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Integration of shared transport at a public transport stop: mode choice intentions of different user segments at a mobility hub

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ABSTRACT

To create an integrated transport system that can compete with and reduce private car usage, we need a better understanding of the transport and user characteristics that relate to people's intentions to use shared and public transport at a mobility hub. For this purpose, this paper describes the results of a survey surrounding the case study of Leyenburg, The Hague in which a scenario of integrating shared mobility at an existing public transport stop is proposed. This study investigates the intention to use shared modes and public transport in a multimodal transport network and the factors and user characteristics that affect this intention. As digital technologies become important in the integration of modalities by offering digital planning and payment options, concerns regarding digital exclusion in transport services are growing. In this paper we developed a digital skills measure to reflects one's ability to perform tasks that are inherent to the digital services seen in the transport sector. Using an ordinal logistics regression analysis, the study has found that the intention to use shared transport is higher for people who are younger, have a high level of education and a high level of digital skills. In addition, having prior experience with shared transport in the past year and currently using multiple means of transportation during the trip are positively affecting the intention to use shared transport. The intention to combine shared transport with the bus or tram during a trip is similar to the intention to use shared transport and is related to similar characteristics, except for education. The intention to use the bus or tram is found to be mainly related to current transport usage and trip-specific factors and not to other user characteristics. For transport providers, the results provide evidence that offering shared motor scooters and bicycles would be an attractive option for young and highly-educated users who intend to combine the use of shared and public transport.

1. Introduction

The promotion of public transportation in its current form is seen as a way to address the sustainability impacts that are caused by high levels of private car ownership (Miller, de Barros, Kattan, & Wirasinghe, 2016). In addition, shared mobility is considered to be a promising new mobility system in the development towards sustainable transport, especially as it can address traffic congestion and CO_2 emissions (Rabbitt & Ghosh, 2016) (Taylor, et al., 2016). Furthermore, it is one of the measures proposed to reduce the parking need in urban areas (CROW, 2021) (Jorritsma, Witte, Alonso González, & Hamersma, 2021). Overall, developing and promoting public and shared transportation systems is considered as a way to address the issues regarding the ownership and usage of private cars.

Extracting the potential sustainability benefits of shared mobility requires an understanding of how to integrate shared mobility into the existing urban transportation system and improve its efficiency from social, environmental, and economic perspectives (Machado, De Salles Hue, Berssaneti, & Quintanilha, 2018). Nevertheless, combining the offering and promotion of shared mobility services with public transportation is seen as a way to address the growing pressure on urban transport systems as the various transport modes can together serve as a substitute to the private vehicles (Kamargianni, Li, Matyas, & Schäfer, 2016). Such an integrated system should offer more variety of transport by adding shared modalities while being better able to integrate them within the existing urban transportation by building upon the foundations of public transport. Yet, past studies have shown that shared modalities compete with public transport, walking, and cycling without reducing the use of the private car (Esztergár-Kiss & Lopez Lizarraga, Exploring user requirements and service features of e-micromobility in five European cities, 2021).

For car sharing, the study of Ruhrort (2020) showed that station-based services lead to a net reduction of car ownership. Shaheen, Cohen and Zohdy (2016) found that free-floating services contribute to a reduction of cars on the road, while Hülsmann et al. (2018) found

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that free-floating car-sharing does not negatively affect public transport use, but also does not reduce user's car ownership or transport-related CO_2 emissions. Two studies regarding bicycle sharing in the Netherlands showed that shared bicycles are often used as a substitute for the bus, tram, metro, walking, using a private bicycle (Jorritsma, Witte, Alonso González, & Hamersma, 2021) or even the car (Ma, Yuan, Van Oort, & Hoogendoorn, 2020). Hence, it is important to ensure that shared and public transport complement each other in order to serve as an attractive alternative to private vehicles.

The integration of multiple transport modalities can be divided into a digital and a physical component (Zeng, Hidalgo, Mackie, & Schleeter, 2014). The digital integration encompasses the building blocks of information and fare integration, which are often aimed to be manageable by both service providers and passengers via digital information systems on a real-time basis (Esztergár-Kiss, Kerényi, Mátrai, & Aba, 2020). The integration of infrastructure and operations of public transport and shared modalities is referred to as "the physical" integration (Zeng, Hidalgo, Mackie, & Schleeter, 2014). A physical location that enables, at a minimum, the physical integration of different means of transport is often described as a mobility hub. One of the general definitions of mobility hubs is: "recognisable places with an offer of different connected transport modes supplemented with enhanced facilities and information features to both attract and benefit the traveller" (CoMoUK, 2019). Creating hubs will require space, which is very limited in urban areas. However, the availability of alternative transport at mobility hubs is expected to lead to the reduction of privately owned vehicles which will offset the initial space it costs to create a hub (Witte, Alonso-González, & Rongen, 2021).

In addition to the technical and organisational difficulties of digital and physical integration, this study considers the user perspective as it requires a significant shift in people's behaviour to start using new or different means of transport. The ambition is that the integration of public and shared mobility services can make both services more accessible and useful to a larger user group. However, literature published on this topic notes that this can only be achieved if the barriers of making an effective scheme of shared mobility are accounted for during the integration process (Alonso-González, Hoogendoorn-Lanser, van Oort, Cats, & Hoogendoorn, 2020). Some of the important factors in addressing these barriers are inclusiveness, accessibility, equity in terms of fair distribution of cost, and a citizen-oriented approach where the users' needs are central (Machado, De Salles Hue, Berssaneti, & Quintanilha, 2018).

Various studies have recently attempted to determine factors that relate to people's decisions to use various modalities. These factors include user characteristics, such as age and education, and transport system characteristics, such as performance and the required effort to use it (Jahanshahi, Tabibi, & van Wee, 2020). The relationship between user characteristics and people's intention to use means of transport will contribute to understanding the potential of the various means of transport at a mobility hub and help identify possible limits of the systems in terms of, for example, inclusivity. Regarding inclusivity, people's digital skills can be an important user characteristic to consider as it describes people's ability and willingness to operate connected devices, regardless of their access to these devices (Durand & Zijlstra, 2020). Differences in the level of digital skills will especially be an apparent issue for accessibility and inclusivity of multimodal transport systems when the digital integration component becomes more important (Shaheen & Cohen, 2018).

This study aims to determine the intention of potential users to use shared mobility and public transport when offered in an integrated transport system. With this aim, the study contributes to both policy makers' and transport providers' attempts to create integrated transport systems that increase the use of shared and public transport. The research questions are defined as follows:

- What is people's intention to use the shared car, shared bike, and shared motor scooter when they are offered at a mobility hub together with the public transportation (bus and tram) and how does this compare to the existing transport usage?
- Which user and transport characteristics are related to people's intention to use any of the transportation offered at the mobility hub and affect the potential uptake of the multimodal transport system?

A survey is conducted within the catchment area of the public transport stop "Leyenburg" in the Dutch city of The Hague in collaboration with the city's public transport company (HTM). The remainder of this paper is structured as follows. Section 2 presents past literature on determining people's intention to use different means of transport and the factors that can be related to this intention. Section 3 provides more details about the methodology, including the case study, survey, and data analysis. In section 4, the representativeness of the analysis is discussed, and the study's results are presented. Finally, sections 5 and 6 provide a discussion and concluding remarks, including future research directions.

2. Literature review

The concept of shared mobility and its effect on existing transportation has increasingly been addressed in academic literature. The integration of public transport with shared transport in a multimodal system has also received growing attention, especially concerning the concepts of mobility hubs and digital integration of transport. Regarding this study's aim, a review will be provided of the literature in these domains covering the understanding of people's intention to use means of transport and the characteristics of these potential transport users.

2.1. Intention to use a new transport system and the related factors

Determining the potential uptake of the multimodal transport system requires an understanding of the public's acceptance or rejection of this system (Jahanshahi, Tabibi, & van Wee, 2020). In the case of this study, the desired behaviour modification is to get people to use one of the multiple means of transport at the mobility hub or to conduct trips that combine multiple modalities. To understand what makes people modify their current behaviour, different researchers have studied theories and tried to develop models that could describe people's acceptance or rejection of ideas (Jahanshahi, Tabibi, & van Wee, 2020). In recent years, the Unified Theory of Acceptance and Use of Technology (UTAUT) model developed by Venkatesh, Morris, Davis and Davis (2003), Venkatesh, Brown, Maruping and Bala (2008), and Venkatesh, Thong and Xu (2012) is adapted and applied in the transportation research domain. The models contain various factors that are considered to influence people's intention to use a system.

Adapting from these original models and the methodology of Jahanshahi, Tabibi and van Wee (2020), as this is one of the most recent studies to apply the UTAUT model in a transportation context, the theoretical framework in Figure 1 presents, among others, these factors. The theoretical framework contains adaptations of the original UTAUT constructs of *Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Price Value*, and *Perceived Safety* to suit the purpose of this study. They are referred to as the general barriers to use transport. As such, the relation between the transport barriers and the intended user behaviour can be evaluated in this study. Travel time and number of transfers are used as transport barriers adapted from the UTAUT construct of *Performance Expectancy*. From the *Effort Expectancy,* multiple payment methods and ease of use are considered as factors. The remaining UTAUT constructs are adapted to the transport barriers of the opinion of others, facilities at public transport stops, travel costs, and feeling safe.

In addition, various user characteristics are considered in UTAUT models for transport such as age, gender, income, and education (Jahanshahi, Tabibi, & van Wee, 2020) (Venkatesh, Morris, Davis, & Davis, 2003) (Venkatesh, Thong, & Xu, 2012). Travel behaviour is added in this study as an adaptation of the experience variable found in the

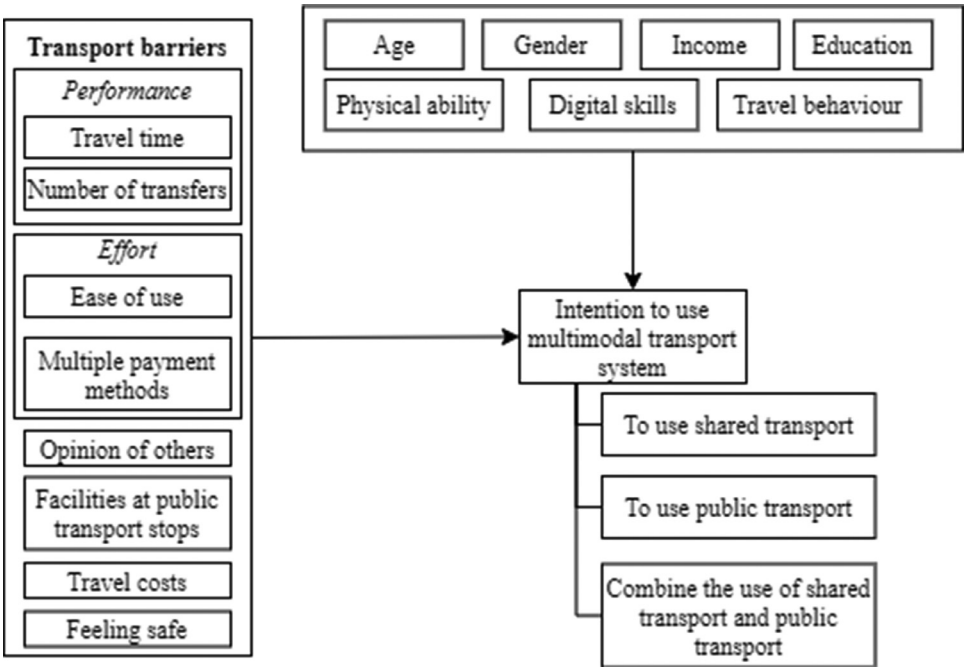

Figure 1. Theoretical framework adapted from the UTAUT models presented by Venkatesh, Morris, Davis and Davis (2003), Venkatesh, Thong and Xu (2012) and Jahanshahi, Tabibi and van Wee (2020).

original UTAUT models. It encompasses the experience with transport such as cars, public transport, and existing shared means of transport. Finally, based on the importance of an individual's capabilities to being able to access transport systems, two additional user characteristics are considered. Physical abilities are included as people with limited physical abilities can experience certain types of transport as less accessible and inclusive than others, compared to people without these limitations (Kett, Cole, & Turner, 2020). The final variable is that of personal digital skills.

2.2. User characteristics of shared transport users

Following the user characteristics from section 2.1, we review past literature that tries to determine their effect and relation in the domain of shared and multimodal transport systems. The success of new modalities and transport systems is influenced by the usage of the systems, which has led to a significant number of research aiming to characterise the users. Studies on bicycle sharing in five cities across the United States, Canada, and Mexico City in 2012 and 2013, showed that, in comparison with the general population, people that use shared bicycles tend to be wealthier, higher educated, younger and more often male (Shaheen, Martin, Chan, Cohen, & Pogodzinski, 2014) (Shaheen, Cohen, & Zohdy, 2016). A more recent study in The Netherlands, looked at the impacts on modal shift by comparing station-based and free-floating bicycle sharing systems (Ma, Yuan, Van Oort, & Hoogendoorn, 2020). It showed, for example, that male and multimodal commuters are more likely to use free-floating bicycle sharing. Another study in the Netherlands showed more than half of the Dutch car sharers is between 31 and 50 years old and slightly less than one-third is younger than 30 (Jorritsma, Witte, Alonso González, & Hamersma, 2021). It also found a relationship between a higher shared car usage and single-person households or households without children. In addition, the study found that primarily young people, males, and highly educated people use the shared bicycle.

Besides characterising users of these shared modalities, people that use multiple modalities during a single trip are also characterised in studies. Based on data from 2015 till 2017, research of KiM (2019) in the Netherlands determined that the use of multiple modalities in a single trip is higher for people aged between 18 and 30 years, with a higher income, with higher education, and for people that face a lower car availability. In addition, the level of urbanisation and trip motive affect people's decision of using multiple modalities in a single trip rather than one (KiM, 2019).

2.3. Digital skill as user characteristic affecting travel behaviour

The digitalisation in transport services, among which the mentioned aspects of digital fare and information integration, provides various advantages to multiple parties (Durand & Zijlstra, 2020). For travellers, the digitalisation in transport means instant access to travel information and increased levels of customisation and flexibility. However, at the same time, the increased use of such digital technologies creates new rules which impose new requirements on (potential) users. Examples of such rules are the smart public transport cards and the central role the smartphone has taken in the last decade (Durand & Zijlstra, 2020). Not everyone can or wants to follow the pace of these digital developments in transport services. Durand and Zijlstra (2020) show that this digital inequality is a complex and gradual process in transport services. Besides the access people have to electronic devices and an internet connection, the range of what they are able and willing to do with them also matters and is not directly dictated by their material access (Zhang, Zhao, & Qiao, 2020).

Online travel information makes it easier to access and possibly understand information that was previously unavailable or hard to find (Durand A., Zijlstra, van Oort, Hoogendoorn-Lanser, & Hoogendoorn, 2021). With this reasoning, digital services can reduce the resistance to use transport services, especially for inexperienced users. However, people with a lack of knowledge on how to operate a smartphone and use features applied in online travel information services have, in general, a higher likelihood of having restricted access to this travel information (Zhang, Zhao, & Qiao, 2020).

The digital skills that are needed in transport services can be described as two types: medium- and content-related skills. Medium-related skills are the skills that relate to operating a digital medium. They are required to successfully develop content-related skills (Van Dijk & Van Deursen, 2014). Content-related skills relate to skills such as searching, finding, processing, and critically assessing information (Van Dijk & Van Deursen, 2014). In transport, if the experienced

difficulty of selecting the right piece of travel information is too high it can result in people abandoning their journey (Lamont, Kenyon, & Lyons, 2013).

The digitalisation that is linked to the integration of shared and public transport will increase the necessity of digital skills to be able to use these types of transportation. Therefore, having a low level of digital skill becomes an additional barrier to transport and people with reduced digital skills might see their mobility options remain the same or even shrinking (Durand & Zijlstra, 2020). Following this trend, there is a risk of polarisation due to the digitalisation in transport services, which could result in transport-related social exclusion (Durand & Zijlstra, 2020).

Even for general purposes, Non, Dinkova & Dahmen (2021) concluded that around 23% of the Dutch respondents do not possess a basic level of digital skills based on a survey of the OECD (2013). Based on Eurostat measurements collected from self-reported measures of the ability to perform tasks, around 20% of respondents aged 16 to 74 years in the Netherlands did not possess at least the basic level of digital skills in 2019 (Eurostat, 2021). From the same data, however, around half of the respondents from the Netherlands did possess an "above basic" level of digital skills in 2019, compared to the 33% average in the European Union (CBS, 2020a).

In addition to measuring the level of digital skills, studies have tried to link digital skills to certain demographic variables. The study of Non, Dinkova and Dahmen (2021), using the data of the OECD (2013), shows that individuals with low digital skills are generally older, lower educated and more often female. Additionally, Durand, Zijlstra, van Oort, Hoogendoorn-Lanser and Hoogendoorn (2021) conclude that older people with lower income and education and those who are part of minority groups are more vulnerable to digital exclusion from transport services.

2.4. Research gap and contribution

Summarizing the literature, most studies have focussed on understanding the modal shift caused by shared transport and the characteristics of the users of these new shared mobility systems. KiM (2019), which is our closest prior art, has found characteristics of people that use multiple modalities during a trip, but this characterisation is not linked to specific modalities. To understand the benefits of integrating shared and public transport, both physically and digitally, this paper focuses on investigating which factors influence the intention to use modalities in the system, including public transport, and how these factors compare for the various modalities.

In addition, with the development of shared transport, the digital component in transport is growing as some of the shared mobility systems offer only digital options to plan and pay for a trip with a vehicle (Durand & Zijlstra, 2020). However, as seen in our literature review, various levels of digital skills exist, and a lack of these skills can result in transport-related social exclusion. Hence, this paper will study if digital skills affect people's intended use behaviour of transport modalities to get a better understanding of the possible extent of this transport-related social exclusion. In addition, the digital skill measures found in literature would only partly represent the presence of skills needed to operate the developing digital platforms for transport services. Hence, this study will develop a digital skill measure that reflects one's ability to perform tasks that are inherent to the digital services seen in the transport sector. This measure allows evaluating the potential digital exclusion that can be caused by the digitalisation in transport, as seen in multimodal transport systems.

3. Methodology

To study this intention to use shared transport modes at a mobility hub, a survey is conducted concerning a theoretical mobility hub based on an existing public transport stop. The mobility hub is defined as a location that combines the offering of the bus and tram together with the transport means of shared car, shared bicycle, and shared motor scooter.

3.1. Case study

To conduct our survey, a case study has been developed in collaboration with HTM, a public transport company in the city of The Hague. The case study concerns the public transport stop Leyenburg in The Hague. Figure 2 provides an overview of the stop and its surrounding area. This stop includes the transport modes of bus, tram, and HTM's 'HagaShuttle', a self-driving minibus. It is also located next to a drop zone for the 'HTM fiets' and shared motor scooters from various providers can be used in the area surrounding the stop. The 'HTM fiets' is a bicycle sharing system using more than 215 designated drop zones where the bicycles can be picked-up or returned (HTM, 2022). The use of these bikes is facilitated purely by the means of a separate app. Currently, a significant amount of these drop zones is located close to or at public transport stops (van Marsbergen, 2020).

The public transport stop Leyenburg classifies as one of the 20 busiest stops for HTM (HTM, 2021). It serves as a connection to the public transport network for people living in surrounding neighbourhoods and the people travelling to or from the hospital 'het HagaZiekenhuis'. In addition, the stop is used by travellers to switch between different vehicles in the public transport network, for example from bus to tram. Overall, this variety of characteristics, such as being an important public transport connection for a neighbourhood, facilitating transfers between public transport modes, while also serving an important destination in the form of a hospital make this stop a suitable case to include people with a variety of travel behaviours in this study.

3.2. Survey

To collect the data required to address the paper's research questions, a survey has been developed that targets the following three groups of either current or potential users of the public transport stop:

- The public transport users currently travelling from, to, or via the stop Leyenburg.
- The visitors of 'HagaZiekenhuis'.
- People living in the vicinity of the stop Leyenburg.

The latter two groups are a mix of public transport users and non-public transport users. Both a paper and a digital version of the questionnaire were used to reach the three target groups. A flyer was created with a QR-code and weblink that both direct to the digital questionnaire made using Qualtrics software. The paper version of the questionnaire consists of four pages and its English version is made publicly available at https://doi.org/10.17632/gr2fn7b7yw.1.

The digital questionnaire was open from June 21st, 2021, to August 1st, 2021. During a period of two weeks, starting at June 21st, flyers and the paper version of the questionnaire were distributed among the three target groups. Finally, the digital version of the questionnaire was also shared on the website and social media page of HTM and on the internal platform for employees of the hospital. In total around 4290 flyers have been distributed of which 2910 flyers were received by households in either their mailbox or by handing it to them in person (103 of the 2910 flyers) in the area surrounding the Leyenburg stop. The remaining flyers were distributed to people at the public transport stop and outside of the HagaZiekenhuis. In addition, 146 paper questionnaires have been handed to people that indicated they preferred the paper version of which 131 were handed out at the public transport stop in front of the HagaZiekenhuis. The other 15 were handed to people from households that were approached in person in a selected area in the neighbourhood based on the characteristics of age, income, and type of housing obtained from a CBS data set of 2017 (CBS, 2017). Overall, 710 responses were collected of which 48 responses were received

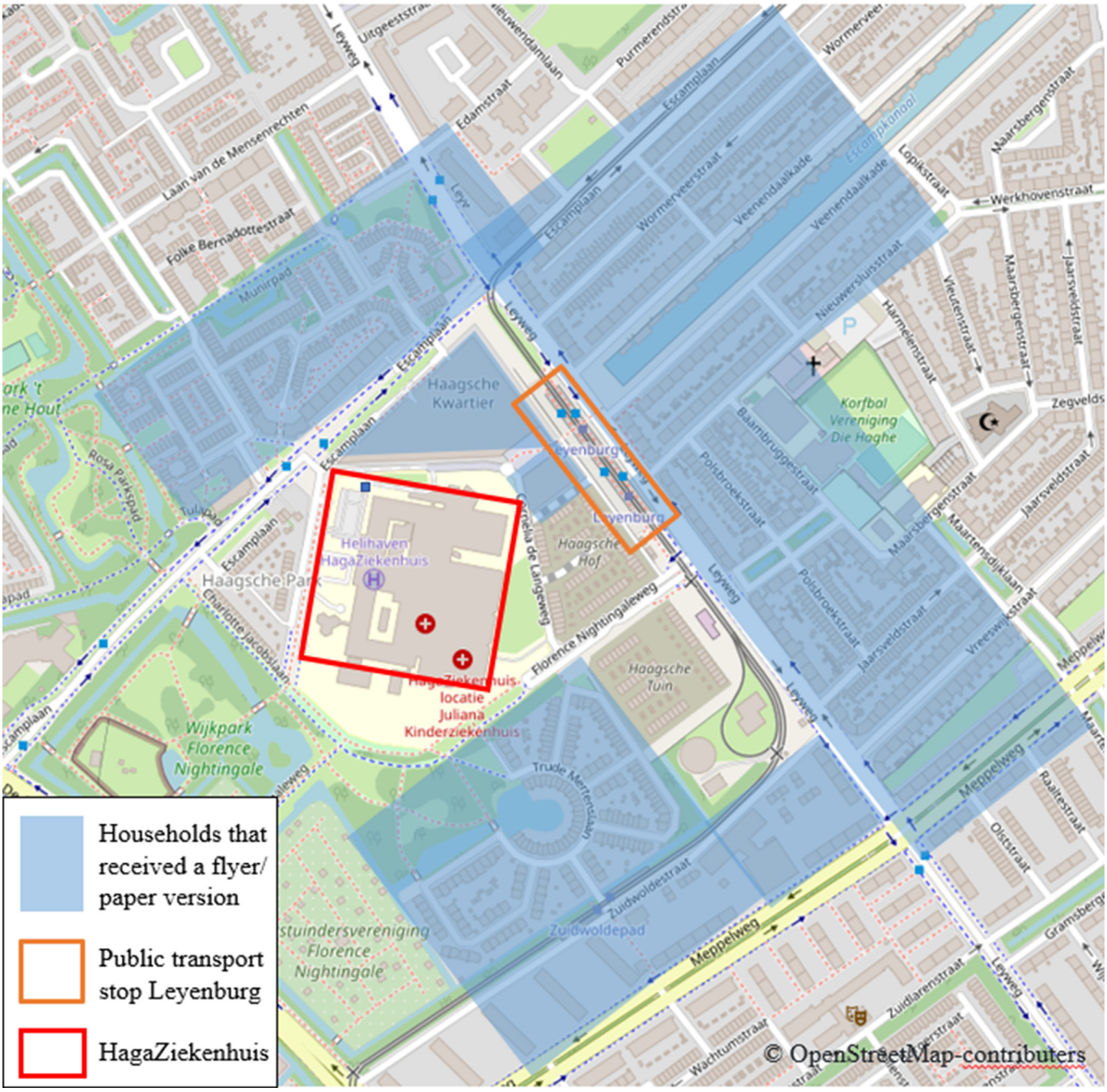

Figure 2. An overview map of the case study area. The top of the map corresponds with the north direction.

on paper. The other 662 responses were collected via the digital questionnaire, where 348 respondents indicated that they had been made aware of the survey through the distributed flyer. The remaining 314 digital respondents got to the digital questionnaire via one of the other distribution methods or did not specify how they were made aware of it.

Both the digital and paper version of the questionnaire were available in English and Dutch. In our survey, a person with a migrant background is considered someone of which at least one of the parents is born outside the Netherlands (CBS, 2021). During the development of the questionnaire, it was tested and read in advance by a committee of 10 members, consisting of employees of HTM and researchers from the University of Twente.

The content of the questionnaire consists of four parts:

- 1 - Personal experience in travelling and digital activities in the past year
- 2 - Importance of the transport barriers
- 3 - Travelling to/from Leyenburg and the intention to use transport in the mobility hub scenario
- 4 - Personal information

Parts 1,2, and 4 contain questions concerning the factors and user characteristics included in the theoretical framework that might be related to people's intention to use certain means of transport in the multimodal transport system at the hub. All questions were asked using likert-scales or multiple answer options, except for the age of the respondents

which was asked as a question with an open answer. For a more detailed overview of the questions, see the publicly available paper version of the questionnaire at https://doi.org/10.17632/gr2fn7b7yw.1. For the digital activities, the questions ask about the frequency of performing activities that relate to the components of information/planning and payments on a smartphone using a likert-scale.

These digital activities are used to measure people's level of digital skill relevant for app-based transport services based on the following self-constructed scale. Except for the first category, which will represent persons with no relevant digital skills at all, the categories will represent different levels of content-related skills. The frequency of performing activities related to the components of planning and digital payment is used in the digital skill scale consisting of four categories with the following labels:

- Level 0 – No skills at all – No access to a smartphone, so not even general medium or content-related skills have been developed.

A person in this level did not have any access to a smartphone in the past year.

- Level 1 – Low level of skills – used a smartphone but not frequently performed planning activities via an app.

A person in this level has used a smartphone in the past year.

- Level 2 – Medium level of skills – used to plan a trip using an app but less used to do digital payment activities via an app.

A person in this level has also, in addition to the above, planned a trip with either his/her own transportation or PT using an app at least *often*.

- Level 3 – High level of skills – used to do both planning and payment/reserving related activities via an app.

A person in this level has also, in addition to the above, used an app to transfer money to someone at least *often*.

Part 3 of the questionnaire covers people's intention to use various means of transport, which is asked using likert-scale questions. The respondents are asked about this intention by sketching a scenario in which they would repeat a previously executed trip when shared mobility would be present together with the existing public transport near the origin of their trip. All people that indicate to have never travelled within the boundaries of the case study in the past year will skip part 3 and proceed to part 4 of the questionnaire. For all other respondents, if they started their trip in the vicinity of the public transport stop Leyenburg, this was specifically mentioned as the location where the shared car, bicycle, and motor scooter would become permanently available at a fixed location close to the existing public transport (bus and tram). As the choice of mean of transport is often determined at the origin of the trip, people that indicated the area of Leyenburg to be the destination of their trip were provided with a slightly different scenario. Here, the created scenario described the situation where the shared modalities would be permanently available at a public transport stop near their home. The statements related to the intention to use transport were asked for a future trip from the respondent's home to their destination in the area of Leyenburg. Regarding the digital integration of the modes, it was stated that a trip could be planned, reserved, and booked using an app on a smartphone.

3.3. Data analysis

The survey resulted in N=710 usable responses for the analysis after removing the empty responses and the responses of people indicating to be younger than 18. Using these responses, various descriptive statistics are obtained for the variables that contribute to the understanding of the respondent's user characteristics, including digital skills, and the intention to use shared and public transport. To analyse the relationship between variables of intention to use a certain means of transport and the factors like the transport barriers and the user characteristics, a subset of responses is used containing N=538 cases. These cases are retained because they contained answers to at least one of the questions related to the intention to use means of transport. The study's main result will originate from an ordinal logistic regression analysis aimed to determine the influence of the independent variables of user characteristics, transport barriers, and other trip-specific factors on the dependent variables of intention to use types of transport in the multimodal transport system.

The analyses were executed using the software SPSS statistics. For the ordinal logistics regression analyses, the assumption of proportional odds is considered by using the test of parallel lines, where the assumption is upheld if the test is not significant (Liu, 2009). Additionally, the collinearity diagnostics of SPSS Statistics are used to ensure that there is no multicollinearity among the independent variables. Here, tolerance values less than 0.1 (Menard, 1995) and VIF values greater than 10 (Myers, 1990) are considered to indicate an issue of collinearity among the independent variables.

An ordinal logistic regression analysis was executed three times, once for every ordinal dependent variable listed in Table 1 that refers to people's intention of using a certain mean of transport or combining the use of shared transport with the bus or tram. For each of the analyses, the same set of independent variables is used, as presented in Table 1. The Kendall's Thau correlation values among the ordinal independent variables do not exceed $\tau = +/-.35$. Hence, none of the independent variables is omitted because of strong correlations between them. The results of the ordinal logistic regression analyses will show whether or not an independent variable is able to significantly predict the dependent variable. For each of these significant independent predictor variables, the relationship with the dependent variable is described using the b-value and the odds ratio (exp(B)) resulting from the analysis. This odds ratio is crucial for the interpretation of logistic regression (Field, 2018). With categorical predictor variables, the odds ratio represents the change in odds caused by a unit change in the predictor variable (Field, 2018). If it is greater than 1, it indicates that as the predictor increases with one step, the odds of the outcome occurring increase. The other way around, if the value is less than 1, it implies that as the predictor increases, the odds of the outcome occurring decrease.

To satisfy the requirements of the ordinal regression analysis, three dummy variables are created for the nominal variable of household composition as it contained more than two categories. The dummy variables are created for the categories of *single parent, two persons without child(ren),* and *two-parent*, with the category *single person* being the reference category. For people's current travel behaviour, three variables are extracted from the questions; one indicating if someone used a car at least weekly, one indicating if someone used public transport (train, bus, tram or metro) at least weekly, and finally, a variable indicating if someone had any experience in the past year with either the shared car, shared bicycle, or shared motor scooter. For people's level of education, the multiple-choice answers based on the Dutch education system are converted to terms of a low-, middle-, and high-level of education in accordance with the definition as used by the national statistics office CBS (2019). In addition, the people without any education have been assigned to the lowest of the three levels.

Additionally, multiple independent variables are obtained by combining the results of several questions in the questionnaire. First, using a Principal Component Analysis (PCA) and Cronbach's alpha (α) it is checked if the questions for the transport barriers related to Performance Expectancy (PE) and Effort Expectancy (EE) can be combined into their respective higher-level constructs. The PCA analysis was conducted with the four transport barriers of which two were designed to relate to PE and two relate to EE. The results showed that when two factors were retained, they represented the PE and EE constructs as designed after the initial four transport barriers were loaded onto the factors using oblique rotation (direct oblimim). The eigenvalue of factor 1 (PE) was 1.89 and that of factor 2 (EE) was 0.92. However, only for the factor PE did α

Table 1
List of variables included in the model for the ordinal logistic regression analysis.

Independent variables	Dependent variables	
Frequent Car User	Country of birth	Intention to use shared transport
Frequent PT User	Limited physical ability	Intention to use bus or tram
Shared transport experience	Household composition	Intention to combine use of shared transport with the bus or tram
Digital skills	Transport barrier (TB) – Performance Expectancy	
Frequency of trip	TB – Ease of use	
Location of trip	TB – Multiple payment methods	
Origin/destination of trip	TB – Facilities at PT stops	
Nr. of transport means used during trip	TB – Feeling safe	
Gender	TB – Travel costs	
Age	TB – Opinion of others	
Education		

support the variable's ability to describe the results of the two transport barriers related to it, with $\alpha = 0.64$. For EE, the question related to ease of use and the question related to having multiple payment methods for transport were not found to measure the construct of EE sufficiently, with $\alpha = 0.43$ supporting this. Hence, both these questions are kept as individual variables in the model for the ordinal logistic regression analysis. Secondly, the dependent variables describing people's intention to use means of transport include the results for both mobility hub scenarios used in the questionnaire. In addition, the questions related to the intention to use a shared car, shared bicycle or shared motor scooter in the mobility hub scenarios are used to construct a new variable indicating the intention to use any of these shared means of transport. The highest response on any of these three questions is transferred to the new variable which then contains the same ordinal scale of disagree, neutral, agree.

A final important note regarding the methodology is that household income is not included as an independent variable in the model because of the low number of useful responses on the related question. Only 354 out of the 538 responses for the regression analysis were useful for the income variable. A Kendall's thau correlation analysis shows a moderate and positive correlation of a person's income with the education variable (τ=.29, p<.001) for the 354 useful responses. Hence, the level of education will be used as an indicator of the level of household income to be able to consider this variable in further analyses and conclusions in line with the study's theoretical framework.

4. Results

The first two sub-sections will describe characteristics of the respondents, among which their representativeness compared to larger populations. Hereafter, the focus will be on the mobility hub scenario and the analysis of people's behavioural intention towards the use of means of transport in a multimodal transport system. This includes, in the final sub-section, the results of ordinal logistic regression analysis concerning the model as detailed in the section above.

4.1. Socio-demographic characteristics and representativeness of the sample

The socio-demographic characteristics of the respondents are explored and compared with larger populations to check the representativeness of the collected data. Table 2 provides an overview of these characteristics and the distribution of all the respondents among the different categories.

The main comparison is made between the survey's respondents and the population of the municipality of The Hague, as most of the respondents live in The Hague. The data of the population is obtained from the Municipality of The Hague (2021) and CBS (2020b), the Dutch national statistical office. As can be seen in Table 2, the data from the survey has a higher response from females (59%) compared to the almost equal distribution of males compared to females as is present in the population of The Hague. For the different age classes, a bias can be noted towards more people of age 55-74 years and fewer people of age 18-54 years compared to the population of the Hague. In addition, the respondents of the survey contain more highly educated (48.3%) and less low educated people (16.0%) compared to the general population (32.1% and 31.5%, respectively). Finally, for the household composition, the significant difference can be found in having fewer one-person households and more multiple-person households without children compared to the municipality statistics. Overall, these biases towards more female and higher educated respondents are not unexpected for a survey. In addition, the strong representation from older age categories is explained by the distribution strategy and might be caused by the hospital visitors among the respondents.

Finally, comparing the respondents from the paper questionnaire with the digital respondents based on their age and digital skills shows that there is a significant difference in characteristics. 75% of the paper respondents (N=44) are older than 65 years, where this is 20.3% for the digital respondents (N=497). For digital skills, 88.1% of the paper respondents qualified for level 0 or level 1 digital skills, whereas only 30.7% of the digital respondents have these low levels of digital skills. Based on these characteristics, a significantly different audience is reached with the two types of questionnaires.

4.2. Descriptive statistics

In addition to the socio-demographic characteristics of the respondents, other moderating variables such as the travel behaviour and digital skills are considered to possibly influence people's intention to use means of transport. The results are summarized below to gain a better understanding of the measured variables before they are discussed in the context of the regression analysis.

4.2.1. Frequencies of transport mode use

Figure 3 shows the frequencies of respondents' transport mode usage from July 2020 to July 2021. Comparing the use of public transport and the car among the respondents, 87.5% of the respondents has used the bus, tram, or metro at least once in the past year compared to 77.7% for the car. Overall, 94.8% of the people have not used a shared car in the past year.

For the regression analysis, the variables of *frequent car user* and *frequent public transport user* are applied, referring to people that use these means of transport at least once per month. From all respondents with relevant answers (N=649), 18.2% qualify as both a frequent car and public transport user. 26.2% are not a frequent car user but use public transport frequently, whereas 37.1% are a frequent car user but not a frequent user of public transport. Finally, the remaining 18.5% does not qualify for either frequently using the car or public transport. To better understand the distribution, only around a third of the frequent car users, use public transport frequently.

4.2.2. Digital skill scale

To understand the variation of digital skills among the respondents, Figure 4 shows the distribution of the respondents (N=698) among the

Table 2
Socio-demographic characteristics of the survey's respondents and corresponding percentages for the population of The Hague (Municipality of The Hague, 2021) (CBS, 2020b).

Gender	Sample Survey N=575	Population The Hague	**Household composition**	Sample Survey N=556	Population The Hague
Male	40.3%	49.8%	One person	33.9%	47.1%
Female	59.0%	50.2%	Single parent	7.3%	9.3%
Other	0.7%		Two person without children	33.7%	22.6%
Age	N=557		Two-parent	24.7%	21.0%
18-24 years	9.9%	11.5%	**Income household**	N=385	
25-34 years	17.2%	19.4%	< 25,000 euros	19.2%	
35-44 years	12.7%	18.2%	25,000-45,000 euros	45.7%	
45-54 years	16.0%	17.7%	> 45,000 euros	35.1%	
55-64 years	19.4%	14.7%	**Country of birth**	N=563	
65-74 years	17.4%	10.9%	The Netherlands	88.3%	
≥ 75 years	7.4%	7.6%	Outside of the Netherlands	11.7%	
Education level	N=574				
Low	16.0%	31.5%			
Middle	35.7%	36.4%			
High	48.3%	32.1%			

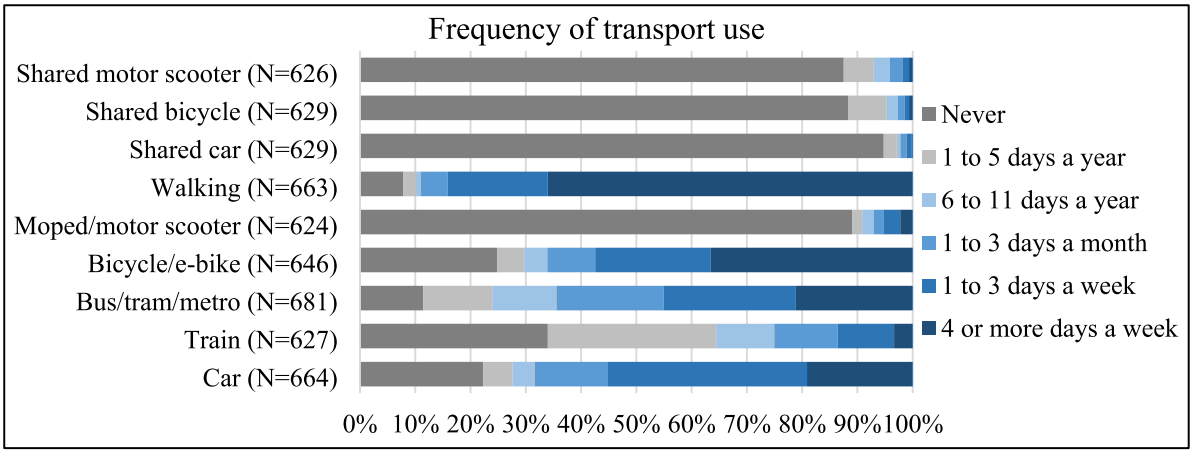

Figure 3. Frequencies (in percentage) of the respondent's use of different means of transport in the past year.

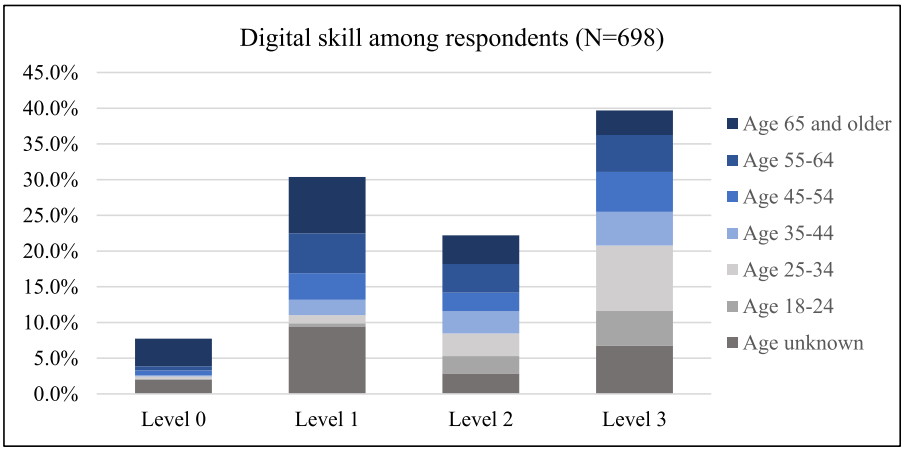

Figure 4. The distribution of the four digital skill levels (explained in section 3.2) among the respondents of the survey (N=698) and the age distributions within these levels.

four levels of digital skill as defined in section 3.2. First, 7.7% has never used a smartphone in the past year (level 0) and thus possesses no relevant digital skills for the app usage in the transport domain. Level 1 is a significantly larger group (30.4%) which represents the people that had access to a smartphone but not frequently used it for transport-related planning activities. 22.2% of the respondents have used a smartphone and used it frequently to plan a trip (level 2). The highest level of skills (level 3) is possessed by 39.7% of the respondents and they have also frequently performed payment-related activities on their smartphones in addition to the planning activities.

In the theory of digital skills, relations were noted between age, education, and a person's digital skills, among others. In this study's analysis, a significant and a moderate to relatively strong correlation is noted between the digital skill measure and people's age (τ=-.333,

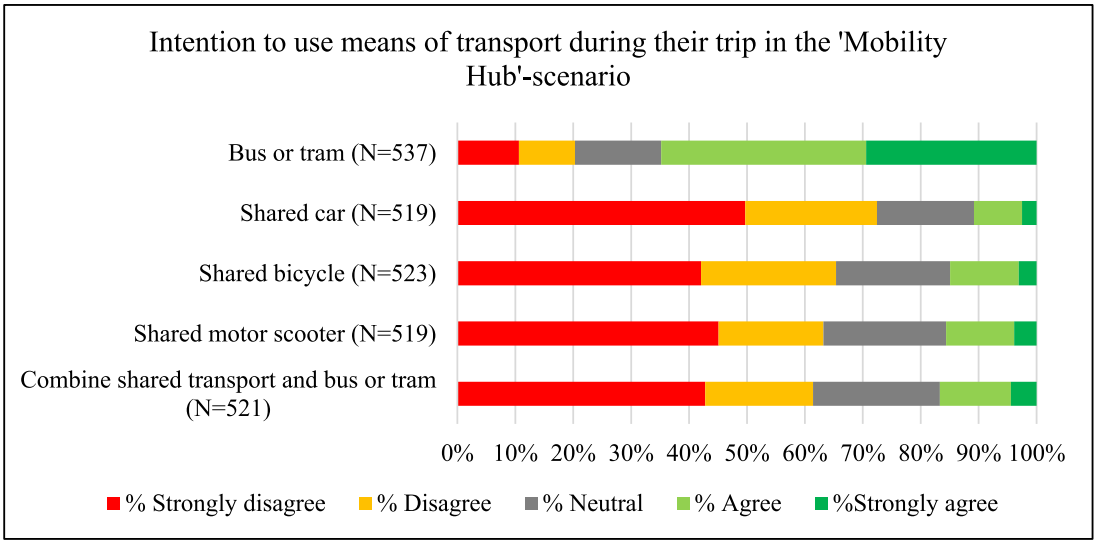

Figure 5. Response to the statement 'I want to use a … as (one of) the means of transport during this trip'.

p<.001) and a slightly more moderate correlation with people's education (τ=.193, p<.001). Among the other variables, a weak but statistically significant correlation is noted between digital skills and frequent car users (no/yes) (τ =-.089, p=.031) and frequent public transport users (τ=.098, p=.016).

4.2.3. People's intention to use means of transport and their current use

To get an understanding of the overall intention to use the various means of transport included in this study, the results for these variables will be discussed below. First, Figure 5 shows that, for all three means of shared transport, less than 20% of the survey's respondents agreed or strongly agreed with the statement that they would intend to use the shared means of transport during their most frequent made trip in the past year, if these were made available at a mobility hub nearby. Only 10.8% of the respondents intend to use the shared car compared to 15.0% for the shared bicycle and 15.7% for the shared motor scooter. Finally, the majority (64.8%) of the respondents intend to use (agree and strongly agree) the available public transport at the mobility hub during their trip.

Table 3 below, shows that people's age and level of education relate significantly to whether someone belongs to one of the two groups of people. When comparing Table 3, to the characteristics of all respondents (summarized in Table 4), it can be noted that the two groups are generally younger. Interestingly, people with no prior experience but with the intention to use shared transport have a higher distribution in the age category of 18-24 years compared to the group that has prior experience but no intention to use shared transport. The latter group consists of more people in the group 35-44 years. Based on Table 3 and Pearson Chi-square results, it can be noted that the people that do not intend to use shared transport, even though they have experience, are more likely to not use the car on a weekly basis (not frequent). The people that intend to use shared modalities, but have not used them before, show a significant relation with the number of means of transport they currently use during their trip and their digital skills.

4.2.4. Comparison of potential users of shared cars, bicycles, and motor scooters

Among the shared means of transport, the people that intend to use the shared motor scooter tend to be younger and slightly lower educated than the potential users of the shared bicycle and shared car. The correlations between age and the intention to use each of these shared modes are significant (p<.001). However, for education there is no significant correlation (Kendall's thau) between the intentions to use shared car, shared bicycle, or shared motor scooter. The distributions of people that use a car and/or public transport frequently or not differ among the three means of shared transport, see Table 4. However, only for the shared scooter (τ=.091, p=.034) and the shared car (τ=.105, p=0.016) is the correlation with current car use significant. The current public transport usage only correlates with the intention to use shared motor scooter (τ=.134, p=.002) and not with the intention to use the shared car or the shared bike. From the people that intend to use a shared motor scooter a slightly higher percentage are frequent car and frequent public transport user. Finally, the finding that people that have the intention to use a shared mean of transport are generally using more means of transport during a single trip seems to be the most apparent for the shared bicycle.

4.3. Results of ordinal regression analysis – intended use behaviour

This section will present the results of the ordinal logistics regression analysis for three dependent variables: intention to use shared transport, intention to use the bus or tram, and intention to combine the use of shared transport with the bus or tram. We note that no multicollinearity exists among the selection of variables. Further assumptions and quality of the models will be discussed for each of the analyses individually in the sections below.

4.3.1. Intention to use any means of shared transport

The results for the analysis of the model with the dependent variable 'the intention to use shared means of transport' and 21 independent variables are described below (N=423). Table 5 shows an extract of the ordinal logistic regression analysis for the dependent variable of the intention to use shared transport. Here, only the independent variables with a significant, or almost, significant relation (p<.05) are shown. As the Wald statistic and related significance can contain inaccuracies (according to Field (2018)) the likelihood ratio Chi-Square statistics are also obtained for each predictor variable as a whole. When necessary, the significance values from these results will also be highlighted. Based on these results, digital skill is a significant predictor of the intention to use shared transport, as well as the experience with shared transport. The other two variables related to travel behaviour, the frequency of car and public transport use, cannot be marked as having an influence on someone's intention to use shared transport. Hence, whether someone uses a car frequently, or means of public transport does not affect their intention to use shared transport, based on these results.

Table 3
Pearson Chi-square test results of significantly related characteristics of two different types of people regarding their previous use and intended use of shared transport.

	People without experience, but with intention to use shared transport		People with experience, but no intention to use shared transport	
	%	χ^2	%	χ^2
Age	N=71		N=41	
18-24 years	25.35%	χ^2=29.841 p<.001	14.63%	χ^2=18.126 p=.003
25-34 years	19.72%		24.39%	
35-44 years	19.72%		29.27%	
45-54 years	15.49%		12.20%	
55-64 years	11.27%		17.07%	
≥ 65 years	8.45%		2.44%	
Education level	N=72		N=42	
Low	4.17%	χ^2=9.651 p=.008	9.52%	χ^2=8.722 p=.013
Middle	33.33%		19.05%	
High	62.50%		71.43%	
Frequent car user	N=72		N=42	
No	41.67%	χ^2=0.494 p=.482	61.90%	χ^2=4.973 p=.026
Yes	58.33%		38.10%	
Nr. of transport means during TRIP	N=72		N=42	
One	56.94%	χ^2=6.759 p=.034	54.76%	χ^2=0.388 p=.824
Two	12.50%		26.19%	
Three or more	30.56%		19.05%	
Digital skill	N=72		N=42	
Level 0	1.39%	χ^2=18.894 p<.001	2.38%	χ^2=3.861 p=.277
Level 1	13.89%		23.81%	
Level 2	20.83%		19.05%	
Level 3	63.89%		54.76%	

Table 4
Percentage distribution of answers among potential user characteristics for all respondents and the three groups that intent to use three means of shared transport.

		Intent to use:		
	All respondents	Shared bicycle	Shared car	Shared motor scooter
Gender	N=575	N=75	N=56	N=81
Male	40.3%	36.0%	42.9%	35.8%
Female	59.0%	64.0%	57.1%	64.2%
Other	0.7%	0.0%	0.0%	0.0%
Age	N=557	N=75	N=55	N=81
18 -24 years	9.9%	17.3%	23.6%	25.9%
25-34 years	17.2%	33.3%	29.1%	34.6%
35-44 years	12.7%	12.0%	9.1%	16.0%
45-54 years	16.0%	12.0%	14.5%	9.9%
55-64 years	19.4%	17.3%	14.5%	11.1%
≥ 65 years	24.8%	8.0%	9.1%	2.5%
Education level	N=574	N=75	N=56	N=81
Low	16.0%	9.3%	7.1%	7.4%
Middle	35.7%	29.3%	33.9%	40.7%
High	48.3%	61.3%	58.9%	51.9%
Household composition	N=558	N=75	N=54	N=79
One person	33.9%	34.7%	29.6%	25.3%
Single parent	7.3%	8.0%	9.3%	10.1%
Together without children	33.7%	26.7%	37.0%	26.6%
Together with children	24.7%	30.7%	24.1%	36.7%
Other	0.4%	0.0%	0.0%	1.3%
Country of birth	N=563	N=75	N=55	N=81
The Netherlands	88.3%	90.7%	87.3%	92.5%
Other	11.7%	9.3%	12.7%	7.5%
Frequent car user	N=664	N=75	N=55	N=79
No	44.9%	45.3%	40.0%	40.5%
Yes	55.1%	54.7%	60.0%	59.5%
Frequent PT user	N=687	N=75	N=55	N=80
No	53.9%	45.3%	56.4%	45.0%
Yes	46.1%	54.7%	43.6%	55.0%
Experience with shared transport	N=622	N=69	N=50	N=75
No	78.3%	55.1%	62.0%	49.3%
Yes	21.7%	44.9%	38.0%	50.7%
Nr. of transport means during trip	N=573	N=78	N=56	N=81
One	55.1%	42.3%	51.8%	46.9%
Two	22.9%	17.9%	16.1%	19.8%
Three or more	22.0%	39.7%	32.1%	33.3%

Table 5
Parameter estimates of ordinal regression analysis with dependent variable: Intention to use shared transport (N=423).

	b	Std. Error	Wald	Sig.	Exp(B)	95% CI for odds ratio	
						Lower	Upper
Threshold							
[Intention to use shared transport = disagree]	-3.718	1.363	7.440	0.006	0.024	0.002	0.347
[Intention to use shared transport = neutral]	-2.349	1.356	3.003	0.083	0.095	0.007	1.341
Location							
Digital skill = level 0	-1.593	0.621	6.571	0.010	0.203	0.062	0.664
Digital skill = level 1	-0.879	0.301	8.516	0.004	0.415	0.228	0.755
Digital skill = level 2	-0.409	0.270	2.292	0.130	0.664	0.390	1.131
Digital skill = level 3	0a				1		
Experience with shared transport = No	-1.393	0.277	25.201	0.000	0.248	0.143	0.432
Experience with shared transport = Yes	0a				1		
TB - Ways of paying = not important	-1.028	0.404	6.487	0.011	0.358	0.162	0.791
TB - Ways of paying = a bit important	-0.748	0.412	3.294	0.070	0.473	0.209	1.071
TB - Ways of paying = fairly important	-0.477	0.386	1.528	0.216	0.621	0.292	1.317
TB - Ways of paying = important	-0.382	0.348	1.202	0.273	0.683	0.345	1.351
TB - Ways of paying = very important	0a				1		
Frequency of trip = 1 to 5 days a year	0.537	0.422	1.624	0.202	1.712	0.744	3.935
Frequency of trip = 6 to 11 days a year	-0.386	0.491	0.618	0.432	0.680	0.265	1.745
Frequency of trip = 1 to 3 days a month	-0.775	0.381	4.133	0.042	0.460	0.215	0.988
Frequency of trip = 1 to 3 days a week	-0.064	0.259	0.061	0.805	0.938	0.566	1.556
Frequency of trip = 4 or more days a week	0a				1		
Nr. of means of transport during trip = 1	-0.498	0.269	3.427	0.064	0.608	0.355	1.040
Nr. of means of transport during trip = 2	-0.842	0.324	6.768	0.009	0.431	0.228	0.813
Nr. of means of transport during trip = 3 or more	0a				1		
Trip origin/destination = HagaZiekenhuis	0.406	0.223	3.313	0.069	1.501	0.966	2.333
Trip origin/destination = other	0a				1		
Age class = 18-25	2.267	0.514	19.459	0.000	9.649	3.441	27.056
Age class = 25-34	1.433	0.431	11.071	0.001	4.192	1.786	9.838
Age class = 35-44	0.898	0.450	3.986	0.046	2.454	0.995	6.052
Age class = 45-54	0.781	0.439	3.156	0.076	2.183	0.908	5.245
Age class = 55-64	1.019	0.404	6.371	0.012	2.770	1.238	6.198
Age class = 65 and older	0a				1		
Education = low	-1.246	0.428	8.473	0.004	0.288	0.125	0.664
Education = middle	-0.261	0.244	1.150	0.284	0.770	0.480	1.236
Education = high	0a				1		

Only the selection of (almost) significant variables are shown.
Link function: Logit.
a. This parameter is set to zero because it is redundant.

For digital skills, the odds ratio of 0.203 for level 0, indicates that the odds of someone in level 0 to intend to use shared transport (answered agree) rather than not is 1/0.203 = 4.926 times smaller than that of someone with digital skill level 3. In the same way, with the odds ratio of 0.415 for level 1, the odds of someone with digital skill level 1 intending to use shared transport rather than not is 2.410 (1/0.415) times smaller than that of someone with level 3 digital skills. For level 2 digital skills, the prediction value with respect to level 3, is not significant.

Moreover, having prior experience with shared means of transport significantly increases the odds of intending to use shared transport in the proposed mobility hub scenario (p<.001). The odds of someone with shared transport experience intending to use shared transport again in the future (answered agree) rather than not is 4.032 (1/0.248) times larger than someone without any experience with shared transport.

Based on Table 5 it can be said that two of the four tested categories of the transport barrier about the necessity of having multiple ways to pay for public or shared transport show a significant relation based on the Wald statistic. However, the predictor as a whole, based on the Chi-Square likelihood ratio, has a significance of p=.115. The same applies to the variable of frequency of trip, even though one category shows p<.05, the overall variable seems not to have a significant prediction value to the dependent variable.

The number of means of transport used during a trip is a significant predictor to the intention to use shared transport. However, the first category shows a significance just above p=.05. From the odds ratio, the odds of someone using two means of transport during their trip being intended to use shared transport rather than not is 2.320 times smaller than that of someone using three or more means of transport during their current trip.

Finally, the age and education of a person are also determined to be significant predictors based on Table 5. For the complete variables, this is confirmed by the significance of the likelihood Chi-square ratio with for age: $\chi^2(5)=23.488$, p<0.001 and for education: $\chi^2(2)=9.234$, p=0.010. For age, the odds ratios are relatively equal for ages 35-44, and 55-64. For the younger groups, the odds ratio is large and shows the decrease in odds of intending to use shared transport rather than not as age increases.

Several independent variables from the model are not included in Table 5, as they do not have a significant role as predictor to the dependent variable of intention to use shared transport. This includes the location of the trip (whether the trip only takes place within The Hague or not), country of birth and physical ability. The latter is interesting because of the active modes of transport included in shared transportation.

4.3.2. Intention to use the bus or tram

Next, the results of the second ordinal logistic regression analysis with the dependent variable being the intention to use the bus or tram will be discussed. For this analysis, N = 424. The model's prediction ability is at a similar level as that of the previous model for the intention to use shared transport. The test of parallel lines of SPSS statistics results in p=.784, indicating that the assumption of proportional odds is met for this analysis. The results are presented in Table 6.

4.3.3. Intention to combine the use of shared transport with the bus or tram

For the last analysis, the ordinal logistic analysis was executed with the dependent variable of the intention to combine the use of shared transport with the bus or tram (N=421). The model fit is proven by

Table 6
Parameter estimates of ordinal regression analysis with dependent variable: Intention to use the bus or tam (N=424).

						95% CI for odds ratio	
	b	Std. Error	Wald	Sig.	Exp(B)	Lower	Upper
Threshold							
[Intention to use bus or tram = disagree]	-2.650	1.645	2.595	0.107	0.071	0.003	1.808
[Intention to use bus or tram = neutral]	-1.598	1.641	0.948	0.330	0.202	0.008	5.138
Location							
Digital skill = level 0	-0.353	0.595	0.353	0.552	0.702	0.225	2.193
Digital skill = level 1	-0.837	0.320	6.826	0.009	0.433	0.230	0.815
Digital skill = level 2	-0.410	0.312	1.721	0.190	0.664	0.359	1.229
Digital skill = level 3	0a				1		
Car user = non-frequent	0.560	0.266	4.427	0.035	1.750	1.031	2.971
Car user = frequent	0a				1		
PT user = non-frequent	-1.799	0.293	37.574	0.000	0.166	0.092	0.296
PT user = frequent	0a				1		
TB - Facilities PT = not - fairly important	-0.127	0.363	0.123	0.726	0.880	0.430	1.801
TB - Facilities PT = important	-0.622	0.283	4.829	0.028	0.537	0.306	0.941
TB - Facilities PT = very important	0a				1		
Frequency of trip = 1 to 5 days a year	1.588	0.494	10.334	0.001	4.893	1.909	12.546
Frequency of trip = 6 to 11 days a year	1.675	0.551	9.255	0.002	5.339	1.851	15.400
Frequency of trip = 1 to 3 days a month	1.082	0.410	6.976	0.008	2.951	1.301	6.695
Frequency of trip = 1 to 3 days a week	0.632	0.291	4.728	0.030	1.881	1.059	3.344
Frequency of trip = 4 or more days a week	0a				1		
Trip origin/destination = HagaZiekenhuis	-0.648	0.252	6.613	0.010	0.523	0.319	0.858
Trip origin/destination = other	0a				1		

Only the selection of (almost) significant variables are shown.
Link function: Logit.
a. This parameter is set to zero because it is redundant.

the Chi-Square, Pearson, and deviance statistics, and results of the R^2 measures confirm the prediction ability for the model. The final consideration is the assumption of proportional odds. The test of parallel lines indicates that this assumption is met as p=.236. Table 7 shows an extract of the analysis, containing all six independent variables that show a significance of p<.05 for at least one of their categories.

We note that only the first category, age between 18 and 25 years, has a significance below p=.05. Finally, people who currently use one or two means of transport during their trip are less intended to combine the use of shared transport with the bus or tram than people who are currently already using three or more means of transport. Hence, someone's existing experience and behaviour regarding the use of multiple means of transport during a trip is a significant predictor of their intentions to combine shared transport and the bus or tram during a trip. This effect is stronger than for the intention to use shared transport, where the b-value was smaller and the category of using a single mean of transport during a trip was not significant.

From the independent variables not included in Table 7, and thus not being a significant predictor to the dependent variable, education is considered to be interesting. From the first analysis, someone's level of education influences someone's intention to use shared transport during a trip. However, from this analysis it results that education does not have an influence if someone intents to use this shared transport together with the bus or tram during the same trip.

5. Discussion

In this section, the results will be put into perspective by discussing the implications of certain decisions made regarding the survey and the data analysis as well as the implications of the sample characteristics.

5.1. Implications of sample characteristics

The variables of age and education were both shown to affect people's intention to use shared transport. These are the variables that have shown a slightly different distribution among their categories when compared to the socio-demographic statistics of the municipality of The Hague and the neighbourhood surrounding Leyenburg. As both age and education were found to influence people's intention to use certain means of transport, the sample characteristics have implications on the study's result. An underrepresentation of younger age group has likely caused the intention to use shared transport to be lower on average in this study than it would be for the population of The Hague. On the contrary, the overrepresentation of highly educated people in this study's sample will have caused the intention to use shared transport to be higher for this sample than it will be in reality. Similar effects might be the case for people's level of digital skills based on the correlations found between digital skill and people's age and education.

The comparison of the public transport users of the sample with bus and tram users of HTM showed that the sample was underrepresented in younger public transport users. Hence, when interpreting results regarding frequent public transport users, similar cautions should be taken. This underrepresentation could have caused the percentage of public transport users who intend to use shared transport to be lower than it would in reality be for users of HTM's busses and trams. For the shared bicycle users of the study's sample, no implications are expected as only their gender differed significantly from the HTM's shared bicycle users and this variable is not found to influence people's intention to use any mean of transport.

Finally, a limitation of this study is its inability to sufficiently compare the sample with The Hague's population based on the percentage of people with a migrant background. This is caused by the fact that the variable of people's country of birth does not accurately reflect whether people have a migrant background. Hence, the study was not able to determine if people's migrant background affects people's level of digital skills and their intention to use the multimodal transport system. As Durand, Zijlstra, van Oort, Hoogendoorn-Lanser and Hoogendoorn (2021) noted a relation between ethnicity and digital skills, future research should try to better include respondent's migrant background by determining their parents' country of birth.

5.2. Consideration of case study and survey characteristics

This study provides an insight into the potential of a collective offer of existing public transport options with the included shared modalities and the characteristics of the potential users via the data collected with

Table 7
Parameter estimates of ordinal regression analysis with dependent variable: Intention to combine the use of shared transport with the bus or tram (N=421).

						95% CI for odds ratio	
	b	Std. Error	Wald	Sig.	Exp(B)	Lower	Upper
Threshold							
[Intention to combine shared transport & bus/tram = disagree]	-2.685	1.399	3.685	0.055	0.068	0.005	1.018
[Intention to combine shared transport & bus/tram = neutral]	-1.290	1.393	0.858	0.354	0.275	0.019	4.059
Location							
Digital skill = level 0	-1.339	0.691	3.757	0.053	0.262	0.068	1.015
Digital skill = level 1	-0.711	0.324	4.820	0.028	0.491	0.258	0.935
Digital skill = level 2	-0.622	0.286	4.712	0.030	0.537	0.308	0.937
Digital skill = level 3	0a				1		
Experience with shared transport = No	-1.062	0.270	15.527	0.000	0.346	0.203	0.589
Experience with shared transport = Yes	0a				1		
TB - Ways of paying = not important	-1.310	0.430	9.267	0.002	0.270	0.114	0.642
TB - Ways of paying = a bit important	-0.508	0.417	1.484	0.223	0.602	0.261	1.385
TB - Ways of paying = fairly important	-0.417	0.389	1.149	0.284	0.659	0.308	1.410
TB - Ways of paying = important	-0.293	0.343	0.730	0.393	0.746	0.376	1.482
TB - Ways of paying = very important	0a				1		
TB - Opinion of others = not important	-1.242	0.595	4.349	0.037	0.289	0.091	0.921
TB - Opinion of others = a bit important	-0.973	0.636	2.341	0.126	0.378	0.110	1.305
TB - Opinion of others = fairly important	-1.185	0.648	3.345	0.067	0.306	0.087	1.075
TB - Opinion of others = important	-0.782	0.701	1.245	0.265	0.457	0.116	1.808
TB - Opinion of others = very important	0a				1		
Nr. of means of transport during trip = 1	-0.676	0.274	6.088	0.014	0.509	0.296	0.875
Nr. of means of transport during trip = 2	-0.998	0.339	8.652	0.003	0.369	0.189	0.718
Nr. of means of transport during trip = 3 or more	0a				1		
Age class = 18-25	1.615	0.528	9.375	0.002	5.030	1.774	14.264
Age class = 25-34	0.843	0.467	3.254	0.071	2.323	0.945	5.709
Age class = 35-44	0.607	0.489	1.537	0.215	1.834	0.705	4.775
Age class = 45-54	0.432	0.476	0.824	0.364	1.540	0.614	3.865
Age class = 55-64	0.759	0.445	2.907	0.088	2.136	0.907	5.028
Age class = 65 and older	0a				1		

Only the selection of (almost) significant variables are shown.
Link function: Logit.
a. This parameter is set to zero because it is redundant.

the survey. However, the sketched integration scenario used in the survey certainly affects the relationships with the intended use behaviour found in this study. Hence, some of the results will be put into perspective. First, the integration scenario proposed in the survey emphasises the digital integration for the shared means of transport and does not specifically mention the need to plan and pay trips with the bus or the tram via an app. Therefore, the relation between digital skills and the intention to use the bus or tram, which showed a weak to almost no prediction value, is not a sufficient reflection of constraints on accessibility for people with low levels of digital skill when digitalisation increases for bus and tram transport. Further research is needed to understand if low digital skills would limit someone to take a trip with public transport if planning and paying should be done via an app.

It is interesting that the variable of trip origin or destination (whether the HagaZiekenhuis or not) affects the intention to use the bus or tram. People travelling to the HagaZiekenhuis have a lower intention to use the bus or tram. From previous research, trip motive is seen to affect mode choice, however, this has not been evaluated in this study. Nevertheless, the significance of the HagaZiekenhuis as origin or destination would imply that it is useful to further investigate the relation of trip motive with the intention to use a multimodal transport system. Going to the hospital is quite a unique trip motive in itself and, as employees of the hospital were also invited to participate in the survey, the trip motive of work could also be an underlying contribution to this significant relationship.

Another possible limitation is the effect of the COVID-19 pandemic, the related restrictions, and people's change in travel behaviour on people's perception of future transport use and their current use of transportation. The year for which respondents indicated their travel behaviour was affected by COVID-19. Hence, the noted differences between current use and intended use behaviour of the multimodal transport system could theoretically be smaller for, for example, public transport as people are using public transport less during the pandemic. For the intended use behaviour, it is uncertain to what extent people have considered the pre-COVID-19 circumstances or one of the various situations seen during the COVID-19 pandemic. Depending on the circumstances at the time, COVID-19 might also affect the conversion of intended use behaviour to actual use behaviour when a multimodal transport system is implemented.

Regarding the factors affecting people's intention to use means of transport, the importance people assigned to most of the transport barriers was not found to have a significant prediction value. The original UTAUT models from which these transport barriers were constructed are commonly used on new but existing systems or services, whereas this study evaluates a possible future scenario that is not implemented. Hence, the lack of a relation between these transport barriers' importance and the intended use of the multimodal transport system should not lead to neglecting these constructs or UTAUT models in future research. Especially not as research on this topic evolves towards more pilot-based performance assessments.

5.3. Managerial implications

For transport providers, the case study of Leyenburg has shown that the intention to use the shared bicycle and shared motor scooter are higher than the intention to use the shared car. Similar user segments as those who intend to use shared transport are intended to combine shared and public transport. Hence, offering shared bicycles and shared motor scooters at a hub thus has a higher potential as this is a larger group with similar characteristics to those who want to combine these shared modalities with public transport. In addition, the intention to use public transport at the mobility hub is higher (64.8%) compared to the

current use (57.2%) during trips to, from, or via Leyenburg. Following the analysis of the intended use behaviour, it is seen that there are significant differences in the factors affecting the intention to use shared transport or the bus or the tram. To target new users that intend to use shared transport, transport providers should consider an audience that is young and highly educated. The intention to combine the use of shared and public transport is affected by similar factors as the intention to use shared transport. This shows that as more of the potential shared transport users are captured, the group of people that wants to combine shared transport with public transport also grows. Hence, having these types of mobility hubs as recognizable places where shared transport modalities are placed such that an easy transition to public transport is possible, will facilitate the uptake of public transport. For further growth of shared modalities, the people who are older and less educated are an interesting group as they currently express a significantly lower intent to use shared mobility. Besides the consideration of digital skills, other barriers to using shared transport for these groups of people should be discovered. Regarding long-term transport policies, the people's intention to use the various means of transport supports policies related to the development of mobility hubs as a mean to promote the use of public transport.

Another managerial implication concerns the digitalization. The various levels of digital skill characterised in this paper can predict the intention of using shared transport. Helping to improve people's digital skills, especially, in the context of the transport domain, would therefore contribute to the improvement of the potential uptake of the shared modalities. In addition, it emphasises the impact of digitalisation in transport that has helped grow the interest in shared and multimodal transport on the intended use of potential user groups. For transport providers working on ways to integrate their own modalities, or potentially integrate modalities of different operators, it is recommended to consider the potential digital exclusion that can occur among existing users or potential new users. Offering different digital and non-digital options to plan and pay for trips would reduce the danger of digital exclusion. Involving the potential user in the development process of digital applications and mobility hubs could lead to a better understanding of how to deal with the various levels of digital skill. It could be useful to understand to what extent alternatives to application usage, such as dedicated machines/pillars at hubs for planning or paying, improve the intended use of transport for people with lower levels of digital skill. The latter suggestions to avoid digital exclusion also apply to future policies in this transport domain. Hence, long-term policies regarding the development of MaaS should include considerations of accessibility for people with low levels of digital skills to ensure that the benefits are more equally shared among different potential user segments. As stated for transport providers, other barriers to using shared transport and mobility hubs should be discovered in time as specific measures could be included in transport policies to ensure the accessibility of these types of transport.

6. Conclusion

In this paper, the intention to use shared and public means of transportation in a multimodal transport network was studied by means of a survey within the case study of Leyenburg, The Hague (N=710). User characteristics, among which digital skills, and transport-related characteristics were evaluated for their potential influence on people's intention to use shared transport and the bus and tram when they are physically integrated at the existing public transport stop.

When shared transport is offered at the existing public transport stop Leyenburg, 15.0% of the respondents intend to use the shared bicycle, 15.7% intend to use the shared motor scooter, and only 10.8% intend to use the shared car. Of the 131 people who intend to use any of the shared means of transport, 72 people have not used any of them in the past year. Capturing the latter group would result in an increase in shared transport usage. Of the 343 people who have no intention to use shared transport only 42 have used shared transport in the past year. From the survey, 64.8% of the respondents intend to use the bus or tram during their trip when shared transport is offered at the stop Leyenburg. This is higher than the 57.2% of people who expressed a current use of the bus, tram, or metro during their trip, indicating a potential increase in the number of bus or tram users. The results show that around a quarter of the people who do not intend to use the bus and tram when integrated with shared transport are currently using the bus, tram, or metro during their trip. However, from the larger group of people who intend to use the bus or tram (64.8%), around a quarter are currently not using it during their trip.

The study has determined several factors which influence the intended use behaviour of shared and public transport when they are integrated at a mobility hub. This supports the characterisation of people that are currently already a potential user of the different means of transport at the mobility hub and it highlights the characteristics of the people that currently have no intention to use certain means of transport. The intention to use shared transport is found to be higher for people with higher levels of digital skill, prior shared transport experience, who are younger, highly educated and those who used multiple means of transport during their trip. Largely the same characteristics are related to the intention to combine the use of shared and public transport, with only the influence of people's education not being significant for this intention. Nevertheless, in accordance with past literature, people's age and education are found to correlate to people's level of digital skills and hence education cannot be neglected as a relevant user characteristic to determine this intention. Finally, one category of the transport barrier of having multiple ways to pay for transport was significantly related to the intention to combine shared and public transport. This might imply that having multiple ways to pay for travelling with multiple of these modalities supports its potential uptake. The other transport barriers are not found to be related to people's intention to use any of the types of transport. The intention to use the bus or tram is found to be mainly related to current transport usage and trip-specific factors. The intention is higher for both people who used public transport more than once a week and people who used cars less than once a week in the past year. In addition, people who performed the trips to, from or via Leyenburg less frequent and those who did not travel to the HagaZiekenhuis had a higher intention to use the bus or tram.

With these results, this paper has contributed to the understanding of the intended use behaviour of multimodal transport systems for different user segments. Besides these user needs, the potential of integrated transport systems at hubs could also be considered in future research by studying the impact of adding or removing means of transport at a hub on the actual usage of the different transport types. This would also further contribute to transport providers' considerations regarding the benefits and costs of mobility hubs. Finally, with the use of pilot studies, future research should attempt to evaluate the actual use behaviour of both public and shared transport when these are integrated. Comparing the actual use of the means of transport with the results of this study might help understand what factors are key in the maximization of the potential uptake of transport at a mobility hub.

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