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DOI

[10.1016/j.cities.2023.104335](https://doi.org/10.1016/j.cities.2023.104335)

Publication date

2023

Document Version

Final published version

Published in

Cities

Citation (APA)

Durand, A., Zijlstra, T., Hamersma, M., Hoen, A., van Oort, N., Hoogendoorn-Lanser, S., & Hoogendoorn, S. (2023). “Who can I ask for help?”: Mechanisms behind digital inequality in public transport. *Cities*, 137, Article 104335. <https://doi.org/10.1016/j.cities.2023.104335>

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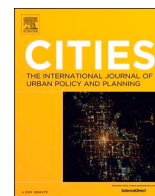
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“Who can I ask for help?”: Mechanisms behind digital inequality in public transport

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ARTICLE INFO

Keywords:

Digitalisation
Digital inequality
Public transport
Transport-related social exclusion
Transport disadvantage

ABSTRACT

Digitalisation in public transport has become pervasive over the past decade, especially in urban areas. While it benefits many, it also leaves some behind. Previous research shows that older adults, people with a lower education level, people with impairments and people with a migration background are more likely to be negatively impacted by digitalisation in transport services. In order to uncover mechanisms behind digital inequality in public transport, we interviewed 39 people belonging to these groups. They experience difficulties due to low digital skills, not using digital technologies on-the-go, not possessing the right devices and due to a complex design of technologies, among others. Many participants reap some benefits of digitalisation though. In fact, individuals can experience benefits on one aspect and difficulties on another. Nevertheless, experiencing difficulties with digitalisation does not necessarily equal to exclusion from public transport thanks to coping strategies like support from one's social network. Still, many coping strategies come with pitfalls such as hidden work and costs. Digital technologies facilitate a self-service approach that paradoxically makes some people more dependent on others. This study can support practitioners and researchers in developing a better understanding of the (sometimes insidious) consequences of technological innovations on individuals.

1. Introduction

While public transport (PT) operators have been historically slow to embrace technological innovations (Nelson & Mulley, 2013; TRCP, 1999), they are catching up. Contactless payment, trip planning apps and online ticketing are nowadays considered basic PT customer services (Palacin, 2021; UITP, 2017). Mobility services running through apps increasingly shape people's choices and preferences, particularly in urban areas (Vecchio & Tricarico, 2018).

The development of digital technologies in public transport services has been accompanied by much enthusiasm that digitalisation will unfold social inclusivity effects. Nevertheless, scholars question this assumption (Banister, 2019; Pangbourne et al., 2019) and have raised concerns around a growing digital divide (Vecchio & Tricarico, 2018; Zhang et al., 2020). *Digital inequality in transport services* refers to the

unequal access to transport services – from buses to shared bikes and on-demand services – due to digitalisation (Durand, Zijlstra, van Oort, Hoogendoorn-Lanser, & Hoogendoorn, 2022). Durand et al. (2022) show that multiple – sometimes overlapping – groups are more likely to be impacted by digital inequality in transport services. These are older adults, people with a lower education level, people with a lower income, people with a migration background, people living in rural settings, women (especially in countries where women are less emancipated) and people with learning and communication issues. There are multiple reasons why these groups are more likely to be negatively impacted by digitalisation. These reasons range from a distrust in technology to the costs of smartphones and a poor design of digital services (Durand et al., 2022).

Previous research on digital inequality in transport services has frequently focused on one particular group of individuals. Older adults

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<https://doi.org/10.1016/j.cities.2023.104335>

Received 19 May 2022; Received in revised form 3 January 2023; Accepted 11 April 2023

Available online 19 April 2023

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are relatively frequently investigated (Bertolaccini & Hickman, 2019; Butler et al., 2021; Carney & Kandt, 2022; Gould, 2021; Harvey et al., 2019; Kos-Labędowicz, 2020). A few other studies focus on people with a cognitive impairment in particular (Bigby et al., 2019; Van Holstein et al., 2021). These studies offer relevant insights, yet they do not allow for conclusions to be drawn across multiple groups of individuals. In parallel, a few studies have investigated digital inequalities in transport services in the general population through quantitative and offline surveys (Goodman-Deane et al., 2022; Groth, 2019; Roca Bosch et al., 2021; Zhang et al., 2020). Yet because questionnaires need to be concise, these studies provide a somewhat bounded understanding of the mechanisms of digital inequality in transport services.

To study these mechanisms, we decided to focus on one type of transport service (public transport) in a (mainly urban) region. This particular focus answers the call of Lam and Ma (2019), who recommended investigating the digital divide by focusing on a specific context. Besides, we decided to shed light on coping strategies. ‘Coping’ is a term from psychology that refers to the way people deal with problems or stressful situations (Lazarus & Folkman, 1984). The term ‘strategy’ refers to the relatively systematic nature of the coping. Analysing coping strategies allows gaining a better understanding of how people deal with a situation in which they are a priori disadvantaged. In light of the above-mentioned gaps and our scope, we formulate our research question as such: *how do groups who are more at risk of digital inequality experience digital transformations in public transport, and what are the coping strategies they might have developed in response to it?*

We conduct this study in the Netherlands, where the public transport sector is leveraging on the opportunities offered by digitalisation (Dutch Council for the Environment and Infrastructure, 2021; Government of the Netherlands, 2021). A smart card has been available nation-wide since 2012 (Van Oort et al., 2015), buses have been cashless since 2018 (OVPro.nl, 2018), online trip planning is widespread and the amount of ticket offices in stations has been halved in 2022 (SporroPro.nl, 2022). Yet while the Netherlands is the front runner in Europe in terms of (mobile) internet coverage and basic digital skills (Statistics Netherlands, 2018, 2020), there are important differences in the population. 19 % of the population aged 12 and older has no or low digital skills, but this statistic rises to 21 % for people with a non-western¹ migration background, 36 % for people with a lower education level and 43 % for people over 65 (Statistics Netherlands, 2019). We focus on these particular groups in this study.

Although this study is based in the Netherlands, it offers relevant insights for international researchers, policymakers and practitioners for two main reasons. First, digital inequality in transport services goes beyond the Netherlands (Durand et al., 2022; Goodman-Deane et al., 2022; Kedmi-Shahar et al., 2020). Second, although mechanisms at play behind digital inequality are likely somewhat context-dependent, we argue that the mechanisms as studied in the Netherlands are interesting to an international audience. This is particularly the case for those interested in transport-related social exclusion, where digital inequality is one of the (underresearched) dimensions (Luz & Portugal, 2022; Lucas, 2019). Besides, the leading position of the Netherlands in terms of digitalisation in general makes it an interesting case. Indeed, such a position offers the opportunity to investigate what happens for certain population groups when digitalisation becomes so embedded in society.

This paper is organised as follows. First, we present our method. Then, we share results in terms of experiences and coping strategies. In the Discussion section, we propose a model that fits together our findings. We finish with a conclusion and a few research avenues.

¹ Note that the use of the term "non-western" is no longer recommended by Statistics Netherlands as of 2022; this development happened after this paper was written and submitted.

2. Method

2.1. Global setup and theoretical lens

We interviewed 39 participants and conducted a rigorous qualitative data analysis, as detailed below. We conducted one-on-one interviews as they allow for personal matters to be discussed by removing normative pressures (Clifton & Handy, 2003).

In this research, we adhere to a critical realist position. It assumes the existence of an independent reality but also accepts that there may be varied interpretations of reality due to a difference in context (Saxena, 2021). Indeed, what we – as highly digitally skilled people and mostly experienced PT users – would define as a *difficulty* with digitalisation in public transport may well be perceived as a normal process for some participants. For critical realists, the way facts are perceived, “particularly in the social realm, depends partly upon our beliefs and expectations” (Bunge, 1993, p. 231). Critical realism-based research seeks to identify mechanisms underpinning events; in this case, the mechanisms at play behind digital inequality in transport services. This lens had consequences both on the fieldwork and on the analysis of transcripts, as explained in the rest of this section.

2.2. Sampling

We used a mix of two purposive sampling techniques to recruit participants. First, we used *maximum variation sampling*. It consists of deliberately including variation in our sample (Patton, 2014), which we did on two dimensions:

- **Access to digital technologies.** To recruit people with various degrees of access to technology, we relied on three main factors: material access to digital technology (specifically, access to a smartphone, a tablet or a computer), digital skills and diversity in use of digital technologies. This is a simplification of the concept of *access to technology* as inspired by research on digital inequality (Van Dijk, 2005) and presented in Durand et al. (2022). The reason for this simplification is that these three aspects were the easiest to ask during the recruitment and to control during the interviews. The three levels of this dimension are shown in Table 1.
- **Use of public transport.** We recruited people with three levels of experience with public transport, as shown in Table 1. The use of public transport is based on estimates of participants before the COVID-19 pandemic. Most public transport users were recruited early enough in the pandemic (second half of 2020) to remember what their public transport use was like before March 2020. The cut-off for “Frequent PT usage” needed to be simple. We chose *once a month or more* as frequent public transport use. Around 37 % of the Dutch population used public transport at least once a month in 2019 (ODiN, 2019).

Since we were mostly interested in people with lower digital access, we purposefully sampled more of them (Table 1). This is called *intensity sampling*. It consists of focusing on information-rich cases that manifest more the phenomenon of interest (Patton, 2014) – here, people who are less comfortable with digital technologies.

In addition to these sampling techniques, we added two criteria. First, we only recruited people who are able to live and to travel independently. Second, in order to be able to focus on digitalisation, we excluded variations in public transport supply by recruiting exclusively people living close to PT, e.g. at most 300 m away from a train station or a bus stop with at least 4 buses per hour. As such, urban and peri-urban areas were a main point of focus.

Participants were recruited through multiple organisations throughout the Netherlands. These organisations are welfare and care institutions, a nation-wide organisation for people with low literacy levels, workplaces for people with impairments, community centres as

Table 1
Composition of the final sample in terms of our two main sampling dimensions.

Public transport use	Frequent PT use	Infrequent PT use	No PT use	Total
Digital access	Using PT more than once a month	Using PT at least once a year, at most once a month	Using PT less than once a year	
High digital access: more digitally self-reliant Material: smartphone and computer Skills: positive self-assessment, rarely/never needs help Usage: high diversity	4	1	0	5
Medium digital access Material: smartphone and computer/ smartphone only/ computer only Skills: positive or negative self-assessment, but needs help sometimes Usage: high or low diversity	7	5	1	13
Low digital access: less digitally self-reliant Material: smartphone and computer/ smartphone only/ computer only/none Skills: positive or negative self-assessment, but often needs help Usage: low diversity (usually mainly leisure/social)	5	10	6	21
Total	16	16	7	39

well as advocacy groups for people with a mild cognitive impairment or for older adults. A dozen organisations were contacted. Key contact persons in such organisations assisted in recruiting participants by spreading flyers (both digitally and offline) within their network. They also helped pre-screening participants based on the aforementioned criteria. A second screening took place once the team assisting the interviewer had a first phone contact with participants.

As previously mentioned, we focused on people with a non-western migration background, older adults and people with lower education level. For the latter, we chose to focus mainly on two sub-groups for which we deemed digital inequalities to be most relevant, namely people with a mild cognitive impairment and people with lower literacy skills. As low literacy concerns one in six Dutch person aged 16 and older (Netherlands Court of Audit, 2016), this is considered an important social issue.

2.3. Data collection

We chose to conduct semi-structured interviews tackling multiple aspects. Semi-structured interviews entail a set of clear instructions in a topic list to be followed by the interviewer, yet with enough freedom to follow leads from the interviewee (Russell Bernard, 2011, pp. 157–158). We used many open-ended questions, as recommended by Saxena (2021) for critical realism-based research. The main topics addressed in the interview were:

- Activities, social participation and travel behaviour.

- *If use of PT*: Current practices related to planning, paying for a trip, looking for information during the trip, responding to disruptions. Role of digital technologies in each of these actions.
- *If no use of PT*: Hypothetical trip with PT and use of digital technologies.
- Use of and attitudes towards digital technologies in general.

All of the interviews were conducted by the same interviewer from an agency experienced with both reaching and interviewing hard-to-reach groups. The interviewer was fluent in Dutch, had broad experience with interviewing the target groups of this study and was trained on the topic through meetings and a pilot interview in the presence of the first author. The study protocol was approved by Delft University of Technology in September 2020. Interviews ranged from 30 to 90 min and were recorded with participants' permission. The interviews were conducted during the COVID-19 pandemic (September 2020 – April 2021). For this reason, not all interviews could be done face-to-face. Participants were left the choice of how they wanted the interview to be conducted. Nineteen took place face-to-face, at a location chosen by the respondent, while twenty were done by phone. An interpreter was available in a few cases. We stopped at 39 interviews as few new insights were being discovered in the last few interviews. Furthermore, Deterding and Waters (2018) deem 30 interviews or more a relatively large number for studies with a semi-structured protocol. The composition of the final sample is shown in Tables 1 and 2. In the Results section, respondents will be referred to after quotes with the letter R, followed by a number, their gender, age, and the typology shown in Table 1. Additional details about our sample are given in Appendix A.

We were mostly interested in the pre-pandemic behaviour of participants. Nevertheless, because we expected that participants would want to talk about their situation during the pandemic, we reserved around five to ten minutes at the beginning of each interview to talk about their experience of travelling during the pandemic. After this, respondents were invited to answer questions with the pre-pandemic situation in mind. The interviewer would regularly remind them if needed.

2.4. Data analysis

All of the interviews were transcribed verbatim. Afterwards, they were uploaded in a qualitative data analysis software (ATLAS.ti 9). The first author was the main analyst and conducted a large part of the analysis in ATLAS.ti. The first author shared and discussed findings with co-authors at least every other week during the analysis period. This was done to ensure confirmability of the results, i.e. the extent to which the study's findings are supported by the data (Shenton, 2004). Besides, two co-authors had access to the transcripts and the first author was directly in contact with the interviewer to discuss findings. The "we" in the following paragraph therefore refers to the first author in close cooperation with a team.

Table 2

Composition of the final sample (some participants belong to more than one group).

Name of the group	Description of the group	Amount
Young older adults	Adults aged 65 to 74 included	17
Old older adults	Adults aged 75 and older	10
People with a lower education level	Adults with a lower education level following the classification from Statistics Netherlands, with a focus on people with low literacy skills and people with a mild intellectual impairment	23
People with a migration background	Adults with a non-western migration background following the classification from Statistics Netherlands (people from Turkey, Africa, Latin America and Asia excluding Indonesia and Japan)	10

We followed a flexible coding approach (Deterding & Waters, 2018), working in three steps:

- First, we read each transcript and indexed them based on the topic list. Parts of the interviews that were about participants' situation during the pandemic were delineated at this stage. In this step, we already started writing memos to be reflexive of our interpretations, to develop case summaries and cross-case analyses, as recommended in qualitative research (Kuckartz, 2014).
- Second, we applied analytic codes. The coding scheme was structured along the two main axes of our objective: experiences with digital transformations in public transport and coping strategies. A combination of inductive and deductive approaches was used:
 - For experiences with digital transformations, we mostly used a deductive approach. For this, we relied on the digital inequality framework introduced in Durand et al. (2022) and shown at the beginning of the Results section.
 - For coping strategies, we started with an inductive approach and later introduced literature on coping strategies (Asmar, Van Audenhove, & Mariën, 2020; Lazarus & Folkman, 1984).

We coded both at a semantic level and at a latent level. Coding at the semantic level means focusing on the explicit and obvious content of the data. Latent codes identify meanings beneath the semantic surface. The latter are especially important for the identification of coping strategies, which are seldom directly verbalised by participants. Since the main analyst was not present for most interviews, she listened to the tapes in order to detect these more hidden meanings.

The authors assessed whether certain experiences of participants would constitute a potential difficulty with digitalisation, and subsequently result in a coping strategy. At the same time, we made room in our coding scheme for the participants' perception. For each item coded as a potential difficulty, we coded the extent to which participants experienced this as a difficulty too or not. This distinction proved fruitful to propose our model in the Discussion section.

- Third, we explored how deeply our results are grounded in the data. The main analyst and the interviewer had regular contact to

brainstorm these results. Furthermore, we relied on the querying possibilities in ATLAS.ti, investigating whether participants had been misclassified along codes and whether diverging patterns had not been too overly stressed.

3. Results

In this section, we first focus on how participants experience digitalisation in public transport: the benefits (Section 3.1) and the difficulties (Section 3.2) they experience. Fig. 1 shows the coding categories we used, organised according to the conceptual framework to investigate digital inequality introduced in Durand et al. (2022). Durand et al. (2022) argue that this framework, adapted from Van Dijk (2005), is a useful departure point to understand digital inequality in transport services. In short, the model of Van Dijk (2005) posits that inequalities in terms of personal position and background result in inequalities of access to digital technologies, which in turn translate into disparities in terms of participation outcomes. On this latter point, we chose to make a distinction between *benefits* and *disadvantages* in the analysis, as shown in Fig. 1. We did not apply a deductive coding strategy for *disadvantages* because they cannot be discussed separately from coping strategies. This is why we will turn to these disadvantages in the Discussion section. Second, we present the results of how people cope with digitalisation in public transport (Section 3.3). We shed light on various types of coping strategies via our inductive approach.

3.1. Benefits of digitalisation

Public transport users recognise the benefits of digitalisation. Half of the participants indicate that they experience benefits with respect to paying and planning. Several participants consider that being able to prepare their trip from home using a tablet or a computer is a nice possibility. Thanks to multimodal planners, people get an idea of the door-to-door journey. Furthermore, the availability of real-time travel information on the smartphone gives people the opportunity to adjust their plans just before departing or during the journey. This provides a sense of control:

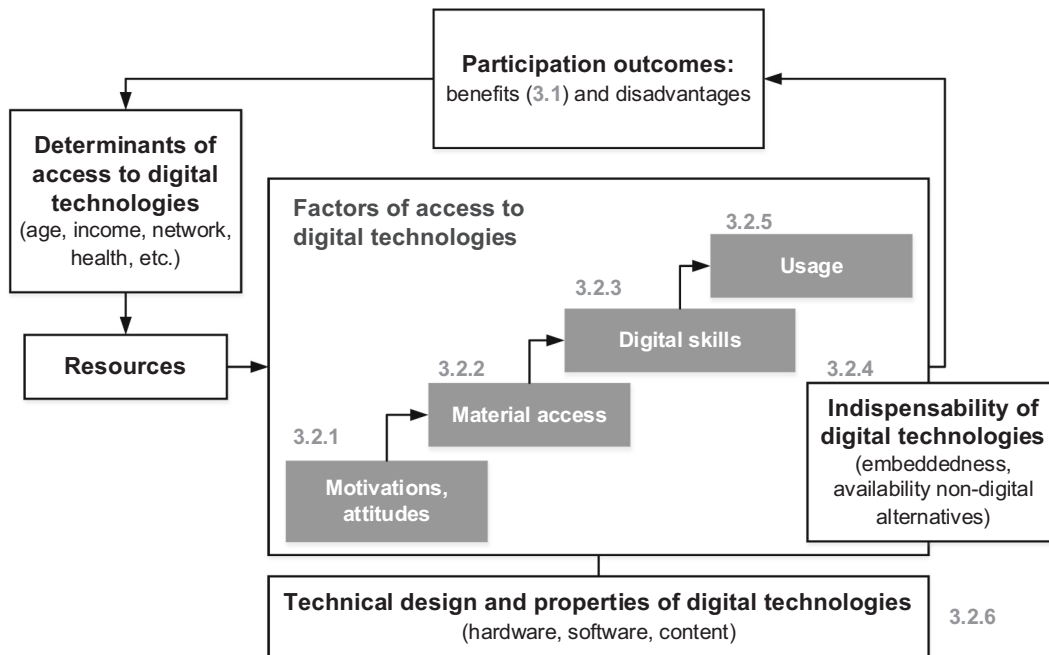


Fig. 1. Organisation of the results pertaining to experiences with digitalisation, as part of the conceptual framework to investigate digital inequality (see Durand et al. (2022), based on Van Dijk (2005)).

“I get comfort out of it [travel app] [...] for a train that goes once every half hour, I like it. And that gives me a good feeling indeed. And you can indeed see whether there are any disruptions. [...] It gives me a good feeling.”

R4, female, 66, medium digital access, frequent PT

Half of the participants mention benefits of digitalisation in relation to travel payments. They almost always refer to the advantages of the ov-chipcard, the Dutch smart card that can be used to access all PT modes in the Netherlands. The smart card saves them time and energy, as it can be quickly topped up from machines or online. The possibility to let the smartcard automatically recharge leads to a lot of satisfaction, when this functionality is activated. It also offers a way out for those who feel uncomfortable with ticket vending machines. A few respondents even stated that they were travelling more, thanks to the convenience of the ov-chipcard:

“The nicest thing about public transport, is when that ov-chipcard came out. [...] I started travelling a lot more. You didn't have to buy a ticket, you didn't have to go to the ticket office, the money would be taken out of your account automatically, I didn't have to worry about that.”

R15, female, 75, low digital access, frequent PT

3.2. Difficulties associated with digitalisation

3.2.1. Lack of motivation and fear

Despite the above-mentioned advantages, potential and actual public transport users also experience various difficulties linked with digitalisation. One of them is that people can feel discouraged from using digital services for various reasons:

- Some can find online travel information, but not the piece of the information they are looking for, such as the presence of toilets in public transport or the accessibility of stations and stops. There is a mismatch between the available information and people's own information needs (Pangbourne et al., 2010).
- Infrequent and non-PT users who are less digitally self-reliant explain that the time and energy investment required to understand digital technologies is often not worth it. As such, they get discouraged from learning about smartcards and online travel information systems.
- In addition, the fear of cybercrime hinders certain online activities, such as buying e-tickets. This finding is in line with previous literature (Harvey et al., 2019; Musselwhite, 2019).

“No, no, no! I don't transfer money via the internet. No, because you are always warned. There are far too many criminals on the internet. I don't want to be trapped by them.”

R6, female, 83, medium digital access, infrequent PT

3.2.2. Lack of or inadequate devices

The lack of ownership of the right devices, such as a computer or a smartphone, is an obvious obstacle to reaping benefits of digitalisation. Malfunctioning software, old devices, unstable operating systems, dead batteries, a limited data bundle, no wired internet and high costs can also be barriers, as already described in literature (Golub et al., 2019; Groth, 2019). Furthermore, having only a smartphone is not sufficient. Comparing prices and managing files, for example when filing a complaint, is harder on a mobile device. In general, we found confirmation that the ownership of a device is a poor indicator of the extent to which people reap benefits or are guarded against difficulties of digitalisation in public transport. This is in line with digital inequality research (Van Dijk, 2005).

3.2.3. Low digital skills

Some people lack the necessary digital skills to use online travel information or obtain a ticket. It may concern basic digital skills, such as

installing apps or activating mobile data. Yet these skills form the precondition for more advanced skills. Information and strategic skills are particularly relevant (Vecchio & Tricarico, 2018). Yet half of our participants showed low levels of such skills. They cannot request an ov-chipcard, buy a ticket for an international bus service or manage subscriptions (that require creating an online account). Additionally, some people know how to find one piece of information (e.g. bus line number), but not all the information they need (e.g. departure time of next bus).

Digital skills also play a role in operating ticket vending machines. Challenges lie in the use of the touch screen, fear of making the wrong choices and being unable to make corrections, understanding the displayed information and, ultimately, making choices. When added up, these challenges can lead to stressful situations:

“At the moment I wouldn't dare [using a ticket machine]. I think if I had to go and buy a ticket now, I'd get really high blood pressure and my heart rate would go right up. I know that for sure. I would also be afraid of losing my bank card.”

R10, male, 61, low digital access, frequent PT

3.2.4. Low digital flexibility

Dealing with the new, more or less formal rules that digitalisation brings along can be a challenge for some people. This requires a meta-skill called *digital flexibility*. It is about the ability to move easily between platforms and services (Asmar, Mariën, & Van Audenhove, 2020). We identified low digital flexibility on multiple levels. To begin with, some may have difficulties dealing with the fast pace of digital transformations, such as changes in the ticketing system and updates that modify apps overnight. Others report that cash-free payments (bank cards or smart cards) make transactions harder to follow. They are deemed too abstract and not tangible enough, sometimes leaving the perception that prices have dramatically increased. Next, the decrease in availability of public transport staff at stations raises concerns, as do the increasing expectation that people have access to real-time travel information. Such expectations can manifest implicitly, for instance when people have the feeling that they need a smartphone to travel. They can also manifest explicitly:

“Someone from [PT operator], yes. He took out his mobile phone, he looked on the internet and he said: ‘Yes, here it is, you should have had a look.’ I said: ‘Yes, it's only just now, because I have another train here.’ ‘Yes, but it's not running, it's cancelled. You'll have to look on the internet, then you'll know what's running.’ And then he was gone.”

R8, female, 68, medium digital access, infrequent PT

Finally, the fast uptake of digital technologies in public transport has led some participants to mistakenly believe that some analogue options have completely disappeared. For instance, they believe that the possibility to request money back after a disruption via a service desk is gone. This likely reinforces the operator's conviction that analogue channels are becoming superfluous.

3.2.5. Not using digital technologies on-the-go

The trend towards an increasingly mobile use of digital technologies fits well with the act of travelling: people can access the internet on-the-go. However, the mobile use of technologies is not evident for everyone. Some participants exclusively use their smartphone at home. Reasons not to use it on-the-go include low skills, stress, a lack of access to wi-fi, no or not enough data, ergonomic difficulties and an outdated phone. Not using digital technologies on-the-go particularly creates difficulties when disruptions occur. As highlighted by Bertolaccini and Hickman (2019), it shouldn't be expected that everyone can access information on-the-go.

3.2.6. Problems with the design of systems in public transport

The interviews highlight the importance of an inclusive design, from websites to ticketing systems. For instance, tiny letters can create an additional barrier in the search for travel information. New apps or updates of previous apps are not always compatible with assistive technologies, such as screen readers. The ticketing system in general can also create challenges for some people. The combination of paying for the ov-chipcard, paying for a subscription and paying for a journey appears sometimes difficult to understand. Rules are not always clear, highlighting the importance of clear communication. For instance, some participants do not know whether they can get the off-peak discount if a part of their trip was done in the peak hour. They also do not know where to find that piece of information. As already highlighted in literature, we find confirmation that both hardware and software can create barriers (Durand et al., 2022).

3.3. Coping strategies

3.3.1. Support

A main way to cope with digitalisation in public transport is to rely on **support from their social network**: a partner, children, grandchildren, parents, friends, neighbours, fellow volunteers or colleagues. Around half of the participants used this coping strategy. This finding is supported by literature, both in transport (Kos-Labędowicz, 2020; Misra et al., 2022) and in general (Dedding & Goedhart, 2021). We found three types of social support, aligned with digital inequality research (Asmar, Van Audenhove, & Mariën, 2020):

- Support through guidance. It consists of explanations, advice and feedback on how to use certain digital services like public transport operators' websites. Whether the help is spontaneously offered depends on the level of intimacy with the one helping. Digital inequality research confirms the importance of intimacy in predicting the possibility to find support in one's network (Asmar, Van Audenhove, & Mariën, 2020).
- Support through substitution. It consists of people performing tasks for others without any specific goal to teach the supported person. They act as proxy users. People facing difficulties with digitalisation can make use of this type of support for a one-time action, like installing an app, creating an account or printing an e-ticket.
- Emotional support. The social network can play the role of motivator or safety net. Knowing that they have access to a close source of support can give people the confidence and the motivation to at least experiment with digital tools. Some participants explain that they only undertake certain actions, such as looking for travel information, because they know they can fall back on someone if needed:

"Well, two days in advance I am already working on preparing my trip [...]. How should I do that? How am I going to do that? Who can I ask for help? That's where it starts."

R10, male, 61, low digital access, infrequent PT

Relying on one's social network comes with advantages: assistance is close and familiar and there is a good understanding of each other's needs (Van Dijk & Van Deursen, 2014). Yet it also comes with pitfalls. We identified three of them:

- The social network is not necessarily a sustainable form of assistance. This is particularly the case when individuals rely on a few people and when they are mostly supported by proxy users. Indeed, this type of support does not foster learning. Older adults who systematically rely on their partner are particularly vulnerable, as summarised by a participant:

"I'm still used to having my husband, but it would be different if he were to pass away, and then I would be in a difficult situation."

R15, female, 75, low digital access, frequent PT

- Family and friends are not always available, either because they live too far or because they do not have enough time to help. Participants also expressed a reluctance to burden their network, resulting in asking help on one aspect but not on another, or postponing a trip.
- People may have no one to turn to in their close network. Their family and friends may even be discouraging them from learning digital skills or getting a computer. Furthermore, it is not always easy to find someone who both knows how public transport works and who is comfortable with digital tools. This may lead to a form of resignation:

"Interviewer: And are there things you would still like to learn to do by yourself on your phone?"

Participant (via interpreter): I think this is enough already.

Interviewer: Oh, you are satisfied. Yes, okay. And for example, if I say that travel information can also be found via the phone, would you be interested in that? Travel information for public transport.

Participant (via interpreter): Yes, but who is going to teach me? [...] I don't know."

R37, male, 71, low digital access, frequent PT

Some of the respondents cope with digitalisation in general by relying on **formal sources of support** like volunteers and computer courses. In a few cases, this proved useful to cope with digitalisation in public transport too. Computer courses can give people the confidence to try using digital technologies. Yet they do not always guarantee that people will be able to translate these skills in public transport. In general, respondents who followed a course explained that their social network was important to help them practising and to teach them additional skills, such as how to use a travel planner. Other than courses, respondents mention that volunteers, social workers and care coordinators can provide them with punctual help, like to buy an e-ticket. The role of care coordinators in such tasks has been extensively documented in Oluyede et al. (2022).

Another way to cope with digitalisation in public transport consists of finding **support in the transport system itself**. Interviewees indicate that favourable responses by fellow travellers can be very helpful. They can help for quick actions. For instance, a few participants explained that they would look for people with a smartphone to ask them information when feeling uncertain about their trip. Others explained that they rely on the help of fellow travellers acting as proxy users to buy a ticket. Relying on other travellers can also give people the opportunity to successfully learn on-the-job.

Public transport staff can also offer assistance. A majority of the interviewed public transport users regularly rely on such support. It can be about asking for reassurance, getting travel information or getting a ticket. Service desks can also be used for punctual and seemingly small actions, but with large impacts. One of such examples is help activating an option on the smart card or requesting a smart card: these are done once and do not need to be repeated. Most interviewed non-PT users cannot imagine starting using public transport without being able to directly talk to a member of staff. A few participants explained that they would go to great lengths to find a station with a service desk. For example, they would bike one hour (one way), make special detours or go by car:

"Participant: Then I went all the way to [place] with my car to buy a ticket, to have that for my trip. Then I could go straight on, because I already had that ticket.

Interviewer: Yes, you bought it on another day.

Participant: Yes. Another day and at another station with a ticket office, yes."

R19, female, 79, medium digital access, infrequent PT

As such, this strategy can involve a form of hidden work. Extra costs are not uncommon. Participants highlighted that discounted tickets are not available at service desks, and topping up smart cards or getting a ticket there comes with a small extra fee (except for people aged 75 and older and people with impairments).

3.3.2. Other coping strategies

People who cannot or won't access support, whether it be punctually or structurally, develop other coping strategies. One of them is **fare evading**. It means not paying for a ticket or not buying the right ticket. A few participants mention this. It can be intentional or unintentional, as [Delbosc and Currie \(2019\)](#) explain. The main reasons for fare evading indicated by participants are difficulties using ticket vending machines, confusion about the ticketing system or the impossibility to locate a vending machine when needed. Sometimes, the interviews also revealed financial issues, which could play a role in deciding not to pay.

For people who do not have access to travel information on-the-go specifically, a common way to cope is to **write down all the travel information** they need on a piece of paper or print a travel advice. Even some participants who can access their smartphone on-the-go use this strategy. Some people reported writing information for alternative journeys, in case something might go wrong. When the trip does not go as planned, a few participants explained that they would rely on support from staff or fellow travellers. When this was not available or helpful, they would **go back home**. This is even the case for those who have a smartphone and cannot or do not want to use it on-the-go.

At the other extreme, some participants with a low digital access explain that they mostly take trips **without consulting any prior travel information**. They do not remember schedules and are neither willing nor able to look for travel information online. This may lead to long waiting times, particularly in the case of low frequencies:

“Participant: *We check when the bus comes once we are at the station [...] They often come every half hour or so. So then if it has just left, then you're out of luck, you have to wait half an hour.*”

R9, female, 74, low digital access, frequent PT

A few participants mention that they **avoid using public transport for unknown destinations**, even when public transport would be a suitable option. Those with access to a car argue that it is more convenient. Digitalisation may well have nothing to do with such a choice. Yet a few of these participants mention bad experiences when searching for public transport travel information. They could not find the information they needed or used wrong information and got lost. In their interviews among older adults in Sweden, [Olausson and Kamel \(2020\)](#) also noted that some participants would be relying more on their car and using less public transport because of digitalisation.

Some public transport users do not seem to know how to look for online travel information and are simply used to travelling by public transport along the same routes. A few expressed the wish to explore places beyond the well-trodden paths, but they encounter too many difficulties along the way and cannot find adequate support. Non-PT users who are less digitally self-reliant and have no car access did not explore much beyond their neighbourhood. Other factors (poverty, loneliness, etc.) might play a role and people may have adjusted their preferences. Yet a few explain that having more digital skills would make it easier to start using PT, like the following participant:

“*That would make it easier to travel by public transport, if I were more digitally literate. I would like to participate more in society. Especially the family, acquaintances and friends who live further away. [...] I would be able to do much more if I could travel more.*”

R38, female, 68, low digital access, no PT

4. Discussion

4.1. Patterns across participants

We uncovered some patterns in terms of *who* experiences difficulties. Note that these patterns are meant to have a *theoretical* generalisability, and not a generalisability to the wider population. Firstly, those who name benefits are often more digitally self-reliant and use public transport frequently. Secondly, older adults aged 65 to 74 with a medium to higher education level and without a migration background encounter fewer to no difficulties. This highlights the need for researchers to look beyond this relatively easy-to-reach group when investigating the impacts of digitalisation in transport services. Thirdly, participants experiencing difficulties are usually less digitally self-reliant. This can make access to public transport particularly complex for non-PT users who are less digitally self-reliant.

In line with digital inequality research ([Helsper & Van Deursen, 2017](#)), we find that people who experience the most problems with digital technologies may be the ones with fewer opportunities to receive high-quality support. A majority of the respondents relying on their social network to cope with digitalisation in public transport have a medium digital access. People reporting being unable to rely on their social network are usually less digitally self-reliant, have more frequently a migration background and mentioned money concerns at some point in the interview.

A majority of the participants experience at least one difficulty linked with digitalisation in public transport. Importantly, we note that people can reap benefits on one aspect and experience difficulties on another. For instance, one may enjoy the benefits of real-time travel information but be uncomfortable with a smart card.

4.2. The self-reliance paradox

Our study confirms that digital technologies can promote self-reliance among travellers. However, this is not the case for everyone. Digital technologies facilitate a self-service approach that puts marginalised users at risk, as both [Van Holstein et al. \(2021\)](#) and [Oluyede et al. \(2022\)](#) already noted in the context of urban transportation. Digital technologies actually make people who are less at ease with digital technologies more dependent on others. As a participant puts it when explaining her difficulties with ticket vending machines:

“*Then you are again dependent on someone else to support you and help you with that. Yeah that can be very difficult. And again, you have to dare to ask.*”

R12, female, 41, medium digital access, frequent PT

In other words, the great emphasis on personal responsibility through digitalisation actually reduces the self-reliance of some citizens. This is called the self-reliance paradox ([Keizer et al., 2019](#)).

4.3. Visualising mechanisms behind digital inequality in public transport

Digital inequality in transport services is the result of a combination of a lower access to digital technologies and the use of certain coping strategies. Our analysis allowed us to make links between potential difficulties experienced by participants and coping strategies. Participants' perceptions play a key role here. In instances when participants acknowledged that they face a difficulty related to digitalisation in public transport, we see that they would try to seek support. In instances when they are satisfied about their situation – while we assess that they might be facing a difficulty – we see other types of coping. We give here an example of such a situation. A participant repeated twice that she is perfectly happy with the travel information she can find online. Yet whenever something unexpected would occur (her usual travel information website is temporarily down, or she needs to look for a different piece of information), she would find herself stuck. She is unable to

navigate other popular travel information websites. We coded this as a potential difficulty in terms of digital skills, even though she does not explicitly acknowledge it as such.

We deemed the link between coping strategies and participants' perceptions important to explain mechanisms of digital inequality. In fact, coping strategies are responses to how stressful events, or difficulties, are perceived. We therefore propose a model that fits together our findings, based on the transactional stress model developed by Lazarus and Folkman (1984). This model has been applied in other fields too, like cyberbullying (Parris et al., 2012), social media use (Wolfers & Schneider, 2021) and students' well-being (Dvořáková et al., 2019). In their model, Lazarus and Folkman (1984) described *coping* as a process resulting from the relationship between the stressor and available resources. They argued that when facing a potential stressor, one conducts a primary and secondary appraisal. The primary appraisal stage requires assessing the situation to determine the extent to which there is a difficulty or threat. The secondary appraisal stage involves the person evaluating their resources and taking action accordingly. Decisions made during each stage will elicit certain coping strategies.

We propose that when facing a potential difficulty pertaining to digitalisation in public transport, people also conduct two – conscious or unconscious – appraisals. To begin with, they assess whether they are facing a difficulty. For instance, *is not managing to get this piece of travel information a difficulty for me at the moment? Or: can I manage with the ticket vending machine on my own?* When people do perceive a difficulty, they assess whether they have the resources to do something about it. They may ask friends, family, neighbours, and colleagues, summon the

courage to ask questions to strangers at the station, put in the money to call a helpline for assistance, etc. In circumstances when such resources are available, people are able to get support. In other circumstances, we see different strategies such as fare evading, postponing the trip, accepting potentially longer journeys, travelling less with public transport or going back home. These last few coping strategies are also used by those who do not seem to perceive a difficulty about the situation they are facing. This proposed model is shown in Fig. 2. The three boxes on the right side serve as labels to the different parts of the model.

Our proposed model depicts several mechanisms at play behind digital inequality in public transport. Getting support seems like the best course of action. Yet it sometimes comes with pitfalls, as explained in Section 3.3.1: family and friends are not always available or helpful, getting a ticket from a ticket office desk may require a long detour and extra money, etc. The other coping strategies reveal more visibly mechanisms of digital inequality in public transport, ranging from postponing a trip and fare evading to avoiding public transport altogether. We note that a particular person is not necessarily bound to a single path: one may manage to get help once, and decide to postpone a trip the following time. Additionally, this model does not encompass the spontaneous or preventive support one may receive (mostly from their close social network). The paths in this model are based on our empirical material. We do not exclude that further research on this topic finds slightly different paths, for instance between not acknowledging a difficulty and fare evading.

This model adds value to the conceptual framework presented in Fig. 1 because it allows for a person-centred understanding of the

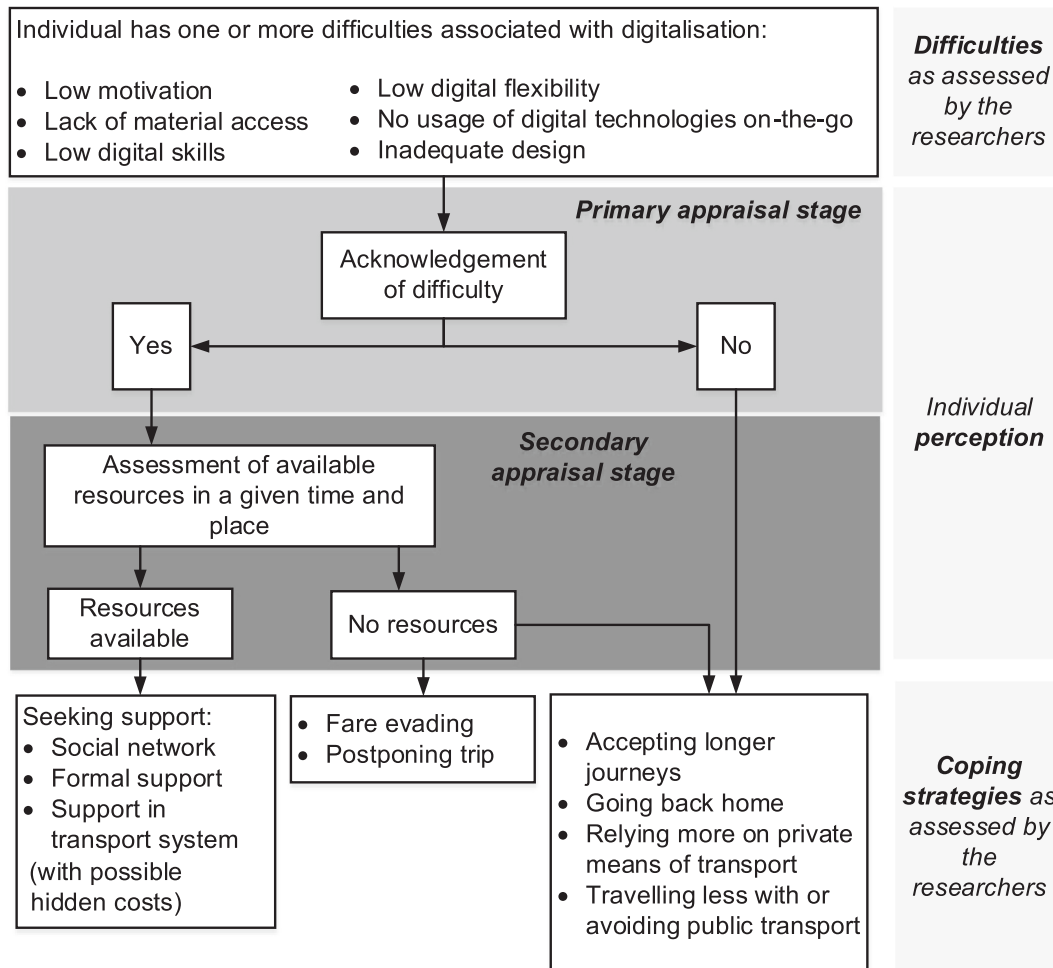


Fig. 2. Proposed process model of coping with digitalisation in public transport, inspired by Lazarus and Folkman (1984).

mechanisms behind digital inequality. Specifically, this model shows how a lower access to digital technologies coupled with a limited access to resources can put people at a disadvantage when dealing with digitalisation in transport. Nevertheless, experiencing difficulties with digitalisation in public transport does not systematically translate into exclusion from public transport. This is even the case for people with a lower digital access. Instead, there are different layers of disadvantage. In line with digital inequality research (Asmar, Van Audenhove, & Mariën, 2020), we find that social resources can be translated into digital resources among those willing to learn and able to receive support through guidance. Half of the less digitally self-reliant participants were able to find some support in their social network.

4.4. Limitations

Our research has a number of limitations. The first lies in the recruitment of respondents. Although we succeeded in speaking to a diverse group of respondents, our group is likely to contain more people who are proactive in learning digital skills, and relatively fewer who are truly excluded. Someone who is proactive in learning digital skills is also easier to recruit because they will be in touch with an organisation that offers courses or support to this person. Still, there were also many participants who were not in touch with such organisations. We paid a lot of attention to their perspective during the analysis.

The interviews took place just before, during and after the second COVID-19 wave in winter 2020/2021. We aimed to limit the influence of the pandemic on our respondents' interviews, as discussed in the methods. Most respondents were able to talk about the pre-pandemic situation, but a few had more difficulty doing so. The interviewer regularly reminded them that the answers to the questions had to be about the pre-pandemic situation. Where respondents did not comply, we marked the passage in the transcripts. It is therefore possible that we missed a couple of respondents' experiences of digitalisation in public transport because they were worried about the pandemic.

5. Conclusions and further research

This study aimed to understand how various groups who are more likely to be impacted by digital inequality experience digital transformations in public transport, and the coping strategies they might have developed in response to it. Our interviews reveal that one can reap benefits of digitalisation and experience difficulties at the same time. Access to travel information and smart cards have brought benefits among many of the participants, especially among frequent public transport users and the more digitally self-reliant ones. Using the framework of digital inequality introduced in Durand et al. (2022) as a guide, we see that low digital skills, not using digital technologies on-the-go, not possessing the right devices and a complex design of technologies can indeed pose difficulties. We also unpacked the concept of "adapting to the new rules" brought about by digitalisation in transport services and hinted at in literature (Van Holstein et al., 2021), coined *digital flexibility*. It refers to the ability to adapt to the constant changes brought about by digitalisation, such as app updates, cash disappearing or fewer ticket offices.

Nevertheless, experiencing difficulties with digitalisation in public transport does not systematically translate into not using or not daring to use public transport. Coping strategies play a role in this, with support from individuals' social network as a main strategy.

Investigating coping strategies sheds light on the various mechanisms at play behind digital inequality in public transport. Our proposed process model of coping with digitalisation in public transport shows that the extent to which difficulties translate into disadvantages for the access and use of public transport depends on one's perception of the difficulty and on their coping resources. These copings resources depend on a myriad of factors: individuals' broader socio-economic context, their social network, financial resources and other transport options.

Coping strategies serve a purpose and may even result in people becoming more digitally self-reliant in PT. However, they may also come with risks and pitfalls, involving hidden work and costs, or preventing people from accessing the best prices. This highlights the insidious nature of some mechanisms of digital inequality in public transport. In the language of transport planners, using these coping strategies would amount to raising generalised costs, where travel costs, travel time and comfort components are impacted. While many people may gain self-reliance through digital technologies, this study highlights clearly the existence a self-reliance paradox. Those who are less comfortable with these digital technologies are likely to become even less self-reliant, frequently requiring support from others. Ultimately, digitalisation can also contribute to driving some people away from public transport. They might fall back on private means of transport, if available.

Because of the increasing use of digital technologies in public transport systems globally, we expect the results of this study to be applicable in other countries. Local context and cultural norms likely play a role, but we expect that our categories of difficulties and coping strategies can be transferred to other contexts to some extent. The same goes for our proposed model of coping. Besides, researchers who would like to investigate the impacts of digitalisation in transport services among so-called "vulnerable groups" in a given context can get inspired by the methods described in this study.

So far, we have scarcely mentioned policy implications of this study. This is because our primary goal was to shed light on the mechanisms of digital inequality in public transport. Nevertheless, this study demonstrates the usefulness of actions to mitigate digital inequality. While formal and informal support systems are important, they are not available to everyone. Furthermore, there are also flaws in the support that people can get from the transport system. Thinking about solutions to mitigate digital inequality in transport services requires a broad reflection, one that touches design, governance and more – beyond the transport system itself. Therefore, we suggest further research into solutions to mitigate digital inequality in public transport and in other (urban) transport systems. This is a task we have taken up as part of a follow-up of this study, and we would like to encourage others to do so as well; sources of inspiration here are Kolotouchkina et al. (2022) and Lam and Ma (2019), among others. Based on the results of this paper, it seems likely that policy actions to mitigate digital inequality in transport services will need to look into multiple perspectives. For instance, setting up programs to teach digital skills applicable in transport will likely not reach everyone, and complementary approaches will be needed.

Last but not least, this study can inspire researchers wishing to investigate the access to and use of shared mobility services among populations likely to be impacted by digital inequality. Their "digital only" type of access poses new challenges (see Butler et al. (2021); Groth (2019); Vecchio and Tricarico (2018)), which will become particularly relevant should these modes become more mainstream.

Author statement

This paper is original research. The authors confirm contribution to the paper as follows: study conception and design: AD, MH, AtH, TZ, NvO, SHL, SH; data collection: AD, MH, TZ; analysis: AD; interpretation of results and draft manuscript preparation: AD, MH, TZ, AtH, NvO, SHL, SH. All authors reviewed the results and approved the final version of the manuscript.

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Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Arjen't Hoen:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Niels van Oort:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Sascha Hoogendoorn-Lanser:** Conceptualization, Methodology, Writing – review & editing. **Serge Hoogendoorn:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

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.

Data availability

The data that has been used is confidential.

Appendix A

Table A.1

Composition of the final sample based on personal and mobility characteristics.

Characteristic	Categories	Amount
Gender	Female	24
	Male	15
Age	Younger than 65 (17–64 years old)	12
	65 to 74 years old	17
	75 years old and older	10
Education level (according to Statistics Netherlands)	Higher education level	8
	Middle education level	8
	Lower education level	23
Province (8 out of the 12 provinces are represented)	Friesland	1
	Gelderland	4
	Groningen	1
	North Brabant	2
	North Holland	10
	Overijssel	2
	Utrecht	15
	South Holland	4
Migration background	Yes	10
	No	29
Ownership of an ov-chipcard	Yes	28
	No	11
Use of bus/tram/metro	Yes	27
	No	12
Train use	Yes	28
	No	11
Bike use	Yes	31
	No	8
Car use	Yes	8
	Limited (usually rides along with someone else from the household or prefers to avoid driving)	9
	No	22

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