives at their home | 0.791 | | |
| The public transport options in my neighbourhood | | | |
| Are available at times that are useful to me | | 0.823 | |
| Reach destinations or activities that are important to me* | | 0.808 | |
| Are easy to understand how to use | | 0.756 | |
| Are accessible to people with reduced mobility | | 0.650 | |
| Are affordable to me | | 0.647 | |
| How do you feel about driving? | | | |
| I Feel comfortable driving a car | | | 0.903 |
| I have a lot of experience driving a car | | | 0.868 |
| I prefer not to drive | | | −0.834 |
| I find it hard to drive under difficult conditions | | | −0.718 |
| Cronbach's alpha | 0.822 | 0.766 | 0.853 |
| Kaiser–Meyer–Olkin Measure of Sampling Adequacy | | | 0.807 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | | 3989.212 |
| | Df | | 78 |
| | Sig | | 0.000 |

transport-related variables have significant associations with this transport poverty score. People who perceive the ease of driving, higher quality of public transport and better access to amenities are less likely to suffer from transport poverty.

Model 2.1 and 2.2 assessed predictors of the transport poverty definition by Awaworyi Churchill and Smyth [2]. In model 2.1, several household socio-economic variables show significant associations with the transport poverty score. Single-person households are less likely to experience transport poverty, and low-income households are more likely to suffer from transport poverty. Those who primarily speak Dutch at home have a lower risk to experience transport poverty. In addition, using mobility aids also shows a positive association with the risk of experiencing transport poverty. In model 2.2, people who live in Utrecht show a lower risk to experience transport poverty than those who live in Rotterdam. Among transport-related variables, perception of public transport and access to amenities show negative associations with transport poverty. Ease of driving does not have a significant correlation with vulnerability towards transport poverty in this model.

Model 3.1 and 3.2 assessed predictors of the transport poverty definition by Allen and Farber [1]. For this definition, some of household socio-economic variables are used as indicators in measuring transport poverty, so we did not test these variables as predictors. Model 3.1 shows males tend to be more vulnerable towards transport poverty than females. People who are fully employed are less likely to experience transport poverty. Compared to people with a low education level, those who with a high education level are less likely to experience transport poverty. Those who primarily speak Dutch at home have a lower risk of experiencing transport poverty. Also, urban context matters, since respondents from Utrecht appear to be more susceptible towards transport poverty than respondents residing in Rotterdam, although additional data collection and analysis would be useful for providing additional information about the contextual differences. In model 3.2, perception of public transport and access to amenities show a significant effect on vulnerability towards transport poverty, while the factor ease of driving does not.

Model 4.1 and 4.2 assessed predictors of the Mobimon measurement scale developed by Ettema et al.

**Table 6** Assessing the predictors of different quantified definitions

| | Lucas et al. [22, 24] | | Awaworyi Churchill and Smyth [2] | | Allen and Farber [1] | | Mobimon [10] | |
|---|---|---|---|---|---|---|---|---|
| | Model 1.1 | Model 1.2 | Model 2.1 | Model 2.2 | Model 3.1 | Model 3.2 | Model 4.1 | Model 4.2 |
| Constant | 0.184 | 0.094 | 0.279 | 0.178 | 0.323 | 0.291 | 0.763 | 0.323 |
| *Socio-economic variables* | | | | | | | | |
| Sex | | | | | | | | |
| Female (reference) | | | | | | | | |
| Male | 0.003 | 0.008 | −0.018 | 0.007 | **0.048**$^{***}$ | 0.004 | **0.159**$^{*}$ | **0.219**$^{***}$ |
| Employment | | | | | | | | |
| Retired, student or unemployed (reference) | | | | | | | | |
| Full time job | 0.019 | 0.010 | −0.028 | 0.019 | −**0.141**$^{***}$ | −**0.148**$^{***}$ | 0.144 | −0.113 |
| Part time job | −0.006 | −0.010 | −0.002 | 0.000 | −0.033 | −**0.072**$^{***}$ | 0.048 | −0.075 |
| Education | | | | | | | | |
| Low education (reference) | | | | | | | | |
| Medium education | −**0.032**$^{*}$ | −0.001 | −0.026 | 0.019 | 0.014 | 0.025 | 0.055 | 0.154 |
| High education | −0.013 | 0.014 | −0.010 | 0.044 | −**0.070**$^{***}$ | −0.040 | −0.117 | 0.096 |
| Use of mobility aids | **0.063**$^{**}$ | 0.042 | **0.076**$^{*}$ | −0.028 | 0.006 | −**0.131**$^{**}$ | **0.523**$^{***}$ | **0.369**$^{*}$ |
| Household composition | | | | | | | | |
| Single with children (reference) | | | | | | | | |
| Single without children | −0.026 | 0.002 | −**0.051**$^{*}$ | −0.046 | | | −**0.305**$^{*}$ | −**0.277**$^{*}$ |
| Couple without children | −**0.031**$^{*}$ | −0.008 | −0.047 | −0.054$^{*}$ | | | −**0.354**$^{*}$ | −**0.332**$^{**}$ |
| Couple with children | −0.005 | 0.011 | −0.018 | −0.046 | | | −**0.354**$^{*}$ | −**0.350**$^{*}$ |
| Other household | −0.023 | −0.013 | −**0.055**$^{*}$ | −0.045 | | | −0.151 | −**0.314**$^{*}$ |
| Household income | | | | | | | | |
| Low income (reference) | | | | | | | | |
| Medium income | −0.019 | −**0.024**$^{*}$ | −**0.050**$^{**}$ | −**0.037**$^{*}$ | | | −**0.286**$^{***}$ | −0.142 |
| High income | −**0.062**$^{***}$ | −**0.033**$^{*}$ | −**0.103**$^{***}$ | −**0.056**$^{*}$ | | | −**0.716**$^{***}$ | −0.222 |
| Primary language at home: Dutch | −**0.067**$^{***}$ | −0.014 | −**0.095**$^{***}$ | −**0.060**$^{*}$ | −**0.067**$^{***}$ | −0.053 | −**0.461**$^{***}$ | −**0.271**$^{*}$ |
| City of residence | | | | | | | | |
| Rotterdam (reference) | | | | | | | | |
| Utrecht | 0.012 | −0.016 | −0.009 | −**0.028**$^{*}$ | **0.026**$^{*}$ | **0.046**$^{**}$ | −0.067 | −0.108 |
| *Transport-related variables* | | | | | | | | |
| Ease of driving | | −**0.013**$^{***}$ | | −0.009 | | −0.006 | | −**0.195**$^{***}$ |
| Perception of Public transport | | −**0.019**$^{***}$ | | −**0.018**$^{**}$ | | −**0.021**$^{**}$ | | −**0.374**$^{***}$ |
| Access to amenities | | −**0.034**$^{***}$ | | −**0.047**$^{***}$ | | −**0.018**$^{*}$ | | −**0.405**$^{***}$ |
| Adjusted R Square | 0.091 | 0.197 | 0.064 | 0.114 | 0.136 | 0.150 | 0.140 | 0.448 |

*, ** and *** denote significance at a significance level of 0.05, 0.01 and 0.001 respectively

[10]. In model 4.1, several socio-economic variables, both at individual and household levels, show significant correlation with the transport poverty score. Males are more likely to experience transport poverty than females. People who travel with mobility aids are more vulnerable towards transport poverty. Compared to other types of households, single-parent households have a higher risk of experiencing transport poverty. Household income level has a strong negative correlation with transport poverty scores, high-income households have the lowest risk and low-income households have the highest risk of experiencing transport poverty. Similarly to the three existing definitions, primarily speaking Dutch at home has a negative correlation with transport poverty scores of the measurement scale. In model 4.2, all the three transport-related variables show significant correlation with transport poverty scores. People who perceive the ease of driving, higher quality of public transport and better access to amenities have a lower risk of suffering from transport poverty.

**Table 7** Transport poverty predictors identified by each definition

| | Lucas et al. [22, 24] | Awaworyi Churchill and Smyth [2] | Allen and Farber [1] | Mobimon [10] |
|---|---|---|---|---|
| *Socio-economic variables* | | | | |
| Individual level | | | | |
| Sex | | | ○ | ○ |
| Employment | | | ○ | |
| Education | ○ | | ○ | |
| Use of mobility aid | ○ | ○ | ○ | ○ |
| Household level | | | | |
| Household composition | ○ | ○ | | ○ |
| Household income | ○ | ○ | | ○ |
| Primary language at home | ○ | ○ | ○ | ○ |
| City level | | | | |
| City of residence | | ○ | ○ | |
| *Transport-related indicators* | | | | |
| Ease of driving | ○ | | | ○ |
| Perception of public transport | ○ | ○ | ○ | ○ |
| Access to amenities | ○ | ○ | ○ | ○ |

## 5 Discussion

In this paper, different definitions of transport poverty and a new measurement scale have been examined in order to generate a deeper understanding in the identification of the transport poverty concept and their implications. Using survey data collected among residents of Utrecht and Rotterdam in the Netherlands, we measured transport poverty by different quantified definitions. The analysis has led to newly found outcomes about the notion of transport poverty in general as well as in context-specific situations. The results suggest that the way in which transport poverty is measured matters. Specifically, if policy makers assess transport poverty using a given definition or scale, the results (in this case, the significant variables) will differ. Therefore, comprehensive transport poverty policy goals should be developed using region-specific and level specific (individual, household, neighbourhood) measurements. Policies which fail to do so are likely to miss or misidentify elements of subjective and/or objective transport policy which are likely to be key within a given context.

Each definition of transport poverty has its own set of significant predictor variables (Table 7). In Lucas, et al.'s [22, 24] well-rounded and well-recognized definition, several socio-economic variables at individual and household level and all transport-related variables are strongly associated with transport poverty in Utrecht and Rotterdam, while the variable household income is the most constant significant predictor. In Awaworyi Churchill and Smyth [2]'s definition, most socio-economic variables at the household and city level are associated with transport poverty, and household income and the primary language spoken at home are the most constant predictors. Among the three travel-related variables, perception of public transport and access to amenities show significant associations, while ease of driving does not. In Allen and Farber [1]'s definition, most socio-economic variables at the individual and city level are associated with transport poverty, and employment status, education level and city of residence are the most constant predictors,among transport-related variables, perception of public transport and access to amenities show significant associations while ease of driving does not. In the newly developed measurement scale by Ettema et al. [10], several socio-economic variables at the individual and household level are strongly associated with transport poverty, and sex, the use of a mobility aid, household composition and the primary language spoken at home are all constant in both models, and all the three transport-related variables have significant associations with transport poverty.

Notably, in our analyses of both Allen and Farber [1]'s definition and Ettema et al. [10]'s scale, males are more vulnerable to experiencing transport poverty than females. However, it is widely acknowledged that women are more likely to experience transport disadvantage than men because in many (traditional) situations men tend to have a relatively higher social power to use specific transport modes (often private cars) and women tend to be more risk-averse [4, 5, 21]. The inconsistency can be attributed to two reasons. First, are the observed differences in geographical settings. A substantial portion of

previous research on gender differences was conducted in the Global South, including India, Malaysia, and Pakistan; alternatively, our study was based in the Netherlands, where the transport system is generally developed to be accessible for all populations. Second, is the possible difference between objective and subjective transport poverty. Studies have found that women are more likely to use public transport than men and reported higher perceived accessibility than men [18, 29]. Allen and Farber [1]'s definition measures accessibility poverty, and they use "low transit access to employment" as an indicator of transport poverty. After controlling for "perception of public transport" the coefficient of "sex" became insignificant, while "perception of public transport" shows a negative association with transport poverty, which implies that men are more vulnerable towards transport poverty probably because they have a worse perception of public transport. Ettema et al. [10]'s scale is individuals' self-assessment of all dimensions of transport poverty, and the results represent individuals' perception of transport poverty rather than objective transport poverty under a unified standard. Thus, men and women may perceive transport poverty in different ways. Further research is thus needed to compare transport poverty in different geographical settings and subjective and objective perspectives.

The results indicate that predictors of different definitions of transport poverty vary in scale levels. At an individual level, definitions by Allen and Farber [1] identified most predictors, and all the four definitions identify the predictor using mobility aids. According to Lucas et al. [22, 24], people with a disability make fewer trips, which could be an indicator that their disability is a barrier for travelling. However, the definition by Allen and Farber [1] shows a reverse association that people using mobility aids have a lower risk of experiencing transport poverty. A cause could be the lack of the predictor variables at household level, since they are already indicators of the quantified definition of Allen and Farber [1], so some household-level predictors may be explained by individual-level predictors. At a household level, all the quantified definitions identify all predictors involved in the model. Since travelling is often a household-level decision and related to the daily life of the whole family, an individual experiencing different dimensions of transport poverty is highly dependent on household-level factors. At the city level, the definitions by Awaworyi Churchill and Smyth [2] and Allen and Farber [1] identify the predictor city of residence. Notably, when additionally assessed transport-related variables, city of residence shows stronger associations with transport poverty for both two definitions, while the coefficients of the two definitions are opposite. In the definition by Awaworyi Churchill and Smyth [2], those living in Utrecht are less likely to experience transport poverty,while in the definition of Allen and Farber [1], those living in Utrecht are more likely to experience transport poverty. An explanation for this could be that the research done by Allen and Farber [1] was area-focused instead of focusing on the individual or household. This suggests that some definitions identify predictors not only at the scale level stated in the original statements as presented in Table 1. Awaworyi Churchill and Smyth [2] defined transport poverty at the household level, while our results show that the definition can also be identified at the city-level ; Allen and Farber [1] defined transport poverty at the household and city level, while our results show that their definition also identified several individual-level predictors.

The results also indicate that predictors of different definitions of transport poverty vary in contexts and measurement dimensions. In the definitions of Lucas et al. [22, 24] and the Mobimon (Ettema et al. [10]) measurement scale, all three transport-related variables are identified as predictors, while the definitions of Awaworyi Churchill and Smyth [2] and Allen and Farber [1] only identified the perception of public transport and access to amenities. The extent to which an individual feels at ease while driving a car may influence the level of transport poverty in two definitions, but not in the other two. Since Lucas et al's. [22, 24] definition and the Mobimon measurement scale are more concise and focus on the individual level, an individual's experiences of travelling have strong associations with the risk of experiencing transport poverty. Alternatively, since the definitions by Awaworyi Churchill and Smyth [2] and Allen and Farber [1] namely focus on the household and area level, fewer transport-related variables based on individuals' experiences are identified. Furthermore, the definition by Awaworyi Churchill and Smyth [2] measure in the dimension of affordability poverty, so it explicitly identifies household income, while the definition by Allen and Farber [1] measure the dimension of accessibility poverty, so it explicitly identifies city of residence and access to amenities.

## 6 Conclusion

This paper aims to assess the implications of different definitions of transport poverty by assessing the predictors of four quantified definitions using data from two Dutch cities. The results show that each definition of transport poverty has a specific set of predictors, and the predictors vary in scale levels, measurement dimensions and research contexts. Regarding the scale levels, the definitions developed by Lucas et al. [22, 24], Allen and Farber [1] and the Mobimon [10] measurement scale apply at the individual level, the definition by Lucas et al. [22, 24], Awaworyi Churchill and Smyth [2] and Mobimon

[10] measurement scale apply at the household level, and the definition by Awaworyi Churchill and Smyth [2], Allen and Farber [1] apply at the area level. Compared to their original definitions, Awaworyi Churchill and Smyth [2]'s definition additionally identified the city-level predictor and Allen and Farber [1]'s definition additionally identified individual-level predictors, which implies that these definitions may fit practices and policies at other scale levels than they were originally defined for.

Regarding the measurement dimensions, the definition by Lucas et al. [22, 24] and the Mobimon measurement scale are more concise and apply to composite dimensions. The definition by Awaworyi Churchill and Smyth [2] applies to measure affordability and accessibility poverty, and the definition by Allen and Farber [1] applies to measure accessibility poverty (since household income is already an indicator in its measurement, we did not identify it as a predictor). Allen and Farber [1]'s definition additionally measured accessibility poverty which it is not meant to measure in the original definition, which implies that the definition may also fit practices and policies aiming to deal with accessibility poverty. As for the research contexts, the use of a specific definition depends on the role of the car or public transport in people's daily travel in the research case and the physical and social characteristics of the research area such as population composition. Since the perception of car driving was not identified by either Awaworyi Churchill and Smyth's [2] or Allen and Farber's [1] definitions their definitions may not apply to a context where the car plays an important role in daily travel.

In summary, the implications for transport poverty policy are dependent on which definition of the concept is used. The definitions used vary, in that some definitions use objective numbers in order to identify transport poverty while in other definitions subjective perceptions of transport poverty among individuals or households are used to identify the issue. Thus, different predictors are identified depending on the definition used. Also, when evaluating transport poverty, both objective measurements and subjective perceptions of transport poverty should be considered. If combined, they can provide a more extensive insight into the issue of transport poverty. This can help policymakers evaluate the importance of the used definitions of transport poverty in specific contexts and help them select the most fitting measurement tool for the problem they are aiming to solve. Policy makers interested in developing transport poverty policies should develop policy based on both objective and subjective transport poverty measures. However, in doing so, they should consider at which level (individual, household, neighbourhood, etc.) they wish to implement policy changes and use the most appropriate definition and measurement approach for the given context. Since the results of this study indicate that certain predictors appear to be more relevant depending on the definition used, it is essential for policy makers to first establish the most appropriate definition of subjective and objective transport poverty within a given region before allocating resources for data collection and policy development.

This study also has several limitations. First, the study only assessed socioeconomic variables and subjective transport characteristics as predictors. Other variables such as objective transport characteristics and vehicle ownership may also be predictors and can be assessed in future research. Second, the limited number of variables resulted in the creation of two models per definition. Additional models could potentially show that the indicators for transport poverty vulnerability can change depending on the variables used. In this way, future studies could also compare the homogeneity and heterogeneity across populations experiencing transport poverty. Third, future studies should assess different samples, for example comparing urban, suburban and rural communities. Fourth, a definition applicable to the Global South is urgently needed. Existing definitions predominantly use a Global North perspective, where transport poverty is more an issue of lacking social opportunities. In many regions in the Global South, transport poverty can be even more challenging due to the many dynamics resulting from the informal transport sector. Thus, more attention should be paid to the Global South in future research. Lastly, definitions had to be simplified in order to quantify them. For example, in Allen and Farber [1]'s area-based definition, we measure only by individual indicators while did not involve area-level indicators. If the used definitions are known beforehand, a survey can be developed which adjusts for this, making the quantified definitions more accurate and thus more reliable across geographic contexts.

**Acknowledgements**
The authors wish to thank all participants enrolled in Mobimon survey. We also thank the City of Rotterdam and NWO for their support.

**Author contributions**
TV: Methodology, Analysis, Formal analysis, Writing—original draft. XF: Methodology, Analysis, Formal analysis, Writing. DvL: Conceptualization, Methodology, Analysis, Writing—review and editing, Supervision.

**Funding**
The data collected and used in this study was funded by an NWO Pop Up Grant (438.19.174) and with financial support of the City of Rotterdam.

**Availability of data and materials**
Not applicable.

## Declarations

### Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Received: 20 December 2022 Accepted: 16 July 2023
Published online: 24 July 2023

### References

1. Allen, J., & Farber, S. (2019). Sizing up transport poverty: A national scale accounting of low-income households suffering from inaccessibility in Canada, and what to do about it. *Transport Policy, 74*, 214–223. https://doi.org/10.1016/j.tranpol.2018.11.018
2. Awaworyi Churchill, S., & Smyth, R. (2019). Transport poverty and subjective wellbeing. *Transportation Research Part A: Policy and Practice, 124*, 40–54.
3. Benevenuto, R., & Caulfield, B. (2020). Measuring access to urban centres in rural Northeast Brazil: A spatial accessibility poverty index. *Journal of Transport Geography, 82*, 102553. https://doi.org/10.1016/j.jtrangeo.2019.102553
4. Cheng, Y.-H., & Chen, S.-Y. (2015). Perceived accessibility, mobility, and connectivity of public transportation systems. *Transportation Research Part A: Policy and Practice, 77*, 386–403. https://doi.org/10.1016/j.tra.2015.05.003
5. Chikaraishi, M., Jana, A., Bardhan, R., Varghese, V., & Fujiwara, A. (2017). A framework to analyze capability and travel in formal and informal urban settings: A case from Mumbai. *Journal of Transport Geography, 65*, 101–110. https://doi.org/10.1016/j.jtrangeo.2017.09.001
6. Cunha, I., & Silva, C. (2023). Assessing the equity impact of cycling infrastructure allocation: Implications for planning practice. *Transport Policy, 133*, 15–26. https://doi.org/10.1016/j.tranpol.2022.12.021
7. CPB. (2021). Augustusraming 2021–2022. https://www.cpb.nl/sites/default/files/omnidownload/CPB-Augustusraming-2021-2022.pdf
8. Delbosc, A., & Currie, G. (2018). *Accessibility and exclusion related to well being* (pp. 57–69). Springer International Publishing.
9. Di Ciommo, F., & Shiftan, Y. (2017). Transport equity analysis. *Transport Reviews, 37*(2), 139–151. https://doi.org/10.1080/01441647.2017.1278647
10. Ettema, D., van Lierop, D., & van den Berg, P. E. (2022). Measuring transport poverty in The Netherlands–First results of the MOBIMON study.
11. Farrington, J., & Farrington, C. (2005). Rural accessibility, social inclusion and social justice: Towards conceptualisation. *Journal of Transport geography, 13*(1), 1–12. https://doi.org/10.1016/j.jtrangeo.2004.10.002
12. Friman, M., Garling, T., Ettema, D., & Olsson, L. E. (2017). How does travel affect emotional well-being and life satisfaction? *Transportation Research Part a-Policy and Practice, 106*, 170–180. https://doi.org/10.1016/j.tra.2017.09.024
13. Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport Geography, 12*(2), 127–140. https://doi.org/10.1016/j.jtrangeo.2003.10.005
14. Groth, S. (2019). Multimodal divide: Reproduction of transport poverty in smart mobility trends. *Transportation Research Part A: Policy and Practice, 125*, 56–71. https://doi.org/10.1016/j.tra.2019.04.018
15. Karner, A., Bills, T., & Golub, A. (2023). Emerging perspectives on transportation justice. *Transportation Research Part D: Transport and Environment, 116*, 103618. https://doi.org/10.1016/j.trd.2023.103618
16. Kuttler, T., & Moraglio, M. (2021). *Re-thinking mobility poverty: understanding users' geographies, backgrounds and aptitudes* (p. 317). Taylor & Francis. https://library.oapen.org/handle/20.500.12657/46167
17. Lättman, K., Olsson, L. E., & Friman, M. (2016). Development and test of the perceived accessibility scale (PAC) in public transport. *Journal of Transport Geography, 54*, 257–263. https://doi.org/10.1016/j.jtrangeo.2016.06.015
18. Lättman, K., Olsson, L. E., & Friman, M. (2018). A new approach to accessibility - Examining perceived accessibility in contrast to objectively measured accessibility in daily travel. *Research in Transportation Economics, 69*, 501–511. https://doi.org/10.1016/j.retrec.2018.06.002
19. Linovski, O., Baker, D. M., & Manaugh, K. (2018). Equity in practice? Evaluations of equity in planning for bus rapid transit. *Transportation Research Part A: Policy and Practice, 113*, 75–87. https://doi.org/10.1016/j.tra.2018.03.030
20. Litman, T. (2002). Evaluating transportation equity. *World Transport Policy & Practice, 8*(2), 50–65.
21. Lucas, K. (2012). Transport and social exclusion: Where are we now? *Transport Policy, 20*, 105–113. https://doi.org/10.1016/j.tranpol.2012.01.013
22. Lucas, K., Mattioli, G., Verlinghieri, E., & Guzman, A. (2016). Transport poverty and its adverse social consequences. *Proceedings of the Institution of Civil Engineers - Transport, 169*(6), 353–365. https://doi.org/10.1680/jtran.15.00073
23. Lucas, K., Philips, I., Mulley, C., & Ma, L. (2018). Is transport poverty socially or environmentally driven? Comparing the travel behaviours of two low-income populations living in central and peripheral locations in the same city. *Transportation Research Part A: Policy and Practice, 116*, 622–634. https://doi.org/10.1016/j.tra.2018.07.007
24. Lucas, K., Van Wee, B., & Maat, K. (2016). A method to evaluate equitable accessibility: Combining ethical theories and accessibility-based approaches. *Transportation, 43*(3), 473–490. https://doi.org/10.1007/s11116-015-9585-2
25. Lunke, E. B. (2022). Modal accessibility disparities and transport poverty in the Oslo region. *Transportation Research Part D: Transport and Environment, 103*, 103171. https://doi.org/10.1016/j.trd.2022.103171
26. Luz, G., & Portugal, L. (2022). Understanding transport-related social exclusion through the lens of capabilities approach. *Transport Reviews, 42*(4), 503–525. https://doi.org/10.1080/01441647.2021.2005183
27. Mercader-Moyano, P., Morat, O., & Serrano-Jiménez, A. (2021). Urban and social vulnerability assessment in the built environment: An interdisciplinary index-methodology towards feasible planning and policy-making under a crisis context. *Sustainable Cities and Society, 73*, 103082. https://doi.org/10.1016/j.scs.2021.103082
28. Moore, J., Lucas, K., Bates, J. (2013). *Social disadvantage and transport in the UK: A trip-based approach*. School of Geography and the Environment, University of Oxford, Oxford, UK, TSU Working Paper Series, Ref. 1063.
29. Pot, F. J., Koster, S., & Tillema, T. (2023). Perceived accessibility in Dutch rural areas: Bridging the gap with accessibility based on spatial data. *Transport Policy, 138*, 170–184. https://doi.org/10.1016/j.tranpol.2023.04.014
30. Preston, J., & Rajé, F. (2007). Accessibility, mobility and transport-related social exclusion. *Journal of Transport Geography, 15*(3), 151–160. https://doi.org/10.1016/j.jtrangeo.2006.05.002
31. Shi, K., Yang, Y., De Vos, J., Zhang, X., & Witlox, F. (2022). Income and commute satisfaction: On the mediating roles of transport poverty and health conditions. *Travel Behaviour and Society, 29*, 297–307. https://doi.org/10.1016/j.tbs.2022.07.004
32. Stanley, J., Stanley, J., Vella-Brodrick, D., & Currie, G. (2010). The place of transport in facilitating social inclusion via the mediating influence of social capital. *Research in Transportation Economics, 29*(1), 280–286. https://doi.org/10.1016/j.retrec.2010.07.035
33. Sun, Y., & Thakuriah, P. (2021). Public transport availability inequalities and transport poverty risk across England. *Environment and Planning B: Urban Analytics and City Science, 48*(9), 2775–2789. https://doi.org/10.1177/2399808321991536
34. Titheridge, H., Oviedo, D., Hernandez, R., Ye, N. C., & Mackett, R. (2014). Transport poverty: Concepts, measurement and policy perspectives. In *Proceedings of the Association of American Geographers' Annual Meeting, Tampa, FL, USA*, (Vol. 8).
35. Van Wee, B. (2016). Accessible accessibility research challenges. *Journal of Transport Geography, 51*, 9–16. https://doi.org/10.1016/j.jtrangeo.2015.10.018
36. Van Wee, B., & Geurs, K. (2011). Discussing equity and social exclusion in accessibility evaluations. *European journal of transport and infrastructure research*. https://doi.org/10.18757/ejtir.2011.11.4.2940
37. Verlinghieri, E., & Schwanen, T. (2020). Transport and mobility justice: Evolving discussions. *Journal of Transport Geography, 87*, 102798. https://doi.org/10.1016/j.jtrangeo.2020.102798
38. Whelan, C. T., & Maître, B. (2010). Comparing poverty indicators in an enlarged European Union. *European Sociological Review, 26*(6), 713–730. https://doi.org/10.1093/esr/jcp047
39. Yigitcanlar, T., Mohamed, A., Kamruzzaman, M., & Piracha, A. (2019). Understanding transport-related social exclusion: A multidimensional

approach. *Urban Policy and Research, 37*(1), 97–110. https://doi.org/10.1080/08111146.2018.1533461
40. Zijlstra, T., Durand, A., Hoogendoorn-Lanser, S., & Harms, L. (2020). Early adopters of Mobility-as-a-Service in the Netherlands [Article]. *Transport Policy, 97*, 197–209. https://doi.org/10.1016/j.tranpol.2020.07.019

## Publisher's Note