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Smart Mobility Hubs as Game Changers in Transport

WP5. Impact assessment of SmartHubs Living Labs
T5.3. Equity Assessment

Deliverable D5.3
SmartHubs Equity Assessment

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Abstract

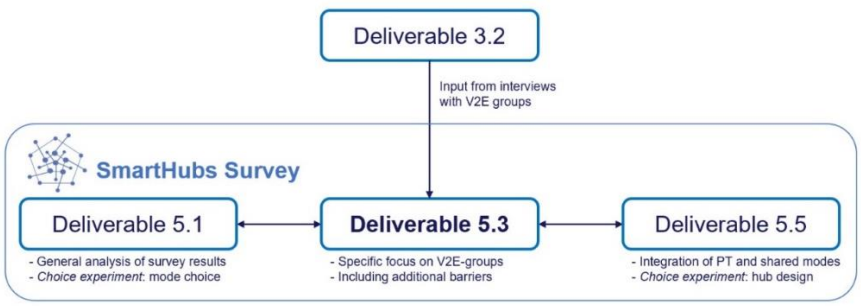
Shared modes and mobility hubs can improve access for all, but only when tailored to the needs of all potential users. This asks for an explicit focus on the specific barriers faced by vulnerable-to-exclusion groups. The SmartHubs Equity Assessment delves into the potential impact of mobility hubs on various population segments, focusing on six vulnerable-to-exclusion (V2E) groups: females, people with low digital mobility skills, low-income citizens, migrants, older people, and mobility impaired citizens. The aim of this report is to analyse *the barriers of vulnerable-to-exclusion groups to access and use shared mobility modes and preferences for other facilities potentially available at mobility hubs*. The analysis is based on a large scale survey conducted in the four living labs of the SmartHubs project (Brussels, Munich, Rotterdam-The Hague and Vienna).

The analysis reveals distinct travel behaviours among V2E-groups compared to their non-vulnerable counterparts. For instance, low-income citizens rely less on cars and more on public transport, while older people and individuals with low digital mobility skills exhibit lower usage of shared modes. Despite interest in certain shared modes like e-bikes and cars, intention to use shared modes remains relatively low among older people, digitally excluded, and mobility impaired citizens. This is due to barriers these groups are facing, ranging from safety concerns to lack of information and skills, impacting their opportunities to use shared modes provided at mobility hubs. The barriers align with preferences on hub design, where the V2E-groups emphasize a need for information provision, but a general lower interest in mobility hub design overall. Low-income and migrant groups show a higher interest in using shared modes, which is partially caused by the presence of students within these sub-samples, who generally show a larger uptake, especially for bikes, mopeds and e-scooters. If students are excluded from the low-income group, this group has a lower interest in shared mobility compared to the average sample.

Experience with shared vehicles, public transport usage, and digital mobility skills emerge as important predictors for the acceptance of mobility hubs. To make the use of shared modes at mobility hubs more interesting for vulnerable groups, more attention needs to be on their specific barriers and needs. Safety, costs, and knowledge & skills stand out as primary barriers, while needs focus on inclusive design and information provision. Emphasizing digital skills training and offering analogue alternatives for planning and booking could potentially improve the adoption of shared mobility hubs. It is important for policymakers to target V2E-groups in their participatory processes, to include their specific barriers in the physical and digital integration of the mobility hubs.

Relation to other SmartHubs deliverables

The relationship between the equity assessment (Deliverable 5.3) and other SmartHubs deliverables is visualized in the diagram below. D5.3 has an explicit focus on the pre-defined vulnerable-to-exclusion groups and analyses the survey results from the perspective of those groups. D5.1 explains the full setup and data gathering process of the survey, and focuses on the full sample of the survey, and focuses on mobility patterns, user clusters and mode choice (Gkavra et al., 2024). D5.5 has an explicit focus on the design of a hub and the willingness to pay for different hub elements (Grigolon et al., 2024). D5.3 uses input from D3.2 regarding barriers and needs of V2E-groups (Martinez et al., 2022).



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1. Introduction

Smart mobility hubs have the potential to become game-changers in urban mobility and accessibility for all citizens when the modes and services are adapted to the needs of all user groups. During the development of smart mobility hubs, it is therefore important to be aware of the barriers and preferences of different groups, especially those vulnerable-to-exclusion (for short, V2E). For these V2E groups, however, it is expected that the use of a mobility hub can be lower, due to the specific barriers they face during their daily trips. As mentioned by Geurs et al. (2024) in the SmartHubs integration ladder, taking into account the opinions and needs of those classified as vulnerable would lead to an increased use and impact of a mobility hub (Geurs et al., 2024; Martinez et al., 2022).

Therefore, to understand the impact of mobility hubs on mobility equity, this deliverable assesses the equity effect on six pre-defined V2E groups, which potentially face specific barriers when using shared modes of transport (bicycles, scooters, mopeds and cars). The assessment will include the current distribution (and intentions) of the use of shared modes and mobility hubs, as well as discuss the issues possible barriers that these groups face that might hinder their use of these modes. The equity assessment in this report is based on the SmartHubs survey conducted in four SmartHubs Living Labs; the metropolitan region of Rotterdam-The Hague, Brussels, Vienna and Lower Austria, as well as Munich.

1.1. Research objective of the equity assessment

The main goal of the equity assessment is to *examine the barriers of vulnerable-to-exclusion groups to access and use shared mobility modes and preferences for facilities potentially available at mobility hubs*. In this report, we examine six different vulnerable groups, namely: females, citizens with low digital mobility skills, low-income citizens, migrants, older people and mobility impaired people. Justification of these groups is provided in Section 4.1. For these V2E groups, the following research questions will be answered:

1. How can V2E groups be characterized in terms of socio-demographics and travel behaviour?
2. Which barriers do V2E groups face that determine their (intention to) use of shared modes at mobility hubs?
3. What determines the difference in use and preference of mobility hubs between the overall population and V2E-groups?
4. What are the preferences of V2E-groups regarding mobility hub design and services?

1.2. Structure of the deliverable

The equity assessment is structured as follows: first, the theoretical framework (Chapter 2) and methodology (Chapter 3) will be discussed. Chapter 4 discusses the V2E groups themselves and their travel behaviour and goes into depth on the characteristics of citizens with low digital mobility skills. Chapter 5 presents the current use of shared modes and hubs, and the experience barriers, while Chapter 6 focuses on the intention to travel via a mobility hub in the future. Chapter 7 focuses on the importance of different hub elements, and Chapter 8 gives a brief insight into the democratic integration of V2E-groups. A conclusion and discussion are provided in Chapter 9.

2. Theoretical framework

This section starts with defining some concepts that are used throughout this study and the SmartHubs project and ends with a brief section on related literature. This section considers the topics of shared mobility, mobility hubs and vulnerable users in the context of equity.

2.1. Definition of concepts

A (shared) **mobility hub** is a physical location where different shared transport options are offered at a dedicated, non-temporary and recognisable location, and public transport is available within walking distance (Geurs et al., 2024, p. 7). This definition focuses on the mobility and transfer components of the hub itself but a hub could offer multiple other mobility-related and non-mobility-related elements (CoMoUK, 2019). Besides the physical integration of multiple modes and services, hubs also incorporate digital and democratic integration dimensions (see Geurs et al., 2024).

The shared transport options that are offered at these mobility hubs can be defined as shared modes or **shared mobility**. These modes, generally, are used within a cities' network and the vehicles are accessible by multiple users for a variety of trip purposes (Feigon & Murphy, 2016). Within this study, shared mobility includes shared cars, (e-)bikes, cargo-bikes, e-scooters and mopeds.

As stated in the introduction of this study, it focuses on **vulnerable users**. Those are defined as individuals with structural transport difficulties, i.e., people who encounter additional barriers when using transport services. Vulnerable users may belong to a certain or multiple vulnerable-to-exclusion groups (**V2E-group**), potentially classified based on socio-demographical, economic, geographical, health-related or cultural factors (De Paepe et al., 2023; Martinez et al., 2022).

V2E-groups are the focus of this study's equity analysis, where **equity** is defined as the morally proper distribution of benefits and burdens over different members of society (Martens et al., 2019, p. 13). This definition of equity also includes some kind of moral or normative judgement to determine when a distribution is fair or equitable (Van Wee, 2022). Generally, two main categories of equity are defined: horizontal and vertical equity (Behbahani et al., 2019). The latter is considered in this study; **vertical equity** compares the distribution between groups of the population that are separated by demographic characteristics, i.e. the vulnerable groups mentioned before (Guo et al., 2020). In this report, we examine vertical equity without making an explicit normative standpoint on distributive justice that disadvantages groups should be treated with priority to increase their levels of access to mobility hub services.

2.2. Related literature

Shared mobility services, as mentioned in Section 2.1, are rising in cities across the globe, with shared micro mobility schemes present in over 50% of European cities at the start of 2023 (EIT Urban Mobility, 2023). Furthermore, the development of (shared) mobility hubs is emerging, offering both shared mobility services as well as other (non) mobility services (Geurs et al., 2024).

Shared modes and mobility hubs have the potential to improve mobility for all, and especially for vulnerable groups by, for instance, improving access to transport (De Paepe et al., 2023; Fleming, 2018). However, vulnerable groups, such as females, low-income groups, people with mobility limitations, ethnic minorities, people with lower education, and others (De Paepe et al., 2023; Di Ciommo & Shiftan, 2017; Lucas, Moore, et al., 2016; McNeil et al., 2018), are more likely to be socially excluded when these new developments in transport are not tailored to the transport and social disadvantages and needs of these specific groups (Lucas, 2012). However, current users of shared modes are generally younger, highly educated and have a higher income, emphasizing that shared modes are, at this moment, not beneficial to all (Fleming, 2018).

There is a reasonable amount of prior research on the uptake of shared mobility by vulnerable groups, primarily focusing on a potential significant difference in current use of or the intention to use shared modes between vulnerable and non-vulnerable groups, but not specifically focused on mobility hubs.

On the topic of bike-sharing systems, for instance, McNeil et al. (2018) found that low-income citizens are currently not using the systems as much as others, but are equally interested in using it in the future (McNeil et al., 2018). A similar pattern is found by Mohiuddin et al. (2023), showing that low-income citizens are less likely to use shared bikes but when they eventually adopt the system, they are more likely to use it frequently (Mohiuddin et al., 2023). In general, bike sharing systems seem a more inclusive system for older people, female, children and lower educated, since there is no significant effect of these socio-demographics (De Paepe et al., 2023). The differences in uptake between V2E-groups lies not only within the socio-economic characteristics of the citizens themselves but also in the spatial distribution of the services, where most services are not distributed equally amongst advantaged and disadvantaged neighbourhoods (Hosford & Winters, 2018).

This raises the topic of two typical ways of approaching equity: social and spatial equity, where the first focuses on targeting vulnerable-to-exclusion groups while the other emphasizes the spatial distribution of good and services (Lee et al., 2017). As stated in Section 2.1, this equity assessment focuses on social equity, following the distributive approach. From this perspective, equity has three perspectives: the benefits and burdens that are distributed, the groups over which this happens and the principle to determine if a certain distribution is just or fair (Martens et al., 2019). From this perspective, it can be determined if certain V2E-groups “stay behind” in the acceptance of shared modes and mobility hubs, comparing sub groups of the population (Guo et al., 2020).

As stated by Paepe et al. (2023), it is unclear whether different vulnerable groups are open to accepting shared modes at mobility hubs, and which barriers they face in potentially using these services to their fullest potential. This acceptability of shared modes, or the degree to which people intend to use the shared modes in the future, depends on several conditions or barriers such as the availability of the modes and resources, affordability or the travel conditions (e.g. safe, comfortable or trustworthy) (De Paepe et al., 2023; Lucas, Mattioli, et al., 2016). When these specific conditions are met, V2E-groups can show a high acceptability of shared modes (De Paepe et al., 2023). Important to note is that the needs, preferences and barriers of people are not homogeneous and interconnected. For example, proximity to shared mopeds is of little use if the mopeds are too expensive or too difficult to use (Pereira et al., 2016).

3. Methodology

This chapter will present a brief description of the SmartHubs survey, which was the main research method used to gather information on V2E groups. A full description of the survey, the data cleaning, data gathering process and sample representativeness can be found in **SmartHubs Deliverable 5.1**.

3.1. SmartHubs survey setup

The goal of the SmartHubs survey was to get more (quantitative) understanding of the current and potential use of mobility hubs, and the importance of physical and digital integration elements in hub design strategies. The survey consists of multiple parts, starting with questions on the *individual* characteristics of the respondents, e.g., residence area, socio-demographics and digital mobility skills, followed by a section on *mobility characteristics* and *mobility hubs*. Here, a distinction is made between hub familiarity and needs and preferences regarding hubs. The survey also contains two choice experiments, one on mode choice behaviour and the other on hub digital and physical elements, which are discussed in Deliverable 5.1 and Deliverable 5.5, respectively. The survey ends with a section on participation and democratic integration, ensuring that the three dimensions of the SmartHubs integration ladder (physical, digital and democratic) are included in the survey (Geurs et al., 2023). The structure of the SmartHubs survey can be found in Figure 1. The full survey is added in Appendix B.

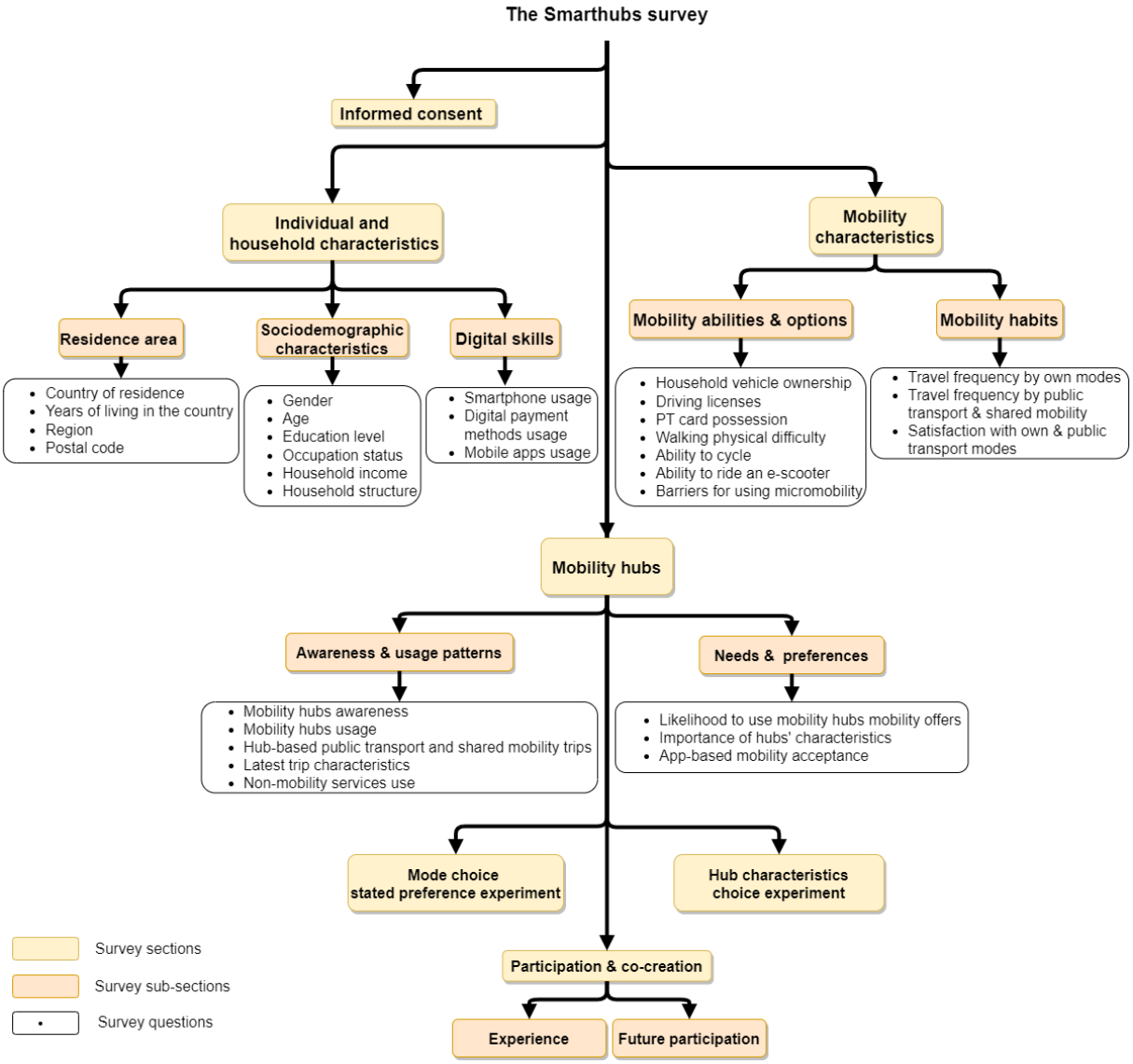

Figure 1. Structure of the SmartHubs survey.

3.2. Data collection

The study area consists of the four living labs of the SmartHubs project: the metropolitan region of Rotterdam-The Hague, Brussels, Vienna and Lower Austria, and Munich. From December 2022 to March 2023, a total of 2515 responses have been collected (number of respondents after data cleaning). Different recruitment methods were used to reach respondents. Survey panel companies were hired to select a representative sample of respondents corresponding to the focus of each of the living labs (77% of the sample). Additionally, the link to the online survey was posted on social media (LinkedIn) and shared by mobility providers through their mailing list (16%). Because our assumption was that respondents with lower digital mobility skills could face difficulties when filling in an online survey, potentially low-digitally skilled respondents were offered assistance to fill in the survey at face-to-face meetings in community centres, libraries, and other gathering places. In total, 6% of the total sample was collected using assisted surveys. Respondents who: (i) did not provide their consent to data sharing, (ii) only opened the starting page of the survey, (iii) did not have a respondent ID or (iv) did not reach the end of the survey or (v) finished the survey in under 4 minutes, were removed from the sample during the data cleaning process (which is described in Deliverable D4.2 (Kirchberger et al., 2023)).

3.3. Survey sample characteristics

Before the recruitment of respondents, minimum sample requirements (i.e. quotas) were set for certain socio-demographic characteristics to allow for an in-depth analysis of vulnerable-to-exclusion groups. To reach these quotas, the SmartHubs survey used a stratified sampling method. Additionally, the teams in the respective SmartHubs living labs used different methodologies to collect the data, as mentioned in Section 3.2. Both potentially have an impact on the sample representativity. Differences between the living lab locations regarding the V2E-groups and impact of the sample will be discussed in Section 4.3 and Appendix A, respectively. A full comparison of the survey sample characteristics with census data of the living labs is provided in Deliverable 5.1.

3.4. Data analysis

This equity analysis focuses on six pre-defined V2E groups and the characteristics of these groups, and analyses if these groups have a significantly different: (i) current travel behaviour concerning shared modes and hubs, (ii) intention to use shared modes in the future, and analyses the corresponding specific barriers these groups potentially face. To do so, statistical methods such as regression modelling and chi-square tests are used in this analysis. The analysis and application of specific methods will be explained in the corresponding sections.

4. Vulnerable-to-exclusion groups

One of the key components of equity are the social groups among which the access to shared modes and mobility hubs is distributed. These groups are differentiated based on socio-demographic characteristics, that make up subgroups of the population (Martens et al., 2019).

4.1. Vulnerable-to-exclusion groups included in this study [1]

From the full list of vulnerable-to-exclusion (V2E) groups that are considered in SmartHubs Deliverable 3.2 (Martinez et al., 2022), the present equity assessment focuses on a selection of 6 groups. Overall, travel behaviour and social-demographic characteristics differ between the subgroups of the population, which will be discussed per V2E-group in the upcoming sections. The representation of the survey sample regarding socio-demographical characteristics, and the characteristics of the six vulnerable groups can be found in Table 1. Using a chi-square test of homogeneity and adjusted z-tests, significant within subgroup differences (e.g. comparing digitally excluded citizens with digitally skilled), are indicated with an asterisk.

Important to note: there is a significant correlation between the country of residence and the vulnerable groups which could influence the outcomes of the study, as mentioned in Section 3.3. Furthermore, individual respondents can be part of multiple vulnerable groups in the analyses.

4.1.1. Low-income

Definition: Citizens with an net household income below €1600,- per month.
Sample size: N = 535

Socio-demographics

Within the group of low-income citizens, there are significantly more females compared to higher income groups. Furthermore, low-income citizens are significantly younger have a lower share of owning a driver's license and are more frequently not born in the country of residence, compared to medium/high-income groups. Regarding digital mobility skills, low-income citizens have a significant high share of low digital mobility skills (levels 0 and 1).

Travel behaviour

Regarding the travel behaviour of low-income citizens, with a chi-square test of homogeneity it was found that the distribution of current travel behaviour was not equal between low-income citizens and medium/high-income citizens for all modes. The use of the private car differs significantly ($\chi^2 = 295.19$, $p < 0.001$), with 67% of low-income citizens never using a car compared to 26% for the rest of the sample. Furthermore, the low-income citizens are more frequent users of both urban PT and the train, walk more often but are less likely to use the private bike, all compared to a medium/high-income.

4.1.2. Older people

Definition: Citizens with an age above 65 years old.
Sample size: N = 391

Socio-demographics

Older people are significantly less able to bike and have higher difficulty when walking. Furthermore, they have a lower income compared to the younger sample and have lower digital mobility skills, where over 23% of the older people can be classified as digitally excluded as well. They also have proportionally more male respondents and a higher share of people born in the current country of residence.

[1] The visualizations of the V2E-groups were adopted from the INDIMO project (INDIMO, 2022).

Travel behaviour

When comparing the older people with the rest of the sample (age below 65 years old), it was found that frequency of private car use is not significantly different between the two groups. The largest differences can be found in the use of the private bike ($\chi^2 = 34.64$, $p < 0.001$); 51% of them never uses the bike, compared to 35% for the rest of the sample. Furthermore, older persons are (significantly) less frequent users of urban public transport and the train but are more likely to use the bus, tram or metro on an incidental base (e.g. once every month) compared to people younger than 65 years old.

Table 1. Socio-demographics of the full survey sample and the six vulnerable subgroups.

Socio-demographics	Full survey sample	*Only females sample*	*Digitally excluded sample (level 0/1)*	*Low-income sample*	*Migrant sample*	*Older sample (65+ years)*	*Physical problems sample*
	N = 2515	*N = 1278*	*N = 452*	*N = 535*	*N = 534*	*N = 391*	*N = 301*
Gender							
Male	48.8%	0.0%	48.9%	44.7%*	50.9%	56.3%*	47.8%
Female	50.8%	**100.0%**	50.4%	54.8%*	48.5%	43.7%*	51.8%
Other / prefer not to say	*0.4%*	*0.0%*	*0.6%*	*0.6%*	*0.6%*	*0.0%*	*0.3%*
Age category							
18-24 years	15.5%	16.6%	11.3%*	29.5%*	21.5%*	0.0%	6.7%*
25-34 years	22.4%	23.6%	13.1%*	22.8%	31.3%*	0.0%	10.0%*
35-44 years	17.9%	17.0%	10.4%*	10.8%*	17.4%	0.0%	10.0%*
45-54 years	15.1%	15.4%	15.7%	11.2%*	13.9%	0.0%	17.7%
55-64 years	13.5%	14.0%	20.4%*	12.9%	8.6%*	0.0%	21.7%*
65-74 years	12.2%	11.2%	22.0%*	10.3%	5.4%*	**78.3%**	26.3%*
75+ years	3.4%	2.3%*	7.1%*	2.4%	1.9%*	**21.7%**	7.7%*
Income level							
< €1600,-	21.3%	22.9%*	26.5%*	**100.0%**	33.0%*	17.4%*	28.9%*
€1600,- – €4800,-	50.1%	47.8%*	43.2%*	0.0%	40.4%*	56.4%*	44.2%*
> €4800,-	13.1%	11.0%*	7.3%*	0.0%	9.2%*	6.4%*	10.6%
Prefer not to say	*15.5%*	*18.3%*	*23.0%*	*0.0%*	*17.4%*	*19.8%*	*16.3%*
Digital skill level							
Level 0 – no phone	5.7%	5.0%	**31.6%**	6.9%*	5.6%	15.6%*	14.0%*
Level 1 – no planning	12.3%	12.8%	**68.4%**	15.5%*	13.1%	17.6%*	22.9%*
Level 2 – planning	47.9%	49.8%	0.0%	42.1%*	39.3%*	56.8%*	47.8%
Level 3 – plan, book, pay	34.1%	32.4%	0.0%	35.5%	41.9%*	10.0%*	15.3%*
Years living in living lab							
Born	78.1%	79.0%	74.6%	66.2%*	0.0%	90.0%*	80.5%
Not born, over 10 years	11.3%	10.7%	15.0%*	10.8%	**53.8%**	10.0%	13.6%
Not born, 6-10 years	2.7%	2.9%	2.2%	3.0%	**12.2%**	0.0%	1.3%
Not born, 1-5 years	5.1%	4.6%	3.1%*	14.0%*	**23.2%**	0.0%	2.3%
Not born, < 1 year	2.2%	2.1%	1.8%	5.0%*	**10.2%**	0.0%	2.0%
Prefer not to say	*0.6%*	*0.6%*	*3.3%*	*0.9%*	***2.6%***	*0.0%*	*0.3%*
Physical problems walk							
Yes	12.0%	12.2%	24.6%*	16.3%*	10.9%	26.1%*	**100.0%**
No	88.0%	87.8%	75.4%*	83.7%*	89.1%	73.9%*	0.0%
Able to bike							
Yes	90.8%	88.3%*	79.0%*	88.0%*	85.2%*	81.1%*	65.1%*
No / never tried	9.2%	11.7%*	21.0%*	12.0%*	14.8%*	19.9%*	34.9%*
Owning driver's license							
Yes	81.4%	78.8%*	69.7%*	68.2%*	70.8%*	82.9%	76.4%*
No	18.6%	21.2%*	30.3%*	31.8%*	29.2%*	17.1%	23.6%*

Note: * The probability distributions were significantly not equal in the population ($p < 0.05$), comparing within the subgroup, not with the whole sample. A chi-square test of homogeneity together with a z-test comparing column proportions was used.

4.1.3. Females

Sample size: N = 1278

Socio-demographics

Compared to the sample of male, females in the sample have a significantly lower income, are less able to bike and have a proportional lower share of owning a driver's license. For all other socio-demographic characteristics, there is no significant difference.

Travel behaviour

There is a significant difference in the use of the car between the proportion of females and males (χ^2 = 9.89, p = 0.007). There is a lower share of female never using the car (35%) compared to male (38%) and a higher share of female using the private car sometimes (13% compared to 9%). Furthermore, female are less frequent bike users compared to man (χ^2 = 30.15, p < 0.001) and are less likely to walk. For the other modes, no statistically significant difference was found between females and males.

4.1.4. Mobility impairments

Definition: Citizens who have problems or difficulties related to walking
Sample: N = 301

Socio-demographics

The mobility impaired people are significantly older than the population that does not have walking difficulties, is less able to bike, has a lower average income, lower ownership of a driver's license and a lower level of digital mobility skills.

Travel behaviour

As could be expected, the group of people with walking difficulties is significantly walking less than the rest of the sample (χ^2 = 58.37, p < 0.001). However, only 15% of the people with mobility impairments does never walk (compared to 4% for the rest of the sample), and 69% walks often (compared to 82%). The group of mobility impaired people is also a less frequent user of the car and bike, with 60% of them never using the private bike at all. Furthermore, they are proportionally different in using urban PT and the train with their share of using PT being lower compared to the citizens without walking difficulties.

4.1.5. Migrants

Definition: Citizens who were not born in their current country of residence
Sample: N = 534

Socio-demographics

The vulnerable group of people not born in their country of residence is significantly younger compared to the people born in the country of residence. Furthermore, the level of digital mobility skills is higher, income is lower and the bike ability is lower for the people not born in their country of residence.

Travel behaviour

The travel behaviour of citizens not born in their country of residence, is significantly higher (compared to the rest of the sample) for the use of urban public transport (χ^2 = 65.13, p < 0.001) and the train (χ^2 = 25.54, p < 0.001), with respectively 71% and 30% often using urban PT and the train, compared to 52% and 20% for the rest of the sample. Regarding the other modes, the groups of migrants is less likely to use the car or walk and is more likely to use a taxi.

4.1.6. Low digital mobility skills

Definition: Citizens with a low (level 0 or level 1) level of digital mobility skills
Sample: N = 452

Socio-demographics
Digitally excluded citizens are significantly older, have a lower income, have more walking difficulties, are less able to bike, and have are more likely to not own a driver's license, compared to digitally skilled.

Travel behaviour
The travel behaviour of digitally excluded citizens differs significantly for a number of modes, compared to the digitally skilled. For instance, the proportion of non-users of the train is 40% for the digitally excluded compared to 14% for the digitally skilled (χ^2 = 166.27, p < 0.001). The digitally excluded citizens' use of the private car and taxi is also significantly less frequent compared to the digitally skilled. Bike use is also significantly lower, with only 21% using the bike often, compared to 41% of digitally skilled.

4.2. Factors explaining digital mobility skills

As explained in section 4.1.6., citizens with low digital mobility skills show significant differences travel behaviour. So, the level of digital mobility skills plays an important role in the ability of accessing (digital) transport services. However, digital mobility skills is not a socio-democratic characteristic which is currently measured or acknowledged in population census databases. It is therefore interesting to see if the level of digital mobility skills can be predicted by more generally collected socio-demographic data.

The digital mobility skills level is based on mobile phone and mobile application use of the respondents. The classification into the different levels of digital mobility skills is aligned with the work of Horjus et al. (2022), who determined four different levels of digital mobility skills which reflect the respondent's ability to perform tasks that are needed to use digital mobility services in the transport sector (Horjus et al., 2022). The digital mobility skills level classifications and the share of survey respondents can be found in Table 2.

Table 2. Digital mobility skills level classifications.

DS level	Classification	Respondents
Level 0	Respondent does not use a mobile phone with internet connection	5.7%
Level 1	Respondent uses a mobile phone with internet connection, but is not using trip planning applications	12.3%
Level 2	Respondent uses a mobile phone with internet connection, and uses trip planning applications (either for their own vehicle or PT, e.g., Google Maps, public transport planners)	47.9%
Level 3	Respondent uses a mobile phone with internet connection, and uses trip planning applications (for their own vehicle or PT), uses applications to *buy tickets/seat reservations* for PT, and uses applications to *transfer money*	34.1%

4.2.1. CHAID analysis

A chi-squared interaction detection (CHAID) decision tree was applied using the predictor variables below. The CHAID method is a multivariate analysis that tries to identify homogeneous groups within the variables by splitting classes (Kass, 1980). A significance level of 0.05 is used for splitting the nodes of the decision tree. The origin node starts with the filtered sample (N = 2056), where answers in certain categories (see Table 3) are dropped. The digital mobility skills level 0 and level 1 are merged, to present a larger section of the sample.

From the Kendall's tau-b correlation matrix in Table 4 (gender and occupancy are omitted since they are no ordinal or continuous variables), it becomes clear that age is significantly and fairly high correlated with the level of digital mobility skills, i.e. a lower age is related to a higher level of digital mobility skills.

Table 3. Independent variables used in the digital mobility skills CHAID analysis.

Independent variable	Type	Coding	Mean
Gender	Binary	0 = Man / 1 = Female	0.49
Age (mean based on continuous variable)	Nominal	0 = Below 25 / 1 = 25-34 / 2 = 35-44 / 3 = 45-54 / 4 = 55-64 / 5 = 65-74 / 6 = Above 74	43.15
Educational level	Nominal	0 = Compulsory education or less / 1 = High school graduate / 2 = Senior high school / 3 = University undergraduate degree / 4 = MSc/MA/PhD or equal [Dropped: 5 = Other]	2.27
Income level	Nominal	0 = < €1600 / 1 = €1601-€3200 / 2 = €3201-4800 / 3 = €4801-6400 / 4 = >€6400 / [Dropped: 5 = Do not know or do not want to say]	1.32
Occupation	Nominal	0 = Self-employed / 1 = Employed / 2 = Working in household / 3 = Student / 4 = Unemployed / 5 = Unable to work / 6 = In retirement / [Dropped: 7 = Other]	2.25
Born in country	Nominal	0 = Born / Not born, but living for: 1 = Over 10 years / 2 = 6-10 years / 3 = 1-5 years / 4 = <1 year / [Dropped: 5 = Prefer not to say]	0.41
Owning a driver's license	Binary	0 = No / 1 = Yes (car and/or motorbike)	0.83

Table 4. Kendall's tau-b correlation matrix of independent variables of CHAID analysis.

		Age	Education	Income	Born	DL	DS level
Age category	*Coeff.*	1,000	-,174**	,078**	-,184**	,050*	-,298**
	Sig.		<0.001	<0.001	<0.001	0,010	<0.001
	n.	2056	2056	2056	2056	2056	2056
Education category (Educ.)	*Coeff.*	-,174**	1,000	,218**	,117**	,114**	,209**
	Sig.	<0.001		<0.001	<0.001	<0.001	<0.001
	n.	2056	2056	2056	2056	2056	2056
Income category	*Coeff.*	,078**	,218**	1,000	-,150**	,212**	,100**
	Sig.	<0.001	<0.001		<0.001	<0.001	<0.001
	n.	2056	2056	2056	2056	2056	2056
Born in country	*Coeff.*	-,184**	,117**	-,150**	1,000	-,146**	,072**
	Sig.	<0.001	<0.001	<0.001		<0.001	<0.001
	n.	2056	2056	2056	2056	2056	2056
Driver's license (DL)	*Coeff.*	,050*	,114**	,212**	-,146**	1,000	,089**
	Sig.	0,010	<0.001	<0.001	<0.001		<0.001
	n.	2056	2056	2056	2056	2056	2056
Digital mobility skills (DS) **level**	*Coeff.*	-,298**	,209**	,100**	,072**	,089**	1,000
	Sig.	<0.001	<0.001	<0.001	<0.001	<0.001	
	n.	2056	2056	2056	2056	2056	2056

Note: ** Correlation is significant at the 0.01 level (2-tailed), * correlation is significant at the 0.05 level (2-tailed)

Results of the CHAID analysis indicate that the occupation of respondents is the main predictor of someone's digital mobility skills level. All other variables, except for the 'born in country' and 'income', seem to be significant predictors. The skills level groups are classified into 3 hierarchical levels, with a total of 20 nodes, from which 13 are terminal nodes. The tree map is shown in Figure 2 and Table 5.

At the origin node, the levels are represented as follows: 15.7% Level 0/1, 47.5% Level 2 and 36.8% Level 3. When considering the final classification in the terminal nodes, 55.5% of cases is classified correctly (risk: 0.445, std. error: 0.011), with 0.0% Level 0/1, 75.5% Level 2 and 24.5% Level 3, caused by the overrepresentation of Level 2 and 3 in the sample. However, the structure of the tree still reveals an underlying structure in the sample when it comes to digital mobility skills. There is a significant difference in the occupation of people (the splitting variable at the first level), where students show the highest percentage of high digitally skilled (Level 3: 66.7%), while people not working (i.e. in retirement, unemployed or unable to work), show the highest percentage of low digital mobility skills (Level 0/1: 33.8%).

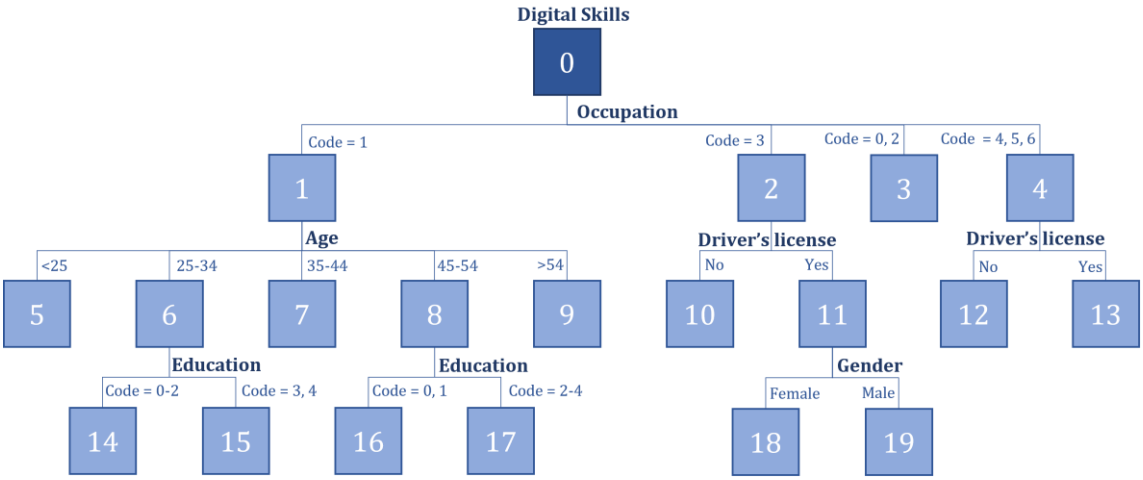

Figure 2. CHAID analysis – decision tree for predicting digital mobility skills level using socio-demographics.

Table 5. CHAID analysis statistics per node.

Node (level)	Level 0/1		Level 2		Level 3		Cat.	Primary independent variables		
	n	*%*	*n*	*%*	*n*	*%*		*Variable*	*Sig.*	*Split values*
0	321	15,6%	977	47,5%	757	36,8%	L2			
1 (1)	121	10,4%	566	48,8%	474	40,8%	L2	Occupation	<0.001	Employed
2 (1)	14	5,4%	73	28,0%	174	66,7%	L3	Occupation	<0.001	Student
3 (1)	26	16,4%	81	50,9%	52	32,7%	L2	Occupation	<0.001	Working in household; Self-employed
4 (1)	160	33,8%	257	54,2%	57	12,0%	L2	Occupation	<0.001	Unemployed; Unable to work; In retirement
5 (2)	14	13,2%	49	46,2%	43	40,6%	L2	Age	<0.001	< 25
6 (2)	24	7,0%	134	39,2%	184	53,8%	L3	Age	<0.001	25 - 34
7 (2)	22	6,9%	156	49,2%	139	43,8%	L2	Age	<0.001	35 - 44
8 (2)	29	12,9%	122	54,5%	73	32,6%	L2	Age	<0.001	45 - 54
9 (2)	32	18,6%	105	61,0%	35	20,3%	L2	Age	<0.001	> 54
10 (2)	8	10,1%	25	31,6%	46	58,2%	L3	Driver's license	0.019	No
11 (2)	6	3,3%	48	26,4%	128	70,3%	L3	Driver's license	0.019	Yes
12 (2)	46	43,8%	52	49,5%	7	6,7%	L2	Driver's license	0.005	No
13 (2)	114	30,9%	205	55,6%	50	13,6%	L2	Driver's license	0.005	Yes
14 (3)	11	11,0%	51	51,0%	38	38,0%	L2	Education level	0.001	Compulsory education; High school graduate; Senior high school
15 (3)	13	5,4%	83	34,3%	146	60,3%	L3	Education level	0.001	University undergraduate; MSc/MA/PhD or equal degree
16 (3)	16	25,4%	33	52,4%	14	22,2%	L2	Education level	0.004	Compulsory education; High school graduate;
17 (3)	13	8,1%	89	55,3%	59	36,6%	L2	Education level	0.004	Senior high school; University undergraduate; MSc/MA/PhD or equal degree
18 (3)	2	2,3%	32	37,2%	52	60,5%	L3	Gender	0.033	Female
19 (3)	4	4,2%	16	16,7%	76	79,2%	L3	Gender	0.033	Male

For both node 2 (students, relatively high digitally skilled) and node 4 (not working, relatively low digitally skilled), owning a driver's license or not is the next significant predictor, where not owning a driver's license goes hand in hand with relatively lower digital skills. This last group (not working & no driver's license) represents the highest share of Level 0/1 digital mobility skills (43.8%). The highest share of high digital mobility skills can be found in node 18 (male students with a driver's license), with 79.2% of Level 3 digital skills. Furthermore, educational level and age are also significant predictors, with a lower educational level being related with relatively lower digital mobility skills (comparing nodes 14-15, and nodes 16-17). However, it should be noted that predicting and classifying digital skills in the sample is difficult due to the overrepresentation of Level 2 in the full sample (see node 0).

4.2.2. Multinominal Logistic Regression

Due to the assumption of parallel odds not being met, a multinomial logistic regression model is fitted to the data instead of an ordinal model, losing the ordered nature of the digital mobility skills scale. The MNL model uses the low digital mobility skills (level 0/1) as the reference category. The model resulted in a McFadden pseudo-R^2 of 0.123, which is not considered as a particular high model fit. Table 6 shows the parameter estimates for the having digital mobility skills level 2 or level 3, compared to level 0/1. The significant coefficients ($p < 0.05$) are marked in bold.

In general, the gender of a person and the duration a person is living in the current country of residence are not significantly related to the digital mobility skills level. The age of a person does matter: having an age of 54 or below significantly predicted the digital mobility skills level (comparing level 0/1 and level 3). The high odds ratios show that, compared to the reference category, people of a younger age are more likely to have level 3 digital mobility skills. This effect is not present for the difference between level 0/1 and level 2, where only the age class 35-44 has a significant effect. It seems that age is predominantly different between the populations of level 0/1 and level 3.

Not owning a driver's license is related with a lower odds ratio of having digital mobility skills level 2 or level 3, compared to level 0/1. A person owning a driver's license is 1.7 and 2.1 times more likely to have level 2 or level 3, respectively. Another dominant predictor is the education level, especially showing an effect for level 3; high school graduates or lower are more likely to have lower digital skills. However, people who are currently students have significant higher odds of having digital mobility skills level 3. Overall, it can be said that people with lower education level, who are not working, have an older age and who do not own a driver's licence, have higher odds to have level 0/1. It should however be noted that the effects are not similar when comparing level 0/1 with level 2 or level 3.

It seems that the group of people having digital mobility skills level 2 is more of a mixed group, whereas there is a more striking difference between the digitally excluded population and the high digitally skilled. Table 7 shows the significant parameters for a MNL model comparing level 2 with level 3 as reference scenario. When comparing the populations of level 2 and level 3, it is found that income shows a significant difference: people with a lower income (below €4800,-) have higher odds of having level 2 skills. Furthermore, a person is more likely to have digital mobility skills level 2 (compared to level 3) when being female, not having an age below 45, with an education level of senior high school or compulsory education, and not being a student.

Based on the MNL model in Table 6, the classification of digital mobility skills per respondent is predicted. This classification is presented in Table 8. The accuracy of the MNL prediction (57.7%) is slightly higher than the prediction based on the CHAID analysis (55.5%, see Section 4.2.1) but still has a high margin of error: 12.4% of digitally excluded citizens is predicted accurately. Therefore, it can be concluded that defining digital mobility skills in general and determining digitally exclusion based on other socio-demographic characteristics is challenging based on the used dataset. Here, it should be

noted that the dataset used for the digital mobility skills level is not fully balanced, with 47.9% of respondents classifying as level 2, which could have influenced the models.

Table 6. Parameter estimates and significance of MNL model for digital mobility skills.

	Digital mobility skills Level 2				Digital mobility skills Level 3			
	B	*Std. Error*	*Sig.*	*Exp(B)*	*B*	*Std. Error*	*Sig.*	*Exp(B)*
Intercept	-0.893	0.763	0.242		**-1.745**	**0.864**	**0.043***	
Gender								
Male	-0.117	0.139	0.398	0.890	0.110	0.152	0.469	1.117
Female	0[a]				0[a]			
Age								
Below 25	0.538	0.467	0.249	1.713	**2.151**	**0.718**	**0.003****	**8.593**
25-34	0.800	0.426	0.060	2.225	**2.616**	**0.691**	**0.000****	**13.675**
35-44	**0.993**	**0.423**	**0.019***	**2.700**	**2.439**	**0.690**	**0.000****	**11.457**
45-54	0.548	0.410	0.182	1.729	**1.785**	**0.684**	**0.009****	**5.960**
55-64	0.383	0.375	0.308	1.466	0.977	0.667	0.143	2.655
65-74	0.185	0.297	0.533	1.204	0.823	0.587	0.161	2.277
Above 74	0[a]				0[a]			
Education								
Compulsory education or less	-0.412	0.256	0.107	0.662	**-0.842**	**0.290**	**0.004****	**0.431**
High school graduate	**-0.507**	**0.249**	**0.042***	**0.602**	**-0.727**	**0.275**	**0.008****	**0.484**
Senior high school	-0.129	0.230	0.574	0.879	-0.476	0.245	0.052	0.621
University undergraduate	-0.040	0.246	0.870	0.961	0.092	0.252	0.715	1.096
MSc/MA/PhD or equal	0[a]				0[a]			
Income level								
Below €1601,-	0.320	0.404	0.429	1.376	-0.501	0.401	0.212	0.606
€1601,- - €3200,-	0.604	0.389	0.120	1.830	-0.130	0.379	0.731	0.878
€3201,- - €4800,-	**0.892**	**0.404**	**0.027***	**2.440**	0.158	0.396	0.689	1.172
€4801,- - €6400,-	0.677	0.438	0.122	1.968	0.457	0.428	0.286	1.579
More than €6400,-	0[a]				0[a]			
Occupation								
Self-employed	0.156	0.378	0.680	1.168	0.521	0.477	0.275	1.684
Employed	0.484	0.300	0.106	1.623	**0.945**	**0.411**	**0.022***	**2.574**
Working in household	0.535	0.494	0.279	1.707	1.074	0.607	0.077	2.926
Student	**1.133**	**0.481**	**0.019***	**3.106**	**2.404**	**0.553**	**0.000****	**11.072**
Unemployed	-0.053	0.373	0.887	0.948	-0.426	0.526	0.418	0.653
Unable to work	-0.455	0.411	0.269	0.635	-0.185	0.568	0.745	0.831
In retirement	0[a]				0[a]			
Born in country								
Born	1.069	0.601	0.075	2.912	0.470	0.551	0.394	1.599
Not born but living >10 years	0.820	0.623	0.188	2.271	0.175	0.585	0.765	1.191
Not born but living 6-10 years	0.364	0.728	0.617	1.438	-0.095	0.686	0.890	0.909
Not born but living 1-5 years	0.579	0.676	0.392	1.784	0.418	0.621	0.501	1.519
Not born but living <1 years	0[a]				0[a]			
Driver's licence								
No	**-0.510**	**0.168**	**0.002****	**0.601**	**-0.720**	**0.197**	**0.000****	**0.487**
Yes	0[a]				0[a]			
Goodness-of-fit: -2LL (Intercept only): 2912.91, -2LL (Full model): 2403.05, McFadden Pseudo-R^2: 0.123								

Note: **, *: Significant at the 0.01 and 0.05 statistical level (both marked in bold); [a] Reference category of independent var. Reference category dependent variable = Digital mobility skills level 0 (i.e. digitally excluded); N = 2056

Table 7. Only significant parameter estimates for MNL model comparing level 2 and level 3.

	Digital mobility skills Level 2			
Only significant parameters	*B*	*Std. Error*	*Sig.*	*Exp(B)*
Gender				
Male	-0.227	0.107	0.033*	0.797
Age				
Below 25	-1.613	0.650	0.013*	0.199
25-34	-1.816	0.635	0.004**	0.163
35-44	-1.445	0.634	0.023*	0.236
Education				
Compulsory education or less	0.430	0.212	0.043*	1.537
Senior high school	0.347	0.158	0.028*	1.414
Income level				
Below €1601,-	0.820	0.281	0.003**	2.271
€1601,- - €3200,-	0.735	0.257	0.004**	2.085
€3201,- - €4800,-	0.734	0.264	0.005**	2.083
Occupation				
Student	-1.271	0.414	0.002**	0.281

Note: **, *: Significant at the 0.01 and 0.05 statistical level; Results of level 0/1 are not shown.
Reference category dependent var. = Digital mobility skills level 3; Reference cat independent var. are identical to Table 7.

Table 8. Classification on digital mobility skills per respondent based on MNL model.

		Predicted digital mobility skills level			Percentage correct
		Level 0/1	Level 2	Level 3	
Observed	Level 0/1	40	237	45	*12.4%*
	Level 2	29	709	239	*72.6%*
	Level 3	4	315	438	*57.9%*
		3.6%	*61.3%*	*35.1%*	***Accuracy: 57.7%***

4.2.3. Conclusions on digital mobility skills

The main conclusions on the analysis to predict digital mobility skills are the following:

- Based on the Kendall's tau-b correlation coefficient, age is quite highly, negatively correlated with the digital mobility skills level. Other significant correlated, ordinal variables are (in order of coefficient): educational level, income, owning a driver's license and being born in the country of residence or not. These variables are all positively correlated with digital mobility skills level.
- Note that the correlation of gender and occupation is not tested, since these variables are nominal.
- From the decision tree, it can be concluded that a respondent's occupation and age are the most significant classifiers for digital mobility skills, where student and employed respondents have higher skill levels compared to not working individuals. Also, lower age is related to higher skills.
- Based on the MNL model, high digitally skills (level 3) are related to persons with a lower age, higher education level, owning a driver's license and being employed or studying.
- There is a high contrast between low and high digitally skilled, whilst the differences between level 0/1 and level 2 are less clear.
- Digital mobility skills are not accurately predicted based on the seven socio-demographic variables that are considered in this research. This firstly implies that other factors determining digital mobility skills may play a role. For example, literature on digital mobility skills also indicate that literacy and numeracy is related to digital mobility skills (Non et al., 2021) which have not been measured in the SmartHubs survey. Secondly, it implies that digital mobility skills need to be measured using a separate metric, such as the digital mobility skills scale used in this project, to examine the role of digital skills in travel behaviour patterns, and shared mobility use, in particular.

4.3. V2E-groups in the SmartHubs living labs

Within this report, the dataset of the SmartHubs survey is treated as one sample. However, it is expected that there are differences between the sub-samples of the different living labs due to differences in sampling size, sampling methods and population. These will be discussed in this section.

4.3.1. Differences between the living labs for V2E-groups

As stated before in Section 4.1, there are some significant differences between the four living labs where the survey responses have been gathered. Table 9 shows the proportion of the vulnerable groups per living lab, showcasing that the share of vulnerable groups differs (from the average percentage) for all living labs. There is not a single living lab causing this significant difference for every group, however, the German living lab has the most different sample compared to the others, which might be caused by the used sampling method (as described in Section 3) or the local context of the living lab.

Appendix A further discusses the impact of the differences in samples between the living labs, focusing on the influence of students on the migrant and low-income groups.

Table 9. Comparison of vulnerable group proportions per living lab.

	Low-income	Older people	Females	Mobility impairments	Migrants	Low digital mobility skills
Living Lab						
Average	*25.2%*	*15.6%*	*51.0%*	*12.0%*	*21.4%*	*18.0%*
Eastern Austria	22.1%	11.9%	52.0%	9.8%	13.3%	12.8%
Brussels	26.6%	14.7%	47.3%	17.1%	30.3%	29.5%
Munich	36.4%	5.5%	48.4%	5.9%	31.9%	11.8%
MRDH	18.3%	25.6%	54.7%	13.8%	14.0%	17.4%
Statistics						
N	2126	2513	2506	2515	2491	2515
Chi-square	50.313**	109.318**	9.391*	38.926**	110.606**	78.217**
Cramer's V	0.154	0.209	0.061	0.124	0.211	0.176

Note: ** Correlation is significant at the 0.01 level, * correlation is significant at the 0.05 level

4.4. Conclusions on the classification of vulnerable-to-exclusion groups

Chapter 4 discussed the classification of the six vulnerable-to-exclusion groups considered in this report. Furthermore, the socio-demographic factors that could predict digital mobility skills are modelled and the difference between the SmartHubs living labs have been explained. The most important conclusions of the chapter are as follows:

Key points of Chapter 4

- Vulnerable-to-exclusion groups are not homogeneous: there is overlap between the groups, making some individuals even more vulnerable for exclusion and leading to potentially different barriers and needs. However, there are also differences within a group, showing the difficulty of considering vulnerable-to-exclusion groups as one.
- Low-income citizens are less frequent car users and more frequent users of public transport. Older people are typically infrequent public transport users.
- Digital exclusion is correlated with a higher age, lower level of education, not owning a driver's license and being unemployed or retired. Still, predicting the level of digital mobility skills based on socio-demographic characteristics is difficult.

5. Use & barriers of shared vehicles and mobility hubs

The current use of and familiarity with shared mobility services and mobility hubs of the vulnerable groups is important to consider for the sake of equity. Current use states the benchmark of current interest of and access to these services, to define the differences in persons' means of transport (Martens et al., 2019). Therefore, this chapter will discuss the current use of shared modes and barriers for using the modes at mobility hubs.

5.1. Current use of shared vehicles of vulnerable groups

The current use of shared bike, e-scooter, moped and car is reported by each survey respondent. This section will discuss the frequency of current use for the different vulnerable groups and the relation between socio-demographic characteristics and the current use of shared modes.

5.1.1. Frequency of current use

The frequency of current shared mode use is grouped to three classes based on the five-point scale as used in the survey (i.e., *Never* = Never, *Sometimes* = 1-11 days per year or 1-3 days per month, *Frequent* = 1-3 days per week or 4 or more days per week). Figure 3 to Figure 6 show the frequency of shared mode use for the full sample, as well as the six vulnerable groups. From these figures, a couple of V2E-groups stand out. The majority of older people does not use a shared vehicle during daily trips, whereas the moped is the least used vehicle with 99% of elderly not using it. Interestingly, the group of mobility impaired people has an above average share of non-users but also an above average of frequent users (e.g., 12% of mobility impaired people uses the e-scooter compared to 7% of the full sample).

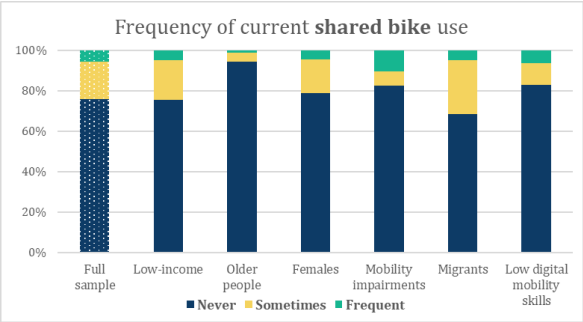

Figure 3. Frequency of current shared bike use

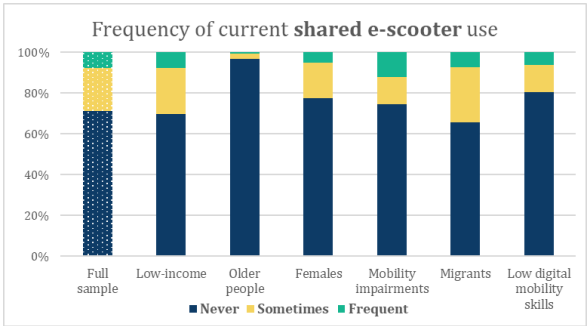

Figure 4. Frequency of current shared e-scooter use
(Note: Dutch data is neglected due to absence of the e-scooter in the living lab)

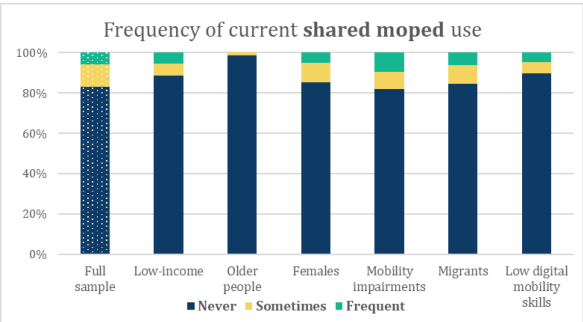

Figure 5. Frequency of current shared moped use

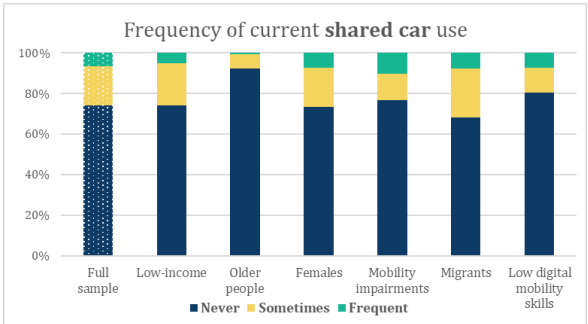

Figure 6. Frequency of current shared car use

People who are not born in the living lab location (i.e., classified as migrants in this study) have an above average use of the shared bike (27%) and shared e-scooter (27%) when it comes to occasional use, compared to the full sample (18% and 21%, respectively). The digitally excluded citizens have a lower use of all shared modes, especially for the shared e-scooter. The current use of females and low-income groups is not very different from that of the full sample. An exception is the use of the e-

scooter, where people with a low-income and females have a lower frequency of using compared to the full sample.

5.1.2. Users and non-users of shared vehicles

In this section, someone is seen as a shared vehicle user when he/she has used the shared vehicle at least once in the past year. The proportion of shared vehicle users has been depicted in Figure 7. What stands out is the pattern of use that can be seen for multiple groups: the shared car is mostly used, followed by the bike, e-scooter and moped, respectively. This pattern is different for people with mobility impairments (i.e., walking difficulties) who prefer to use the seated and motorized shared moped and car. Comparing the use for migrants shows a higher use for all modes, compared to the full sample, except for the shared moped.

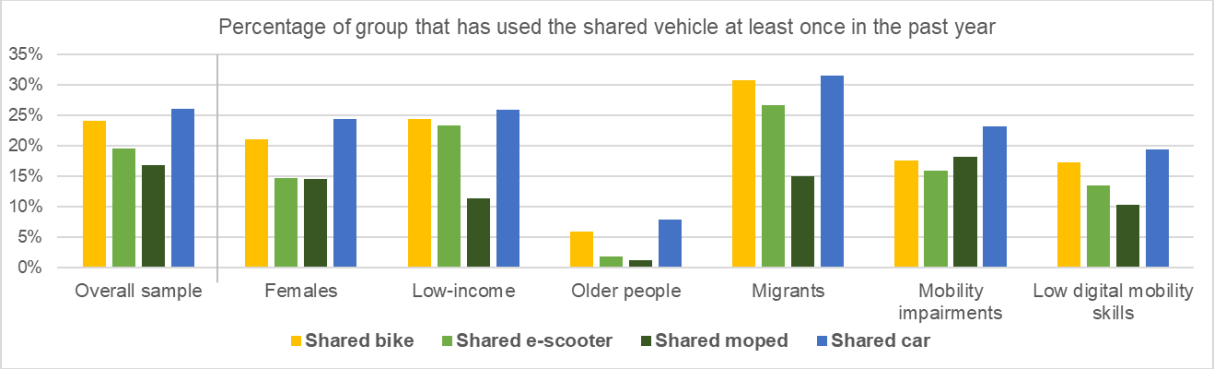

Figure 7. Percentage of sample that has used a shared vehicle at least once during the past year

A Pearson chi-square test of independence is used to determine if the socio-demographic variables (that are used to determine vulnerable groups in Section 4) differ significantly between the group of users and non-users of shared mobility. Users of shared mobility are categorized as such when they have used one or more types of shared vehicles during the past year (Users: 44.2%, Non-users: 55.8%). The results presented in Table 10 show that for all considered socio-demographical categories, there is a significant difference between users and non-users of shared modes.

Table 10. Chi-square test of independence of socio-demographics and shared vehicle use

Variable	N	Pearson Chi-square	df.	Cramer's V	Sig.
Gender⁺	2506	15.571	1	0.079	<0.001**
Age category⁺	2515	462.356	6	0.429	<0.001**
Income category⁺	2126	28.055	4	0.115	<0.001**
Education category	2454	131.720	4	0.232	<0.001**
Living category⁺	2491	56.738	4	0.151	<0.001**
Digital mobility skills level⁺	2515	200.393	3	0.282	<0.001**
Walking difficulty⁺	2515	26.952	1	0.104	<0.001**
Driver's license	2515	21.879	1	0.093	<0.001**
Occupation	2498	270.995	6	0.329	<0.001**

Note: ⁺ These variables are used to determine vulnerability (see Section 4), other variables are added for completeness.
Note: ** Correlation is significant at the 0.01 level (2-tailed), * correlation is significant at the 0.05 level (2-tailed)

The effect size of the relationship between the variable and the use of shared modes is depicted by Cramer's V (0-1). A short description of the relationship per vulnerable groups will be made below:

- **Gender**. Although the relationship is significant, the effect size is not that high. Overall, males show a relatively higher use of shared vehicles compared to females with 45.9% and 40.3%, respectively.
- **Age**. The effect size is the highest, when comparing with all other variables. The difference between users and non-users is specially significant for the lower and higher age classifications.

- **Income**. Income has a significant effect, due to the difference between users and non-users for higher income groups; 69.0% of people with the highest income (>€6401) have ever used a shared vehicle. Interestingly, the use of shared vehicles is not significantly lower for low-income groups.
- **Migrants**. People not born in the living lab, have a higher chance of using shared vehicles. Especially the groups not born, but living between 1 and 10 years have an increased probability of using a shared vehicle, with 69.1% using a shared vehicle.
- **Digital mobility skills.** After age category, the digital mobility skills level has a high effect size, where people with a higher skills level are more likely to have used a shared vehicle in the past.
- **Walking difficulty.** The effect size of waking difficulty is not very high but has a positive correlation, where people without difficulties are using shared modes more, with 46.1% of them using a shared vehicle, compared to 30.2% for respondents with walking difficulties.

5.2. Barriers of vulnerable groups for using shared modes

The non-users of shared modes were asked which barriers they faced to using the four shared modes included in the survey. They could select one or multiple from the pre-determined barriers or state their own. The four different modes will be discussed in the sections below, the shares of respondents in Table 11-14 are based only on the respondents who did respond to one or more barriers.

5.2.1. Barriers for using a shared (e-)bike

The 76% (N = 1906) of the sample who never used a shared bike or e-bike have been asked which barriers they face for not using the bikes. In general, 54.8% of non-users state they prefer their own vehicle and 15% states using the shared bike is too expensive or cannot fulfil their travel needs (15.2%).

Table 11 shows the percentage of respondents who chose each barrier for the V2E-groups. Digitally excluded, low-income and migrant groups show a significant lower share of *'I prefer my own vehicle*' and have an increased share of other barriers. This illustrates the presence of specific barriers for these groups, for instance: lower trust, less knowledge, and more safety concerns. Older citizens show an increased habit of using their own vehicle in combination with safety concerns as well.

Table 11. Barriers for using the shared (e-)bike.

Barriers for using the shared ***bike/e-bike***	Female		Low digital mobility skills		Low-income level		Migrants		Older people		Mobility impair-ments	
	no (%)	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*
I have never heard of it	6.8	7.8	**6.4**	**12.4**	6.5	8.3	**6.5**	**11.4**	7.7	5.8	7.3	7.7
It is too expensive	**17.5**	**12.7**	14.6	17.1	**13.2**	**21.5**	15.5	12.7	**16.6**	**7.5**	15.0	15.5
I have to walk too far	13.1	12.9	13.6	9.5	**14.7**	**9.7**	13.0	12.7	**14.1**	**7.5**	12.7	15.5
It is too dangerous	**5.8**	**8.5**	**6.3**	**12.0**	7.1	9.4	7.4	6.7	**6.5**	**10.9**	6.9	10.6
I do not trust shared vehicles	7.8	6.4	**6.4**	**10.2**	7.3	5.9	7.2	6.4	7.1	6.8	6.9	9.2
I do not know how to use it	3.8	5.4	4.2	6.5	**3.1**	**8.8**	**3.8**	**8.4**	4.4	5.8	4.7	3.5
Cannot fulfil my travel needs	16.0	14.4	15.0	16.4	15.7	15.3	14.8	17.1	14.7	17.7	15.7	9.9
Disappointed experience	2.8	2.1	2.8	0.7	2.6	2.9	2.2	3.7	3.0	0.0	2.6	1.4
I prefer my own vehicle	56.2	53.6	**57.1**	**43.3**	**58.8**	**41.6**	**58.4**	**38.5**	**52.9**	**63.6**	54.9	54.2
Other	6.3	8.1	**6.5**	**10.9**	**6.1**	**9.7**	**6.2**	**12.0**	7.7	5.1	7.1	8.5

Note: Numbers in **bold** show a significant difference between the V2E-group and non-V2E-group ($p < 0.05$, Chi-square test); Colours show if the V2E-group scores significant lower ( ) or higher ( ) than the non-V2E-group.

5.2.2. Barriers for using a shared e-scooter

The non-users of shared e-scooters (71% of the sample) show a wider range of barriers compared to the other shared modes. The most mentioned barrier is *'It does not fulfil my travel needs*' (31.1%), safety issues (29.5%) and preference of using their own vehicle (29%).

It can be seen in Table 12 that also for the V2E-groups, the reasons for not using the shared e-scooter are more extended. Having to walk too far to reach the vehicle is, interestingly, less of a barrier for digitally excluded, low-income and older persons. Safety concerns, missing knowledge are increased barriers for females. 27% of low-income citizens state that the e-scooters are too expensive, which means that the e-scooter has the highest costs barrier of the four vehicles for this specific group.

Table 12. Barriers for using the shared e-scooter.

Barriers for using the shared ***e-scooter***	Female		Low digital mobility skills		Low-income level		Migrants		Older people		Mobility impair-ments	
	no (%)	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*
I have never heard of it	5.4	7.2	6.2	8.3	5.4	8.4	6.1	8.0	6.8	4.2	6.0	13.1
It is too expensive	22.0	19.7	21.6	16.5	**16.2**	**27.2**	21.1	19.8	**23.0**	**6.7**	20.9	19.7
I have to walk too far	16.3	14.3	**16.4**	**8.3**	**18.1**	**10.9**	15.8	12.8	**16.3**	**8.4**	15.5	11.5
It is too dangerous	**26.3**	**32.9**	29.2	31.6	31.1	26.7	30.6	25.7	28.8	34.5	30.1	21.3
I do not trust shared vehicles	12.0	9.4	10.5	11.3	**11.3**	**5.0**	10.7	10.2	10.7	10.1	10.6	11.5
I do not know how to use it	**10.7**	**20.4**	15.1	18.8	15.3	18.8	15.1	17.6	15.7	15.1	15.5	18.0
Cannot fulfil my travel needs	33.8	28.4	31.5	28.6	32.3	32.2	31.5	29.4	**29.0**	**44.5**	31.6	24.6
Disappointed experience	3.6	1.6	2.5	3.0	3.1	2.0	2.0	4.8	2.6	2.5	2.8	0.0
I prefer my own vehicle	**33.3**	**25.1**	29.2	27.8	30.7	23.8	**31.0**	**21.4**	28.3	33.6	28.7	32.8
Other	**8.2**	**13.2**	10.9	9.8	10.4	11.4	11.2	9.1	11.5	5.9	10.8	9.8

Note: Numbers in **bold** show a significant difference between the V2E-group and non-V2E-group ($p < 0.05$, Chi-square test); Colours show if the V2E-group scores significant lower ( ) or higher ( ) than the non-V2E-group. Dutch data is ignored.

5.2.3. Barriers for using a shared moped

83% of the respondents have never used a shared moped, and 63% states that preferring the use of their own vehicle to be the reason for this. As opposed to the shared bike, there is again an increase in the user-knowledge barrier, with 17% mentioning not knowing how to use the shared moped.

Digitally excluded citizens have significantly increased safety issues regarding the shared mopeds (28% compared to 9%, see Table 13). Furthermore, older people have a couple of increased barriers, including safety concern and not knowing how to use the vehicle. These barriers seem to have a stronger impact on the digitally excluded and mobility impaired people as well.

Table 13. Barriers for using the shared moped.

Barriers for using the shared ***moped***	Female		Low digital mobility skills		Low-income level		Migrants		Older people		Mobility impair-ments	
	no (%)	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*
I have never heard of it	3.8	2.8	3.0	4.5	3.0	3.3	2.3	9.7	4.9	0.0	3.8	0.0
It is too expensive	14.6	16.7	16.8	11.2	18.5	15.0	**16.4**	**11.3**	20.1	6.6	16.7	10.1
I have to walk too far	7.5	6.1	7.0	5.6	**8.7**	**3.3**	7.3	3.2	7.8	4.6	6.9	5.8
It is too dangerous	**8.5**	**15.9**	**8.6**	**28.1**	10.7	16.7	**13.1**	**8.1**	**10.4**	**16.6**	**10.8**	**21.7**
I do not trust shared vehicles	8.9	8.1	9.2	5.6	8.1	8.3	8.6	8.1	9.4	6.6	9.0	5.8
I do not know how to use it	15.5	18.7	16.8	19.1	18.1	18.3	17.4	16.1	**16.6**	**18.5**	**16.2**	**23.2**
Cannot fulfil my travel needs	16.9	11.0	14.3	11.2	15.8	10.0	13.4	16.1	**13.3**	**14.6**	14.4	10.1
Disappointed experience	1.4	0.4	1.1	0.0	0.7	3.3	1.0	0.0	1.0	0.7	0.8	1.4
I prefer my own vehicle	66.7	60.2	**65.7**	**52.8**	**64.1**	**51.7**	**65.5**	**48.4**	**59.4**	**70.9**	63.1	63.8
Other	4.7	7.3	5.1	10.1	4.4	11.7	5.0	12.9	6.5	5.3	5.6	8.7

Note: Numbers in **bold** show a significant difference between the V2E-group and non-V2E-group ($p < 0.05$, Chi-square test); Colours show if the V2E-group scores significant lower ( ) or higher ( ) than the non-V2E-group.

5.2.4. Barriers for using a shared car

74% of people have never used a shared car. 57% of them indicated that they prefer to use their own vehicle, 23% states that the shared car is too expensive and approximately 15% think they have to walk to far to reach the car.

Table 14 shows the barriers for the V2E-groups specifically, with the significant differences highlighted. Mobility impaired citizens do not have other barriers than the full sample, while the other V2E-groups show differences. For instance, cost is a large barrier for low-income citizens, while older people feel that the shared car cannot fulfil their travel needs: they prefer to use their own vehicle. Interestingly, the cost barrier is decreased for female and digitally excluded, who have an increased barrier for not knowing how to use it.

Table 14. Barriers for using the shared car.

Barriers for using the shared ***car***	Female		Low digital mobility skills		Low-income level		Migrants		Older people		Mobility impair-ments	
	no (%)	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*	*no (%)*	*yes (%)*
I have never heard of it	6.2	6.9	**5.6**	**11.2**	5.8	7.8	**5.8**	**9.8**	**7.8**	**1.7**	6.5	6.7
It is too expensive	**25.4**	**20.6**	**24.5**	**15.5**	**20.6**	**32.3**	22.4	25.5	**25.7**	**12.0**	23.3	20.0
I have to walk too far	14.9	15.5	**16.1**	**10.8**	**17.2**	**11.7**	15.9	11.8	15.9	12.4	15.1	15.8
It is too dangerous	**1.8**	**3.8**	2.6	3.6	2.3	3.9	2.7	3.1	2.9	2.3	2.8	3.0
I do not trust shared vehicles	9.4	9.7	8.9	12.4	9.5	11.3	9.7	8.6	9.3	10.4	9.5	9.7
I do not know how to use it	**4.0**	**7.0**	**4.8**	**9.6**	5.5	8.2	5.1	8.2	5.5	6.4	5.4	7.3
Cannot fulfil my travel needs	17.0	14.3	16.0	13.5	15.7	16.0	14.8	19.2	**14.4**	**20.1**	15.6	15.2
Disappointed experience	1.9	0.8	1.6	0.0	1.3	1.2	1.3	1.6	1.5	0.7	1.5	0.6
I prefer my own vehicle	59.2	56.3	58.7	52.2	**62.1**	**38.1**	**61.0**	**41.6**	**54.5**	**69.9**	57.5	58.8
Other	**6.6**	**10.5**	**7.9**	**12.0**	**7.2**	**14.8**	8.2	10.2	9.2	6.0	8.0	12.7

Note: Numbers in **bold** show a significant difference between the V2E-group and non-V2E-group ($p < 0.05$, Chi-square test); Colours show if the V2E-group scores significant lower ( ) or higher ( ) than the non-V2E-group.

5.3. Familiarity and current use of mobility hubs

The familiarity of mobility hubs is questioned using the '*Have you ever seen a mobility hub during a daily trip*' statement, and the use with the '*Have you used a mode of transport at a mobility hub during the last year*' statement. The answer categories 'No' and 'I am not sure' are classified as a negative response, 'Yes' as a positive response. The share of V2E-groups and their counterparts answering positive to the statements is shown in Figure 8.

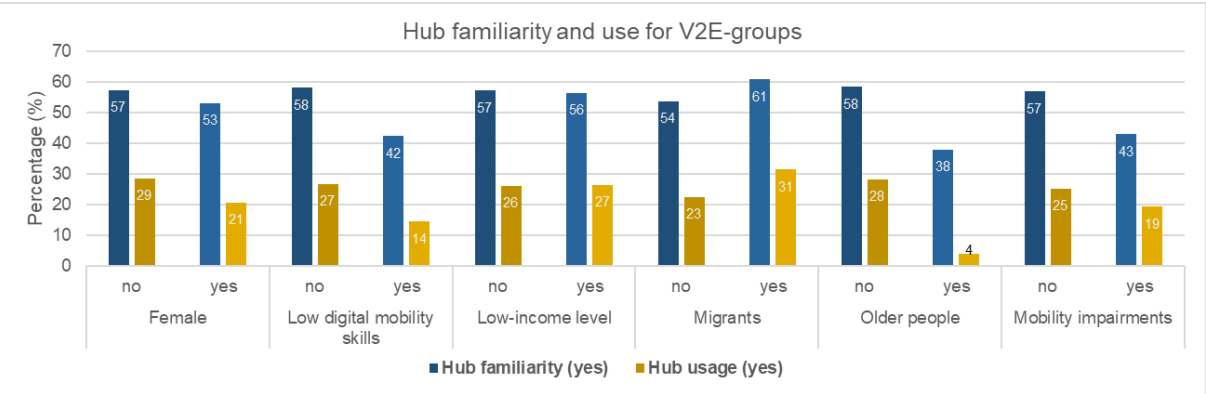

Figure 8. Hub familiarity and current hub use of V2E-groups.

Each group is more familiar with the concept of mobility hubs compared to their personal use. Still, there is a large share, especially for some V2E-groups, that has never seen a mobility hub (ranging from 39% to 62% of respondents). Use of a mobility hub is higher for the low-income (26.5%) and migrant

groups (31.3%) compared to the full sample, of which 24.5% has travelled via a mobility hub. For all other V2E-groups, the use of the mobility hub is lower, ranging from 20.7% for female to only 4.1% for elderly. Most of the digitally excluded citizens has never used mobility hub: only 14.4% of them said they did, compared to 26.7% of people with digital mobility skills level 2 or 3. It seems that people with low digital mobility skills or walking difficulties or elderly, are less likely to travel via a hub using any mode, be it PT or shared vehicles. On average, the V2E-groups have a 7%-point lower use of mobility hubs compared to the non V2E-groups.

Almost all socio-demographics determining the vulnerable groups are significantly different for the familiarity and use of mobility hubs (using a Chi-square test with significance level 0.05). Interestingly, there is not a significant difference between low- and higher-income groups. However, the use and familiarity with mobility hubs is significantly lower (14.9% has used a mobility hub, N = 389) for people who preferred not to share their income level (χ^2 = 22.84, p < 0.001). This indicates that this could be a specific group of people with a lower use of mobility hubs.

5.3.1. Factors related to the current use of mobility hubs

To determine the effect of socio-demographics and some mobility related characteristics on the current use of hubs, a binomial logistic regression was performed with current use of the mobility hub (reference category = *no*) as the dependent variable. The model is statistically significant ($\chi^2(23)$ = 402.65, p < 0.001) and explains 26% (Nagelkerke R^2) of the variance in hub use, correctly classifying 76% of the cases. The parameter results of the model can be seen in Table 15. Checking correlations between the included independent variables show a maximum Kendall's tau-b of 0.334. It should be noted that variables related to the frequency of shared mode use are left out of the model, since there is a very high correlation between current use of a shared vehicle and the use of mobility hubs (Kendall's tau-b = 0.410, p < .001). It goes without saying that currently using shared modes positively influences the use of hubs.

Quite some factors appear to have a significant effect on the current use of mobility hubs. When focusing on the socio-demographic factors that determine the V2E-groups, *age*, *gender*, *income level*, and *digital mobility skills* all show a significant effect on the current use of mobility hubs. Being a female significantly decreases the odds of using mobility hubs, with females being 1.76 times less likely to travel at a mobility hub. Considering income level, there is a significant effect of both the low-income and high-income classes. People with a high income (> €4800,- per month) are 1.71 times more likely to use a mobility hub, compared to the low-income group. The same effect holds for the digital skill level: digitally excluded citizens are 1.73 times less likely to travel via a hub.

The odds of travelling via a mobility hub increase heavily when a person is a frequent user of public transport. Often using the metro, tram or bus increases the likelihood of using a hub 3.77 times. Car ownership does not have a significant effect on hub use. The occupation does have a significant effect, and all other occupations compared to being in retirement show a positive association (although not always significant).

Interestingly, being a student is not associated with a significant difference in the likelihood, although 37% of students has travelled via a hub compared to 4% of people currently retired. This can be caused by the fact that this student population is already explained by other variables, such as the age, frequency of PT use or income category. Another interesting finding is that walking difficulty shows a positive sign, while people with mobility impairments show a lower use of mobility hubs (see Figure 7). Presumably, the variance caused by the walking difficulty variable is also explained by other variables such as the occupation and use of public transport.

Table 15. Parameter estimates and significance of BLR model for current mobility hub use.

Variables	*B*	*Std. Error*	*Wald*	*Sig.*	*Exp(B)*	*CI lower bound*	*CI upper bound*
Constant	-1.284	0.615	4.363	0.037	0.277		
Age	**-0.043**	**0.006**	**59.622**	**<0.001****	**0.957**	**0.947**	**0.968**
Gender							
Male	0[a]						
Female	**-0.567**	**0.113**	**25.121**	**<0.001****	**0.567**	**0.454**	**0.708**
Education							
Compulsory education or less	0[a]						
High school graduate	0.025	0.250	0.010	0.920	1.025	0.628	1.673
Senior high school	-0.007	0.215	0.001	0.973	0.993	0.652	1.512
University undergraduate	0.120	0.216	0.309	0.578	1.128	0.738	1.724
MSc/MA/PhD or equal	**0.599**	**0.221**	**7.366**	**0.007****	**1.821**	**1.181**	**2.807**
Occupation							
Self-employed	**1.454**	**0.392**	**13.775**	**<0.001****	**4.280**	**1.986**	**9.224**
Employed	**0.773**	**0.349**	**4.912**	**0.027***	**2.167**	**1.094**	**4.295**
Working in household	0.836	0.533	2.459	0.117	2.306	0.811	6.555
Student	0.368	0.415	0.788	0.375	1.445	0.641	3.259
Unemployed	**0.967**	**0.413**	**5.486**	**0.019***	**2.631**	**1.171**	**5.911**
Unable to work	**1.008**	**0.484**	**4.342**	**0.037***	**2.739**	**1.062**	**7.068**
In retirement	0[a]						
Born in country							
Born	0[a]						
Not born but living >10 years	0.004	0.184	0.001	0.982	1.004	0.700	1.441
Not born but living <10 years	-0.068	0.184	0.138	0.711	0.934	0.651	1.340
Walking difficulty							
No	0[a]						
Yes	**0.553**	**0.206**	**7.221**	**0.007****	**1.739**	**1.162**	**2.604**
Car ownership							
No	0[a]						
1 car available	-0.052	0.135	0.151	0.697	0.949	0.729	1.236
>1 car available	-0.244	0.186	1.718	0.190	0.783	0.544	1.129
Frequency of PT use							
Never	0[a]						
Sometimes	**0.729**	**0.336**	**4.717**	**0.030***	**2.074**	**1.074**	**4.005**
Often	**1.327**	**0.331**	**16.104**	**<0.001****	**3.769**	**1.971**	**7.205**
Digital mobility skills level							
Level 0/1	0[a]						
Level 2	-0.165	0.198	0.691	0.406	0.848	0.576	1.250
Level 3	**0.551**	**0.201**	**7.519**	**0.006****	**1.734**	**1.170**	**2.571**
Income category							
Low	0[a]						
Medium	0.071	0.160	0.199	0.655	1.074	0.785	1.470
High	**0.537**	**0.204**	**6.953**	**0.008****	**1.711**	**1.148**	**2.552**

Note: **, *: Significant at the 0.01 and 0.05 statistical level (both marked in bold); [a] Reference category of independent var.; Reference category dependent variable: Mobility hub use = yes ; N = 2055; Nagelkerke R^2: .260

5.4. Barriers of vulnerable groups for the use of mobility hubs

A full analysis of the needs and preferences of V2E-groups can be found in ***Deliverable 3.2***

In the context of the SmartHubs project, a study of the vulnerable groups concerning mobility hubs was conducted as part of the Deliverable 3.2, Needs of users and digitally excluded citizens (Martinez et al., 2022). Through this qualitative study, the main vulnerable groups in the context of mobility hubs were identified, considering their relevance as (potential) users, and their types of needs. The findings of the qualitative research in D3.2 further explain many of the quantitative findings in terms of acceptance, uptake and use of mobility hubs, and offer possible explanations to the associations found in the survey analyses. Barriers and needs based on D3.2 will be discussed in this section.

The barriers are grouped into five categories, which are related to the five categories included in the survey on hub design (see Chapter 7). From Deliverable 3.2 and Section 5.2, it can be concluded that V2E-groups face specific barriers on safety and security, pricing and costs, and knowledge/skills and information on using the systems (Martinez et al., 2022). The barriers faced by the V2E-groups on the use of mobility hubs in Table 16 are coded based on these three barriers.

5.4.1. Barriers for the use of shared mobility

The barriers of V2E-groups on the use of shared mobility at hubs show the largest diversity among the three coded categories. Digitally excluded citizens' barriers primarily relate to lack of knowledge or digital mobility skills, which is mentioned by 9.6-19.1% of digital excluded citizens in the survey (Section 5.2). The barriers of low-income groups primarily focus on pricing and lack of economic resources, which is in line with the expectation for this V2E-group. The barriers are more diverse for the other four V2E-groups, something that was also found in the survey results (Section 5.2). These groups have barriers for using the shared mode that originate from different causes, emphasizing the various specific barriers of the V2E-groups for using shared mobility at hubs.

Table 16. Barriers for the use of mobility hub elements for V2E-groups.

V2E-groups	Shared mobility	Non-mobility services	Spatial design	Information (physical and digital)	Digital services
Low digital mobility skills	1. Lack of knowledge about the services and/or how to use them 2. Online booking and/or purchase as only option 3. Requirement of smartphone and/or digital mobility skills to use the services 4. Requirement of credit card to use the service	1. Online booking and/or purchase as only option 2. Requirement of smartphone and/or digital mobility skills to use the services 3. Requirement of credit card to use the service	1. Lack of people/staff to get support from	1. Information (only) provided by digital means 2. Complex display of information, texts and signage	1. Lack of own digital device 2. Lack of internet connection (at home or mobile) 3. Lack of digital mobility skills 4. Fear of mistakes and scams 5. Lack of human support
Low-income citizens	1. Lack of economic resources to pay for the service 2. Lack of a bank account and/or credit card to use the service 3. Inconvenient subscription and/or pricing system	1. Lack of economic resources to pay the service 2. Lack of bank account and/or credit card to pay the service		1. Limited proficiency of the local language	1. Lack of own digital device 2. Lack of internet connection (at home or mobile)
Migrants and ethnic minorities	1. Lack of economic resources to pay for the service 2. Lack of a credit card to use the service 3. Lack of knowledge about the services and/or how to use them 4. Inconvenient subscription and/or pricing system	1. Lack of economic resources to pay for the service 2. Lack of a credit card to use the service	1. Lack of people/staff to get support from	1. Limited or lack of local language literacy 2. Information (only) provided by digital means 3. Complex display of information, texts and signage 4. Audio announcements that are difficult to understand	1. Lack of own digital device 2. Lack of internet connection (at home or mobile) 3. Lack of digital mobility skills

Table 16 continued. Barriers for the use of mobility hub elements for V2E-groups.

V2E-groups	Shared mobility	Non-mobility services	Spatial design	Information (physical and digital)	Digital services
Older people	1. Limited income: preference for cheaper options 2. Lack of knowledge about the services and/or how to use them 3. Inconvenient subscription and/or pricing system 4. Limited physical ability preventing the use of certain modes 5. Requirement of smartphone and/or digital mobility skills to use the services 6. Fear for personal safety 7. Mistrust of the service and its reliability	1. Physical obstacles and lack of adaptation (universal design) 2. Fear for personal security	1. Lack of people/staff to get support from 2. Difficult access to facilities and vehicles 3. Long distances between modes and services 4. Mobility hub located far from home	1. Information (only) provided by digital means 2. Complex display of information, texts and signage	1. Lack of own digital device 2. Lack of internet connection (at home or mobile) 3. Lack of digital mobility skills and motivation to acquire them 4. Fear of mistakes and scams 5. Lack of human support
People with mobility impair-ments	1. Inconvenient subscription or pricing system 2. Fear for personal safety 3. Lack of information, promotion and training to use the service. 4. Limited physical ability preventing the use of certain modes 5. Feeling of uncertainty and insecurity 6. Requirement of smartphone to use the services 7. Lack of adaptation of services to people with impairments (visual and/or hearing)	1. Physical obstacles and lack of adaptation (universal design) 2. Fear for personal security	1. Lack of people/staff to get support from 2. Difficult access to facilities and vehicles 3. Long distances between modes services 4. Mobility hub located far from home 5. Complex distribution of spaces and services 6. Crowding 7. Unsupportive behaviour from staff and/or users	1. Lack of available information about the trip (changes, disruption…) 2. Information (only) provided by digital means 3. Complex display of information, texts and signage	1. Fear of mistakes and scams 2. Interfaces adapted to people with visual or hearing impairments 3. Lack of integration in a single app
Females	1. Inconvenient subscription or pricing system 2. Lack of integrated ticketing 3. Fear for personal safety 4. Mistrust of the service and its reliability 5. Lack of information, promotion and training to use the service. 6. Reduced usability and comfort of the vehicles 7. Requirement of smartphone to use the services	1. Fear for personal security	1. Lack of people/staff to get support from 2. Physical obstacles, when carrying groceries or with children 3. Mobility hub located far from home 4. Unpleasant design, lighting, cleanliness		1. Fear for misuse of personal data

Note: The table presents results of the qualitative research of D3.2 (workshops & interviews), reorganized to correspond with the mobility hub design elements. Barriers without a coding are not related to one of the three main barriers considered.

5.4.2. Barriers for using different mobility hub elements

From Section 5.3, it can be concluded that females, low digital mobility skilled, older people and low-income citizens have a significantly lower use of modes at a mobility hub. This might be caused by the barriers they face when using or trying to use the modes and services at the mobility hub, as presented in Table 16.

The specific barriers faced by females are primarily related to safety and security, such as the *fear of personal safety* and *unpleasant design* and barrier related to information and the related *lack of assistance*. These types of barriers are also crucial for people with mobility impairments; their barriers are primarily related to safety and security as well, specifically the *lack of adaptation* of the spatial design of the hub. A mobility hub should provide this, by providing an inclusive design, adapted to these safety and security needs (Martinez et al., 2022).

Older people, people with mobility impairments and migrants indicate to have specific barriers with a certain knowledge gap or lack of information on the use of (digital) services. As stated before in Section 4.1., older people, digitally excluded and people with walking difficulties are less frequent users of public transport, and thus less informed in using relevant applications, the PT network or how to use the mobility system in general. These groups potentially lack certain skills or cannot understand the information provided, for instance due to limited literacy. So, a mobility hub should provide simple information on its services and the surroundings, presented in a clear way. Assistance by someone present at the hub is also highlighted as a way of overcoming these knowledge and skill barriers.

Additionally, the V2E-groups face barriers due to the digitalisation of the services at mobility hubs. It is becoming essential to be able to have some level of digital mobility skills to use these services, which is an specific barrier faced by digitally excluded citizens but is also mentioned by older people and migrants. As stated by Martinez et al. (2022), people would benefit from training or on-site assistance on how to use these (digital) services, to motivate and encourage them to keep using these systems.

All in all, from both Section 5.3 and 5.4, it can be concluded that V2E-groups have a lower chance of using services at mobility hubs, primarily caused by a lack of knowledge and skills on how to use the (digital) mobility services, and the absence of safe and inclusive design.

5.5. Conclusions on mobility hub use & barriers for V2E groups

Chapter 5 discussed the current use of shared modes and mobility hubs, and the barriers related to non-using shared modes in current travel behaviour. Additionally, barriers and needs for the use of mobility hubs were identified. The most important lessons learned from Chapter 5 are discussed below:

Key points of Chapter 5

- All socio-demographic characteristics related to the classification of V2E-groups show a significant difference in the current use of shared vehicles. This emphasizes the importance of determining the potential user group when developing a hub location, as the composition of this group influences the use.
- Of the V2E-groups, older people and digitally excluded citizens have the lowest use of shared vehicles. The barriers of the V2E-groups for the use are more diverse. Digitally excluded have a higher share of not feeling safe or not having knowledge on the use, while older people prefer their using their own vehicle.

- The odds of travelling using a mobility hub are influenced by the frequency of PT use, occupation, age, income level, digital mobility skills, gender and educational level.
- V2E-groups also show specific barriers on the use of mobility and non-mobility services at hub, primarily related to safety, economic resources and lack of information, knowledge and skills.

6. Intention to use mobility hubs in the future

Chapter 6 focuses on the potential uptake of shared mobility at mobility hubs by the V2E-groups and the importance of different hub elements that might influence this uptake. This is important, as emphasized by Paepe et al. (2023), since it is not particularly clear if different vulnerable groups are open to accepting shared modes at mobility hubs, and which barriers they face in potentially using these services to their fullest potential.

6.1. Intention to use shared vehicles at mobility hubs

Respondents' intention to use a shared vehicle at a mobility hub was measured with six different Likert-scale questions: "*How likely is it that you will use the modes below in case they are present at mobility hubs in your area in the future?*", with an answer ranging from very unlikely (1) to very likely (5). This question has been answered for six shared modes: car, e-scooter, bike, e-bike, cargo bike and moped.

6.1.1. Categorization of the intention to use shared modes

Based on the Likert-scale questions, a final potential use-score is computed using five modes (excluding the shared e-scooter, since it is not available for the Dutch sample), with a final score ranging from a maximum of 25 (very likely) to a minimum of 5 (very unlikely) (using a summation of the Likert-scores).

The respondents have been categorized into four categories, based on their final potential use-scores. These categories are based on Rogers' Diffusion of Innovations (DOI) theory, in which he describes the distribution of a new innovation within the population. He argues that there are five adopter categories, based on their innovativeness. These five categories are based on a normal distribution of the population, resulting in: (I, 2.5%) innovators, (II, 13.5%) early adopters, (III, 34%) early majority, (IV, 34%) late majority and (V, 16%) laggards. Innovators are very willing to adopt and try new technologies, whiles laggards are sceptical and very late with adopting (Rogers, 2003).

The classification of the potential use-scores using the DOI theory is performed similarly by Bösehans et al. (2023) in a study of shared electric mobility hubs, who performed a similar classification based on the intention to use e-bikes and e-cars at electric mobility hubs, to distinguish between potential early and late adopters of these modes (Bösehans et al., 2023). Although the DOI theory focuses more on the time-scale of adoption, the theory can be used to distinguish the sample based on the distribution. A SmartHubs classification of positive-negative intention is used to refer to the classes.

Table 17 shows the shares of respondents per classification. Due to the limited amount of score frequencies and the high share of score 5.0 (i.e. 23.1% of the sample stated to be very unlikely to use all of the five vehicles), dividing the SmartHubs sample exactly following the DOI percentages was not possible. The categorization is made to fit the DOI shares as accurate as possible.

Table 17. Adopter categories shares based on potential use of shared vehicle scores

SmartHubs classification	DOI Categories	DOI share	SmartHubs sample	Percentage	Average score
Positive	Innovators / early adopters	16%	371	14.8%	19.4 [17.0 – 25.0]
Positive/neutral	Early majority	34%	863	34.3%	13.6 [11.0 – 16.0]
Negative/neutral	Late majority	34%	697	27.7%	8.3 [6.0 – 10.0]
Negative	Laggards	16%	582	23.1%	5.0

Based on the classification of Rogers (2003) and Bösehans et al. (2023), the V2E-groups are classified accordingly (Table 18). From both the classification and mean potential use-score, three V2E-groups stand out. People with low digital mobility skills, older people and mobility impaired people all have a significantly skewed distribution amongst the SmartHubs classification, with a higher share of negative intention and a corresponding lower potential use-score.

Table 18. Adopter categories classification per V2E-group

SmartHubs classification	Overall	Low-income	Older people	Females	Physical impair.	Migrants	Digital excluded
Positive	14.8%	15.1%	3.1%[a]	12.9%[a]	12.6%	19.7%[a]	10.8%[a]
Positive/neutral	34.3%	34.8%	14.2%[a]	33.7%	21.9%[a]	40.1%[a]	24.6%[a]
Negative/neutral	27.7%	28.6%	33.8%[a]	28.6%	27.9%	23.6%[a]	22.8%[a]
Negative	23.1%	21.5%	48.9%[a]	24.8%[a]	37.5%[a]	16.7%[a]	41.8%[a]
Mean potential use-score	10.98	11.00	7.60	10.72	9.65	11.96	9.35
Significant difference χ^2-test [b]	-	0.886	<0.001	0.016	<0.001	<0.001	<0.001

Notes: [a] Based on adjusted z-scores, there is a significant difference between the persons belonging to the V2E-group and the non-V2E-group. [b] The Chi-square test determines if there is a significant difference between the V2E-group and the remaining sample, and does not compare the V2E-groups to the full, overall sample.

Low-income citizens and migrants – probably caused by their high share of students – show an increased percentage of a positive intention, although this is only significant for the migrant group. The results of this analysis show that the V2E-groups of low digital skilled, older people and mobility impaired people have a negative attitude towards shared modes and need support in the uptake of these mobility services.

6.1.2. Future use of shared modes at mobility hubs

Based on the intention to use a shared vehicle, the potential of shared modes can be determined for the full sample, as well as the V2E-groups. This is presented in Figure 9 for all six shared modes separately. From Figure 9, it can be noted that overall, the respondents are dominantly positive about potentially using a shared e-bike or bike, followed by the shared car, the other motorized two-wheelers and the cargo bike. Especially older people, digitally excluded and mobility impaired people have a lower intention to use shared modes in the future, compared to the full sample.

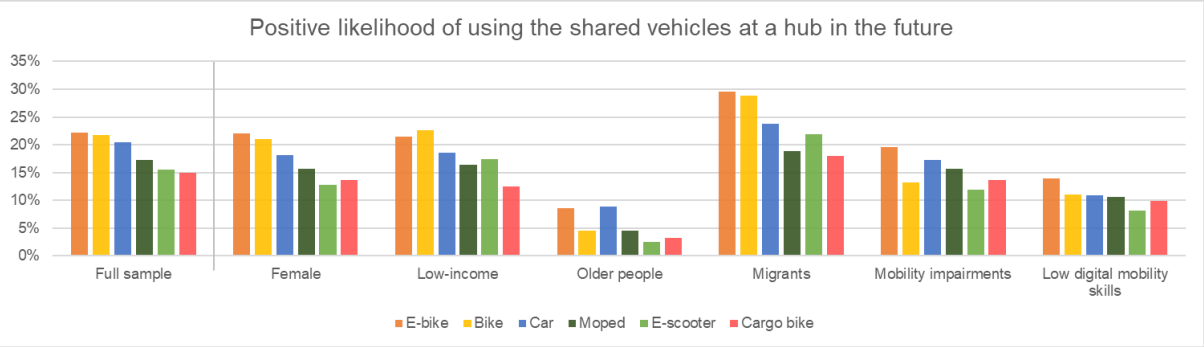

Figure 9. Positive likelihood of using a shared vehicle at a mobility hub in the future for the different vulnerable groups.

The V2E-groups show a different behaviour in terms of intention or preference of vehicles compared to the full sample. Some noticeable differences are listed here:

- Females are generally more interested in using the cargo-bike, compared to other modes.
- Low-income groups are more interested in using the bike (compared to the e-bike) and e-scooter (compared to the moped), which might be caused by the lower costs of these services.
- Respondents with a walking difficulty are relatively more positive about sitting, motorized vehicles, such as the e-bike (compared to the normal bike), moped (compared to the e-scooter) and car.
- Older people are mostly positive about the car and e-bike, which is comparable to the respondents with a difficulty of walking.
- People living in the living lab location but who are not born there (migrants), are relatively more enthusiastic about using the e-scooter (which could be related to the fact that this variable is correlated and dependent on the high degree of students, see Section 6.1.3).

6.1.3. Intention to use for migrants and low-income groups considering students

As stated before in Section 4.3.1 and elaborated in Appendix A, the presence of a large group of students has impact on the results for the migrants and low-income V2E-groups. In the overall sample, 13% of respondents is a student, but in the migrant and low-income groups, this increases to 28% and 34%, respectively. Figure 10 and Figure 11 show the positive likelihood to use the shared vehicles in the future, just as Figure 9, including a two categories that different students and non-students.

Figure 10 illustrates that the high intention to use shared vehicles among the low-income group is influenced by the proportion of students in the sample. Low-income, non-students have a significantly lower intention to use shared vehicles compared to the students, and their intention is also lower than the average for the entire sample. Students have an especially high likelihood for the use of the shared bike, moped and e-scooter, compared to non-students with a low-income. For the students, who are generally younger as well, the shared bike, moped and e-scooter are thus the most promising modes.

In the case of the migrant sample, as depicted in Figure 11, the impact of students is less prominent. Even without the student population, the migrants group has a comparable or slightly higher intention to use shared modes compared to the full sample. Differences are the intention to use the shared e-scooter, where student have a much higher likelihood of using, and the intention to use the car, which is higher among non-student migrants.

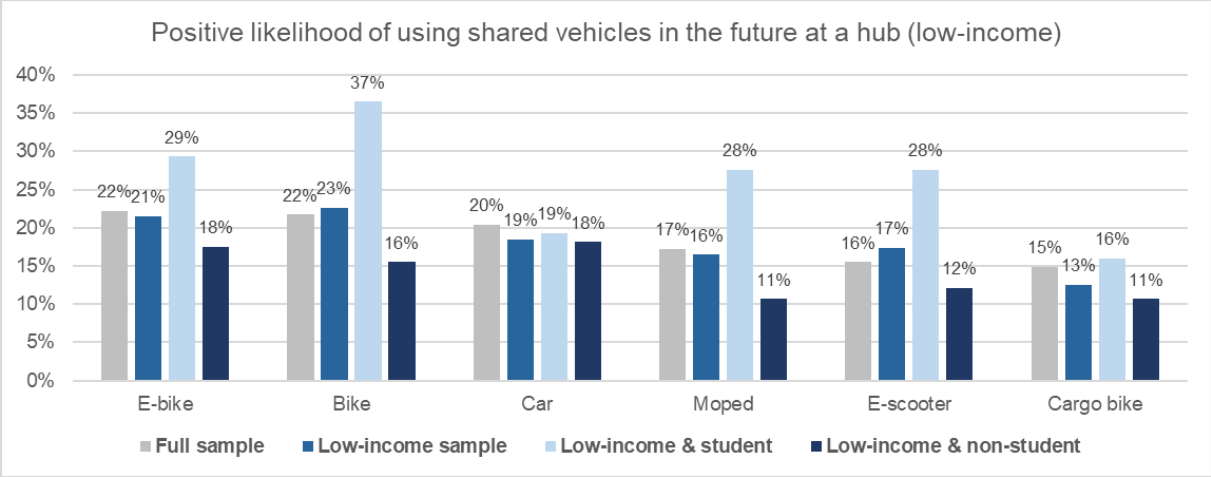

Figure 10. Positive likelihood of using a shared vehicle at a mobility hub in the future for low-income groups.

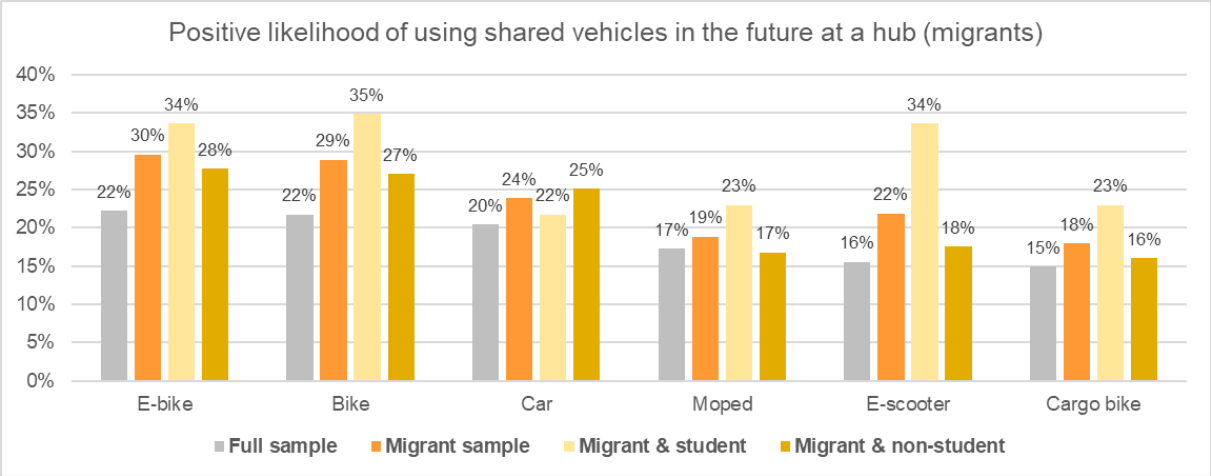

Figure 11. Positive likelihood of using a shared vehicle at a mobility hub in the future for migrant groups.

6.2. Comparison of current use and intention to use modes at mobility hubs

About 24% of all respondents did travel via a mobility hub during the past year, using either PT or shared modes. For the V2E-groups that are considered, this percentage is higher for low-income groups and respondents not born in their respective living lab, while for all other groups it is lower.

When looking into the difference between the current use of mobility hubs (% of the group that has used a mode of transport at the hub in the past year), and the potential future use, per shared mode (% of the groups that is positive (i.e. likely or very likely) to use the mode at a hub in the future), there are some interesting findings. Generally, a decrease in use can be seen, i.e. people are less willing to use shared modes in the future, compared to their current use. It should be noted here that current use includes the use shared modes in, for instance, a free-floating model as well. However, it can still be noted that the potential of using shared modes at a hub is not particularly high.

6.2.1. Current shared vehicle use compared to potential future use

Figure 12 compares the difference between the share of current users of a specific shared mode and the share of respondents who are positive about using the shared mode at a hub in the future. The figure shows the potential of the shared vehicles, as well as the possible influence of the vehicles being parked at a mobility hub on the uptake.

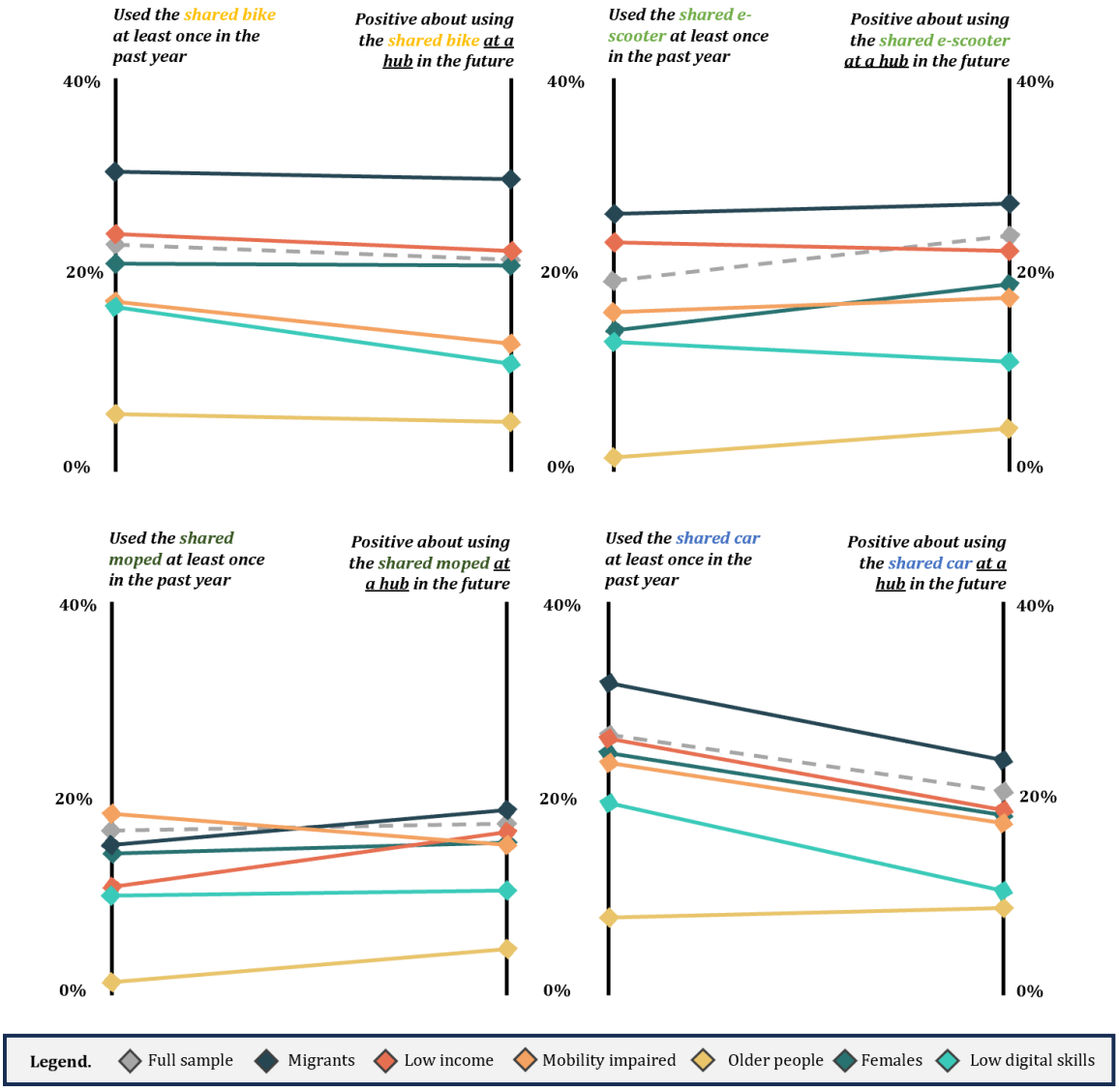

Figure 12. Comparing current use of shared vehicles with the intention to use them at a hub.

The addition of the mobility hub to the question, does not have a positive effect on the uptake of the shared vehicle. For the shared bike, the intention to use it at a hub is similar to the current use, with a slightly declined intention for persons with a walking difficulty and lower digital mobility skills. The shared e-scooter and shared moped show a bit more potential, i.e. for these modes there is an increase for the full sample on the intention to use it. In general, the uptake for the shared moped is lower compared to the other modes. Interestingly, there is quite an increase between current use and intention to use for the walking difficulty and migrant group. The shared e-scooter is a relatively popular mode amongst people with a walking difficulty. However, this group also has a relatively lower intention to use compared to the other groups, which could be caused by the vehicle being present at a hub, increasing the walking distance. The intention to use the shared car at a hub is also lower than the current use. A possible explanation could be that the shared car has a different role in the mobility system, with a less strong relation, as first/last mile mode, with public transportation at a hub.

Figure 13 compares the current and intention to use shared modes of low/high digital mobility skills.

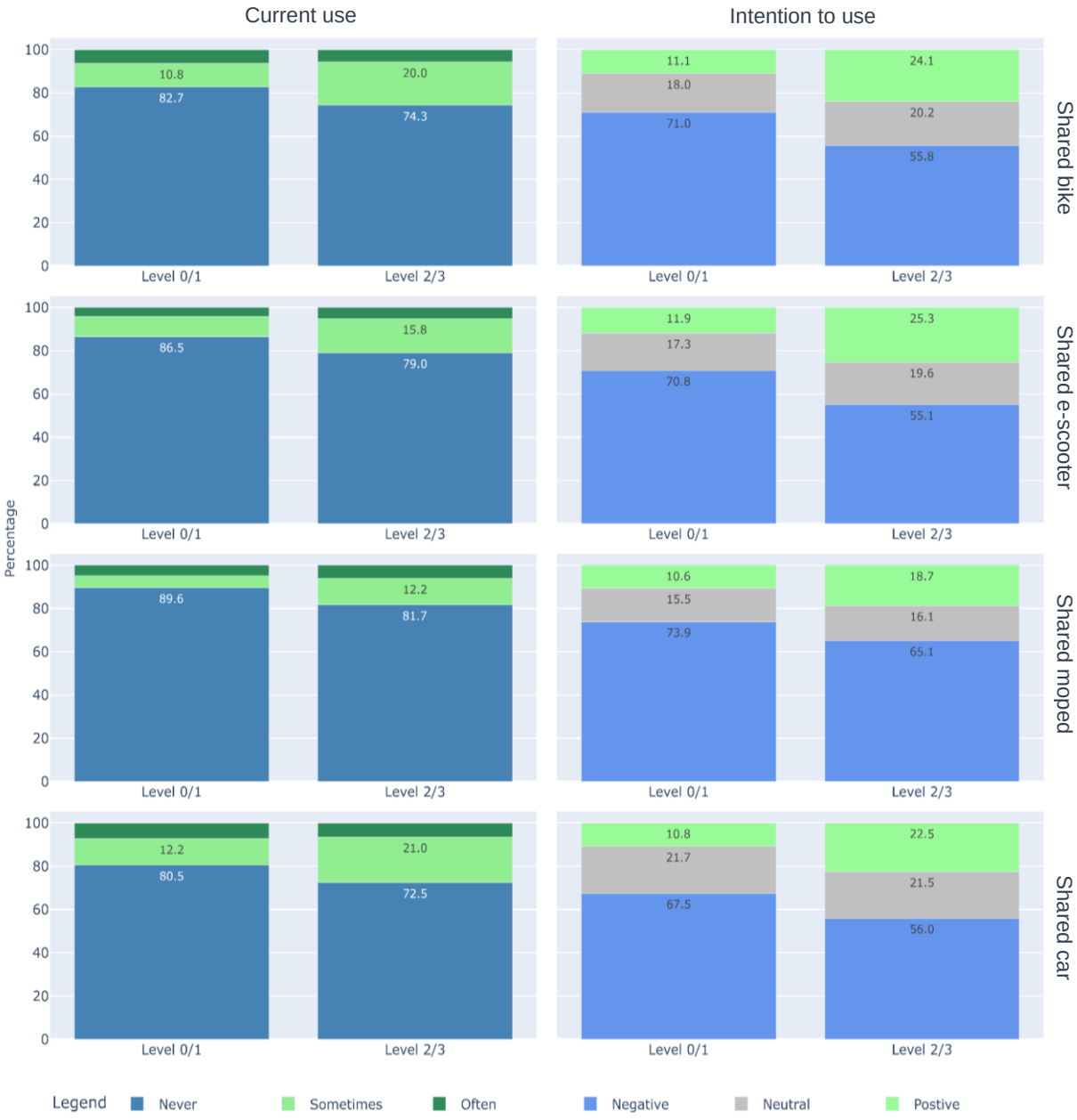

Figure 13. Current use & Intention to use shared vehicles for digital mobility skills groups

The difference between low (level 0/1) and high (level 2/3) skills level is large: digitally skilled are, on average, more than 2 times more willing to use the shared modes. The figure also shows that there is a relatively large group of people who are neutral on the intention to use a shared vehicle, which shows there is growth potential for the use of shared modes at hubs.

6.3. Factors influencing intention to use of shared bikes at mobility hubs

The previous sections showcase the differences in the intention to use shared vehicles for the V2E-groups and the growth potential of the shared modes compared to the current use. Especially older people and low digitally skilled people show a lower intention to use, and thus a potentially unequal situation in future when more mobility hubs are implemented.

In this section, an ordinal logistic regression model, see Table 19, is fitted to the intention to use shared bikes, to be able to proof the relationship between the V2E-groups and the mode use intention.

Table 19. Significant parameter estimates and significance for OLR model of intention to use a shared bike.

	B	*Std. Error*	*Wald*	*Sig.*	*Exp(B)*	*CI lower bound*	*CI upper bound*
Intercept							
Intention to use = very unlikely	-2.055	0.384	28.618	<0.001	0.128	-2.808	-1.302
Intention to use = Unlikely	-1.113	0.382	8.483	0.004	0.329	-1.862	-0.364
Intention to use = Neutral	0.007	0.381	0.000	0.985	1.007	-0.739	0.753
Intention to use = Likely	1.566	0.385	16.565	<0.001	4.787	0.812	2.320
Age	**-0.014**	**0.004**	**11.856**	**0.001****	**0.986**	**-0.022**	**-0.006**
Education							
Compulsory education or less	**-0.336**	**0.160**	**4.417**	**0.036***	**0.715**	**-0.649**	**-0.023**
High school graduate	**-0.321**	**0.153**	**4.389**	**0.036***	**0.725**	**-0.622**	**-0.021**
Senior high school	-0.240	0.126	3.619	0.057	0.786	-0.488	0.007
University undergraduate	-0.095	0.123	0.601	0.438	0.909	-0.336	0.146
MSc/MA/PhD or equal	0[a]						
Occupation							
Self-employed	0.362	0.237	2.335	0.127	1.436	-0.102	0.827
Employed	**0.561**	**0.179**	**9.777**	**0.002****	**1.752**	**0.209**	**0.913**
Working in household	0.512	0.320	2.561	0.109	1.668	-0.115	1.138
Student	0.340	0.252	1.815	0.178	1.404	-0.154	0.834
Unemployed	**0.769**	**0.248**	**9.596**	**0.002****	**2.157**	**0.282**	**1.255**
Unable to work	0.511	0.302	2.862	0.091	1.667	-0.081	1.103
In retirement	0[a]						
Born in country							
Born	**-0.362**	**0.151**	**5.782**	**0.016****	**0.696**	**-0.658**	**-0.067**
Not born but living >10 years	-0.316	0.190	2.763	0.096	0.729	-0.688	0.057
Not born but living <10 years	0[a]						
Frequency of PT use							
Never	**-0.562**	**0.185**	**9.236**	**0.002****	**0.570**	**-0.925**	**-0.200**
Sometimes	**-0.258**	**0.094**	**7.540**	**0.006****	**0.773**	**-0.442**	**-0.074**
Often	0[a]						
Used a shared vehicle in the past							
No	**-1.028**	**0.095**	**117.38**	**<0.001****	**0.358**	**-1.214**	**-0.842**
Yes	0[a]						
Digital mobility skills level							
Level 0/1	**-0.445**	**0.143**	**9.664**	**0.002****	**0.641**	**-0.726**	**-0.165**
Level 2	**-0.325**	**0.095**	**11.616**	**0.001****	**0.723**	**-0.512**	**-0.138**
Level 3	0[a]						

Note: **, *: Significant at the 0.01 and 0.05 statistical level (both marked in bold); [a] Reference category of independent var.; Reference category dependent var.: Intention to use a bike = Very likely; total N = 2055; McFadden R^2: 0.093

Shared bikes are chosen in this model since they are present in any of the living labs and have one of the highest positive intentions in the sample (which benefits the model performance). The ordinal model is statistically significant ($\chi^2(24) = 507.89$, $p < 0.001$) and explains 23% (Nagelkerke R^2) of the variance in hub use. Table 19 shows the results of the analysis, only for the variables with significance. *Income level, walking difficulty, car ownership* and *gender* are dropped from the table because of this.

The results of the logit model show that indeed, from the socio-demographics that determine V2E-groups, digital mobility skills and age are important predictors of the intention to use a shared bike at a hub. Digitally excluded citizens are, for instance, 1.56 times less likely to use the shared bike compared to digitally skilled. However, the highest influential factor is the current use of shared vehicles. When someone already used a shared vehicle before, and thus experienced the potential benefits, increases the odds 2.79 times of using it in the future, showcasing the strong link between current travel behaviour, dependency with modes and the intention. Similarly, the current use of public transport positively changes the likelihood of using shared bikes at a hub.

6.4. Conclusions on the intention to use shared mobility hubs

Chapter 6 discussed the intention to use shared mobility hubs, primarily focusing on shared bikes, e-scooters, mopeds and car. The current use of the modes (both at hubs or using other services models) was compared to the intention to use shared modes at mobility hubs. The lessons learned from the chapter are summarized below:

Key points of Chapter 6

- Older people, digitally excluded and mobility impaired V2E-groups are relatively negative towards the intention to use shared modes at mobility hubs, while migrants are relative positive. This emphasizes the importance of certain capabilities (e.g. digital & physical skills) in the acceptance of mobility hubs.
- Regarding the V2E-groups, there is growth potential for shared, motorized two-wheelers at mobility hubs, especially for those with walking difficulties.
- Experience with using shared vehicles, a higher frequency of PT use and digital mobility skills are important predictors of the intention to use shared mobility hubs. Training, assistance and exposure with shared modes could therefore positively influence the uptake of shared modes at hubs.

7. Importance of hub design elements

This chapter focuses on the importance of five different hub design element categories, related to physical and digital integration on the SmartHubs integration ladder, for the V2E-groups.

7.1. Hub design elements

On the topic of hub design, the stated importance of different hub elements (see Figure 14), regarding physical and digital integration has been revealed in the survey. Respondents stated the importance of the elements using a 5-point Likert-scale.

The different hub elements are the following:

a. Different options of shared mobility
b. Non-mobility services, such as a parcel locker or a coffee place.
c. Attractive landscaping, using art, benches or other placemaking elements.
d. Information provision, such as wayfinding or a digital information kiosk.
e. A mobile app to plan, book and pay the trips made at the hub (i.e. MaaS-application).

(a) (b) (c) (d) (e)

Figure 14. Visualisation of the different hub elements.

The results of these questions can be seen in Figure 15 for both the full sample as well as the V2E-groups. The highest overall importance is scored by the information provision, with 60% of the sample noting this to be important. The second highest importance is assigned to having a MaaS application, allowing rides to be planned, booked, and paid for using any mode of transport. 59% of the respondents consider having a MaaS app important when they are traveling via a mobility hub. Notably, respondents with higher digital mobility skills find this important, whereas respondents with lower digital mobility skills (Level 0/1) consider this less significant.

When comparing the importance of various hub elements across different V2E-groups, a pattern emerges: older individuals, people with lower digital mobility skills, and individuals with mobility impairments find (on average) all elements less important, while migrants think all elements are more important. In general, the availability of various shared transport options is not considered very important, except for migrants. Older people and low digitally skilled people think the availability of shared transport is significantly less important compared to younger individuals and high digitally skilled people. Information provision scores significantly lower for older individuals and those with lower digital mobility skills. However, information provision remains the most important element (i.e., the highest-scoring element) for these groups, which could be related to knowledge and skills barriers (as discussed in Section 5.4).

The share of *neutral* votes is also higher amongst older people and low digital mobility skilled people. Supposedly, these groups think the design of a hub is less important or care less about the design, since they will use it less. However, mobility hubs can also have an impact for non-users (e.g. placemaking, influence on social safety, nuisance), indicating the importance and difficulty of including the opinion of these V2E-groups.

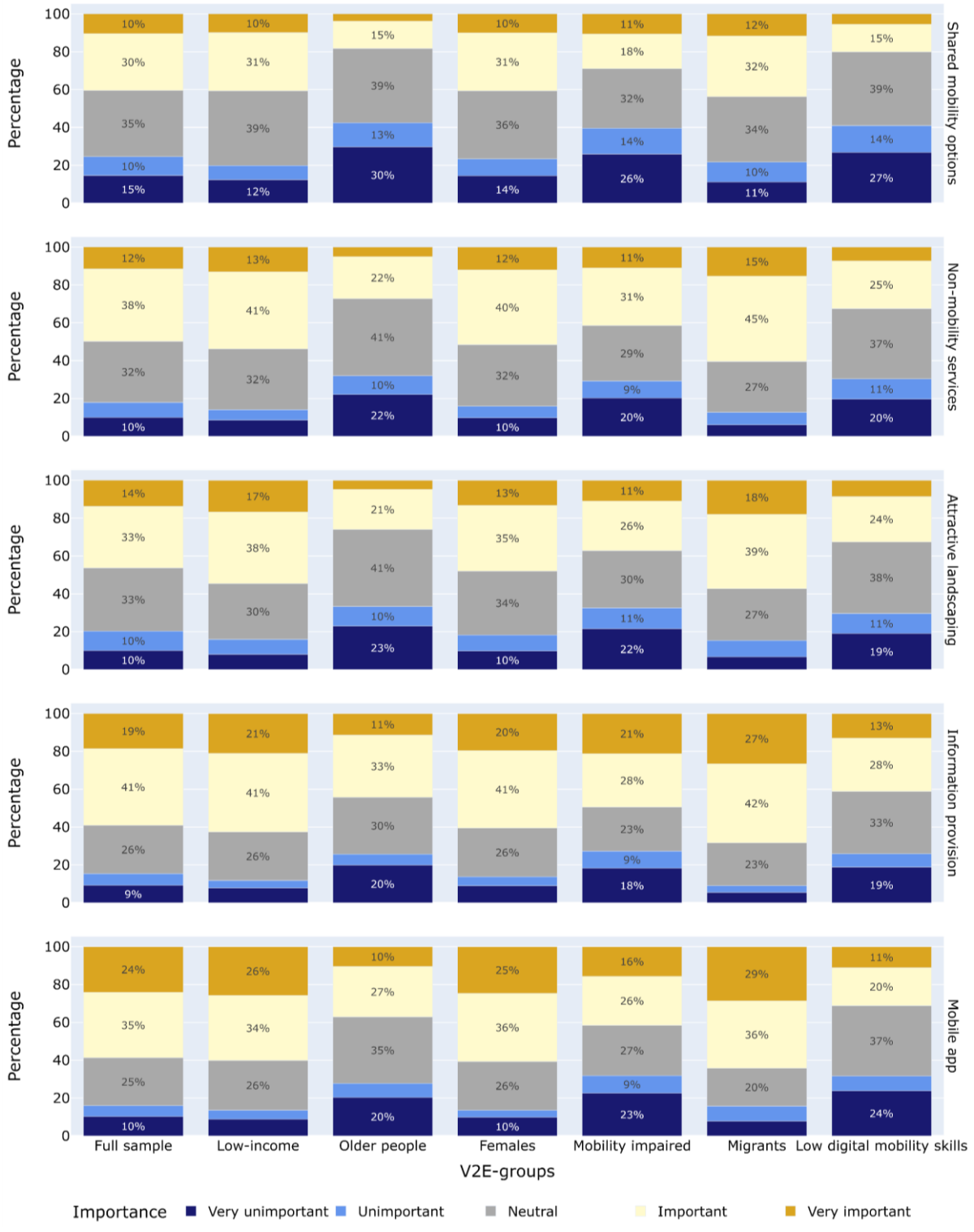

Figure 15. Importance of different hub elements for the full sample and V2E-groups.

7.1.1. Willingness-to-pay for hub design elements

The questions on importance does not include any costs of these hub design elements, which would potentially alter the opinion of the respondents. To include the cost factor, a stated choice experiment on the topic of hub design (related to the same element categories) was included in the survey. The results of this experiment are discussed in Deliverable 5.5, and do also include an analysis of the six V2E-groups (Grigolon et al., 2024).

7.2. Conclusions on the importance of hub design

This chapter focused on the importance of different hub elements for the vulnerable-to-exclusion groups, based on five different Likert-scale questions. The most important findings are listed below:

Key points of Chapter 7

- Older people, people with low digital mobility skills and mobility impaired citizens generally value the importance of mobility and non-mobility hub elements lower. This could imply these V2E-groups have other priorities, criteria or interests.
- Older people and people with low digital mobility skills have a large neutral score, potentially showing a lower interest in mobility hubs in general.

8. Participation of vulnerable-to-exclusion groups

The SmartHubs survey included a final section on democratic integration, focusing on the involvement of respondents in participatory processes. Although this is not explicitly part of the goals of the SmartHubs equity assessment, it could give insight into the current democratic integration of vulnerable citizens.

8.1. Current participation

Reaching vulnerable-to-exclusion groups in a participatory process can be difficult, as recognized by Martinez et al. (2022) in SmartHubs Deliverable D3.2. The survey results showcase a similar pattern, where older people are significantly less (6% compared to 15%) involved in participatory processes on ongoing plans to improve mobility offers in their neighbourhood (see Figure 16). Interestingly, people with mobility impairments state to be currently more involved in participatory processes.

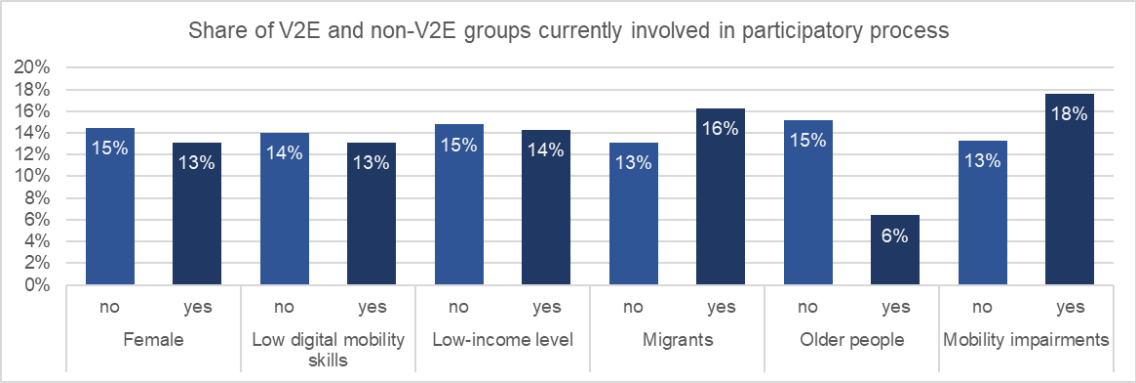

Figure 16. Share of citizens currently involved in mobility related participatory processes in their neighbourhood.

The type of participation also differs per V2E-group. In general, most respondents state they *got information on a proposal and could provide feedback* or *got information without providing feedback*. For older people and migrants, these types of participation are generally lower. The latter states to be more involved in *collectively identifying issues and proposing solutions*, while older people are involved in other types of methods which were not specifically mentioned in the answer options.

When asked if their input was valued most people, both V2E and non-V2E groups primarily state that their input was valued and they received feedback. However, the share of people agreeing to the statement *'My input was not heard'* is higher for females, low-income citizens, older people and people with mobility impairments, compared to their non-V2E counterparts.

8.2. Future participation

The unwillingness to be involved in future participation is shown in Figure 17.

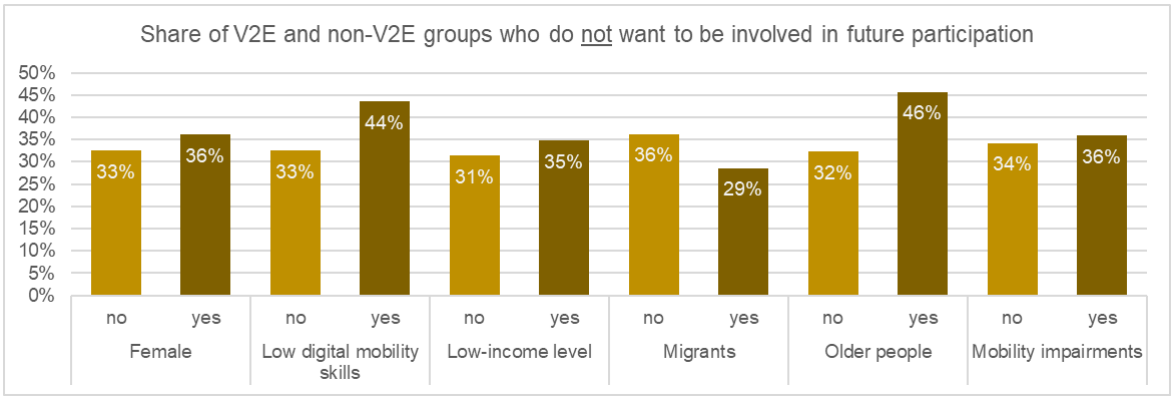

Figure 17. Share of citizens who do not want to be involved in future participatory processes

Older people, together with the digitally excluded citizens, are also significantly less willing to be involved in participatory processes in the future. Still, the majority of respondents is willing to participate in the future but, except for migrants, this percentage is lower for people who are vulnerable-to-exclusion.

8.3. Conclusions on participation of V2E-groups

Chapter 8 has briefly touched upon the topic of participation and the involvement of the V2E-groups in these kinds of processes in the field of mobility. One main conclusion is drawn from this analysis:

Key points of Chapter 8

- Older people are currently less involved in participatory processes regarding mobility in their neighbourhoods, which could lead to a discrepancy between the current mobility offer and their mobility barriers and needs.

9. Conclusion and discussion

In this chapter, the research questions are answered and the implications of the findings are discussed, with a link to the SmartHubs integration ladder.

9.1. Conclusions

The results of the full analysis are summarised per V2E-group in Table 20, giving an overview of the differences between the V2E-groups and characterising the groups based on their travel behaviour and shared mode use at mobility hubs. Regarding the characteristics of the groups (**RQ1**); the groups are not comparable with each other, and all have their own travel behaviour, use and specific barriers. Low-income citizens and migrants show different behaviour compared to the other groups with a higher use of public transport and shared modes, potentially caused by the high uptake of shared mobility for the student population. Older people and people with low digital mobility skills have a low intention to use shared mobility and to travel via mobility hubs, which could be caused by their current, lower travel frequency and distance of travel in general, and/or the barriers they would face travelling by shared mobility.

The specific barriers (**RQ2**) of the V2E-groups can mostly be summarised into three categories regarding safety & security, costs and knowledge/skills. These barriers can be related to both the shared vehicles themselves and the hubs in general. The barriers align with preferences on hub design, where the V2E-groups emphasize a need for information provision (**RQ4**). These barriers and needs, together with a lower interest in mobility hubs as well as a lower willingness-to-pay for hub elements (see Deliverable D5.5), the difference in use of the V2E-groups and the overall population (**RQ3**).

Older people, digitally excluded and mobility impaired people "stay behind" in the adoption and acceptance of mobility hubs, raising an equity issue. However, older people or people with mobility impairments may prefer more transfer-free or door-to-door travel rather than changing modes at mobility hubs, caused by the complexity of transfers at mobility hubs. So, as De Paepe et al. (2023) already questioned, it is not particularly clear if the intention to use shared modes at hubs will be as high for V2E-groups as for the general sample when their specific barriers are addressed.

Table 20. Summary of results of shared mode use and intention to use per V2E-group.

	Chapter 4	Chapter 5			Chapter 6
	Travel behaviour	**Current use of SM (%)**	**Current use of MH (%)**	**Specific Barriers**	**Intention to use SM (score)**
Average	-	*44.2%*	*24.4%*	-	*10.9*
Low-income	- Private car - Private bike + PT & train	45.6%	26.5%	> Costs > Skills to use it	11.0
Older people	- Private bike + incidental PT	13.2%	4.1%	> Safety > Skills to use it > Travel needs	7.6
Females	+ Private car - Private bike	40.3%	20.6%	> Safety > Skills to use it	10.7
Mobility impaired people	- Walking - PT & train - Private modes	30.2%	19.7%	> Safety > Skills to use it	9.7
Migrants	+ PT & train - Private car - Walking	54.3%	31.3%	> Knowledge > Safety	12.0
Low digital mobility skills	- Private modes - Train	28.1%	14.3%	> Safety > Skills to use it > Trust > Knowledge	9.4

Note: Red = significant lower use, Green = significant higher use

9.2. Discussion – implications for the SmartHubs integration ladder

The SmartHubs integration ladder is presented in SmartHubs **Deliverable D2.1** or Geurs et al. (2024)

9.2.1. Physical integration

On the topic of physical integration, the results of the SmartHubs equity analysis showcase the importance of information provision and inclusive design with a focus on safety and visibility. Smart mobility hubs, scoring high on the ladder, include all these elements and have, indeed, a higher potential on the topic of inclusive urban mobility. The inclusion of these elements could increase the uptake of mobility hubs and its services for V2E-groups. Training and assistance on the use of the vehicles (both physically and digitally) is also important, to teach current non-users the skills of using shared modes at mobility hubs.

9.2.2. Digital integration

Digital integration and the availability of mobile applications with planning, booking and paying options are valued as important assets of mobility hubs. However, digitally excluded citizens are facing barriers to use digital services, emphasizing the need for assistance, training in the use of shared modes using digital applications, and the availability of analogue booking options. Smart mobility hubs scoring high on the integration ladder offer both an integrated (MaaS) application and analogue alternatives, which is valued by the V2E-groups.

9.2.3. Democratic integration

As stated previously, V2E-groups have specific barriers and needs in the development and use of shared modes at mobility hubs, both on the physical and digital integration aspect of a mobility hub. To be able to understand and recognize these needs, the V2E-groups need to be actively involved in participatory activities during the development of a mobility hub, as stated in Geurs et al. (2024) discussing the SmartHubs integration ladder, and demonstrated by the SmartHubs co-creation activities in its living labs.

In the development of mobility hubs as a gamechanger for urban mobility, the democratic integration of V2E-groups is key to develop inclusive mobility hubs, including the barriers faced by these groups, as discussed in this report.

9.3. Policy implications

The equity assessment and the outcomes described in this chapter, lead to the following two main policy implications:

- Within the implementation of mobility hubs, focus is needed on the inclusivity of the hubs for V2E-groups, to address the barriers and needs of those groups. It is therefore important to determine the local target group of the hub. In addition, the creation of inclusive mobility hubs will likely have implications for the cost of mobility hub developments, raising questions on the governance and business model of the services provided at the mobility hubs.
- Digital mobility skills are found as an important predictor of using shared modes at mobility hubs. Additional training and guidance (e.g., provided by the municipality, transportation authority, etc.) could therefore increase the uptake of these modes. However, analogue planning and booking options should not be forgotten.

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Appendix A. Impact of student sub-sample on results

As presented in Section 4.3, that the vulnerable groups are not homogeneous across the living labs. Especially the group of migrants (i.e. people not born in their country of residence) differs across the living labs, potentially caused by the large share of students in the Munich sample.

Within the report, students are included in every analysis and not treated differently. In this section of the appendix, the potential impact of the student sub-sample on the results will be discussed.

A.1. Sub-groups of migrants and students

Table 21 shows how the share of students is skewed to the migrant sample living less than 10 years in the country of residence, with 53% of them being a student, impacting the interpretation of results. 69% of the respondents classified as migrant in Munich, is currently a student (28% in the general sample).The student-migrants have different travel patterns than the non-student migrants: they are more frequent users of public transport and less frequent users of the car (based on significant adjusted z-scores), pointing out the difficulty of considering a vulnerable group as one, homogeneous group with similar travel patterns and mobility barriers.

Table 21. Crosstab of migrant characteristics and student population.

Categories determining migration	Non-student		Student	
Born in country of residence	N = 1769	90.4%	N = 188	9.6%
Not born, living > 10 years*	N = 265	93.3%	N = 19	6.7%
Not born, living < 10 years*	N = 117	46.8%	N = 133	53.2%
Valid responses	N = 2151	86.4%	N = 340	13.6%

Note: *classified as migrant V2E group.

A.2. Sub-groups of income and students

13% of the full sample is currently a student. Table 22 shows that of the low-income V2E group, almost 34% is a student, while students are almost not represented in the medium- or high-income groups (less than 6%). Similar to section A.1., student with low-income have a different travel behaviour than non-students with low-income: they are relatively frequent users of PT, use shared two-wheelers more often and are less frequent users of the car.

Table 22. Crosstab of migrant characteristics and student population.

Categories determining income	Non-student		Student	
Low*	N = 354	66.2%	N = 181	33.8%
Medium	N = 1191	94.4%	N = 70	5.6%
High	N = 311	94.2%	N = 19	5.8%
Valid responses[+]	N = 1856	87.3%	N = 270	12.7%

Note: *classified as low-income V2E group. [+] Number of valid responses differ between Table 21 and 22 due to excluding respondents answering 'prefer not to say'.

A.3. Intention to use shared modes at hubs for students

There is a significant difference between students and non-students for the intention to use shared modes. More specifically, the percentage of respondents having a positive intention to use the shared e-bike, bike, moped and e-scooter is significantly higher for students compared to non-students. This difference is visualised in Figure 18. Intention to use the shared car or cargo bike is not significantly higher.

This analysis, together with the findings of sections A.1. and A.2., suggests that the student sample has a significant impact on the results of both the migrants and low-income V2E-groups. This should be considered when interpreting the results of those groups as it could be expected that without considering the students, the intention to use shared modes is lower for migrants and low-income citizens who are not a student. A comparison of the student and non-student sample within the migrant and low-income sample is shown in Section 6.1.3., Figure 10 and Figure 11.

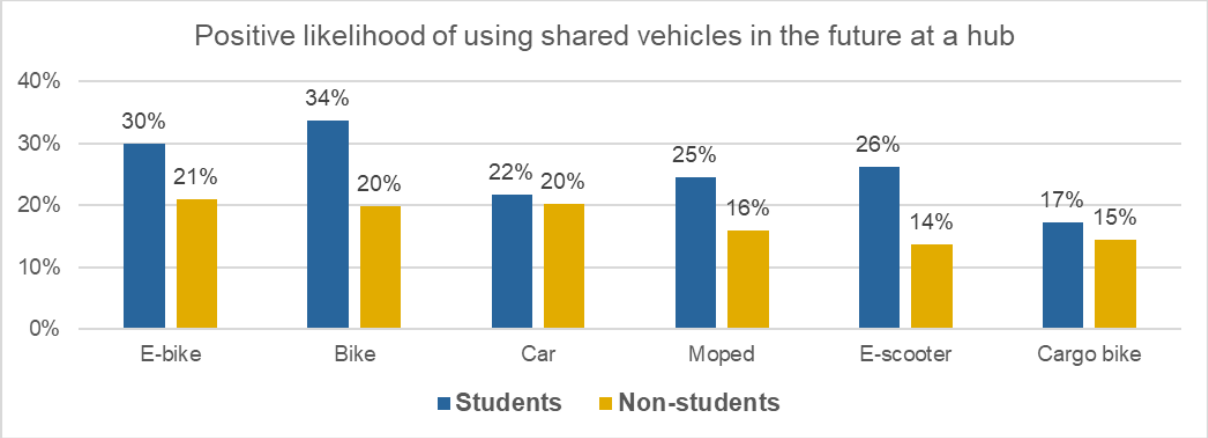
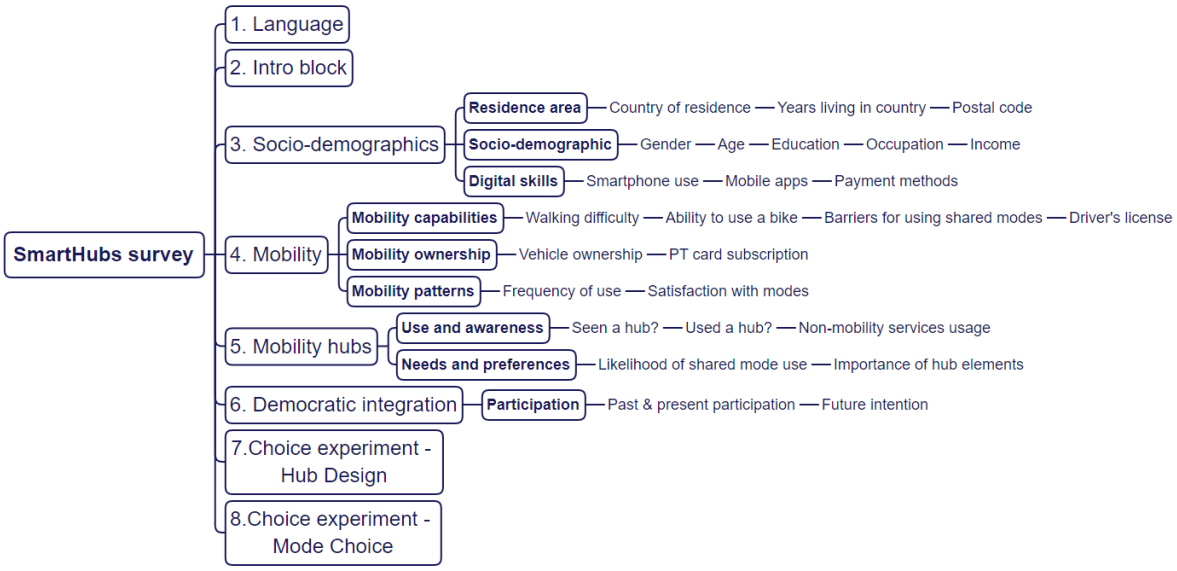


Figure 18. Positive likelihood of using shared vehicles comparison for students and non-students.

Appendix B. The full SmartHubs survey

The full questionnaire of the SmartHubs survey is attached on the following pages. The setup of the survey sections is presented in the figure below. The numbers correspond with the sections of the survey.



This survey was developed by the University of Twente (The Netherlands) and the University of Natural Resources and Life Sciences (BOKU) (Vienna, Austria) in December 2022, as part of the SmartHubs Project. Implemented on Qualtrics by the researchers: Roxani Gkavra (roxani.gkavra@boku.ac.at) and Dr. Anna Grigolon (a.b.grigolon@utwente.nl).

The full survey can be found in the following pages.

1. Language				
ID	Question	Answer Type	Answer set	Routing
Q605	Language/Sprache/Taal/Langue	Drop-down list	Deutsch English Français Nederlands Nederlands-België	-

2. Intro Block				
ID	Question	Answer Type	Answer set	Routing
Q5	Country of residence	Select one	○ Austria ○ Belgium ○ Germany ○ The Netherlands	Q605
Introduction	**Thank you for your interest in our survey!** The SmartHubs project aims to examine how mobility hubs (dedicated on-street locations where travelers can choose from different shared mobility and public transport options) can be a game changer toward inclusive sustainable urban mobility and accessibility. For the design of an ideal mobility hub, citizens' desires and needs are heard. Public transport and shared modes (bikes, scooters or cars) are available for you. There are services available such as public toilets, information kiosks, waiting areas, and urban gardens. You can plan, book, and pay for a trip combining different modes of transport using one smartphone app.  In order to participate in the survey, you must be older than 16 years. The survey will take around 20 minutes. Further information on the Smarthubs project can be found online at the project website You can also contact us by email the responsible researchers Dr Anna Grigolon and Roxani Gkavra at smarthubs@boku.ac.at			
Q30	Consent: Your participation is voluntary: you are not obliged to take part and in case you refuse, this will have no consequences for you. After starting the survey, you can quit at any time and you do not have to provide a reason for doing so. The collection and processing of data are in accordance with the legal principles imposed by the European General Data Protection Regulation (GDPR). In addition, any data collected from you will be anonymised and will be stored and used only for the purposes of the Smarthubs project.	Select one	I hereby confirm that my participation in this survey is voluntary, that I have been adequately informed about the purpose of the study, and that I can withdraw my participation from this survey at any time for any reason.	-

3. Socio-Demographics				
ID	Question	Answer Type	Answer set	Routing
Gender	Gender	Select one	○ Female ○ Male ○ Other ○ Prefer not to say	-
Age	Age (in years).	Text box	○	-
Years living	How many years have you lived in [Q5]?	Select one	○ I was born in [Q5] ○ More than 10 years but I was not born here ○ 6-10 years ○ 1-5 years ○ Less than 1 year ○ Prefer not to say	-
Zipcode home	What is the postcode of your home location in [Q5]?	Text box		-
Education	What is the highest level of education you have completed?	Select one	○ Compulsory education or less ○ High school graduate ○ Senior high school ○ University undergraduate degree ○ MSc/MA/PhD or other equal level ○ Other	-
Occupation	What is your main occupation status?	Select one	○ Employed (working full/part time) ○ Self-employed (working full/part time) ○ Working in household or other unpaid activity ○ Student ○ In retirement ○ Unemployed ○ Unable to work	
Income	What is your net household income per month?	Select one	○ Up to 1600 Euros ○ 1601-3200 Euros ○ 3201-4800 Euros ○ 4801-6400 Euros ○ >6401 Euros ○ Do not know	

Home office	How often do you work from home on average?	Select one	○ Never ○ Less than 1 day per month ○ 1 to 3 days per month ○ 1 to 3 days per week ○ 4 or more days per week	Occupation→Employed (working full/part time) OR →Self-employed (working full/part time)
adults	Number of adults (at least 18 years old) in your household?	Select one	○ 1 ○ 2 ○ More than 2	
kids	Number of non-adult members (children, teenagers) in your household?	Select one	○ None ○ 1 ○ 2 ○ More than 2	
Smartphone usage	Do you have a smartphone with internet connection?	Select one	○ Yes ○ Yes, but I use it only for calls/ messaging and other offline activities ○ No	-
nophone	Which of the following have you used in the last year? Select all that apply.	Multiple choice	☐ Credit card to purchase goods at a store/supermarket ☐ Credit card to shop online ☐ Credit card to purchase transportation tickets	Smartphone usage → No OR → Yes, but I use it only for calls/ messaging and other offline activities
withphone	For which of the following functions have you used your smartphone within the last year?	Multiple choice	☐ App to transfer money to someone ☐ App to plan a trip with your own vehicle (car, bicycle) or walking (for example, Google maps) ☐ App to plan a trip by public transport ☐ App to buy tickets or seat reservation for public transport ☐ App to reserve/book/pay for a shared vehicle (bike, car, scooter) ☐ None of the above	Smartphone usage → Yes

4. Mobility

ID	Question	Answer Type	Answer set	Routing
Q142	Which of the following vehicles are available for you to use in your household?	Multiple choice; text	☐ Bike ☐ E-bike ☐ Car ☐ Moped/Motorcycle ☐ *E-scooter (except NL) ☐ Other (please specify) ☐ None of the above	*Q5 → is not NL
Q82	How many cars do you own in your household?	Select one	○ 1 ○ 2 ○ More than 2	-
Q13	Do you have any physical difficulty when walking?	Select one	○ No ○ Yes	-
Q14	What kind of assistance do you use when walking?	Multiple choice; text	☐ I do not use any assistance ☐ Wheelchair ☐ Rollator ☐ Mobility scooter ☐ A service dog ☐ Caretaker ☐ Other, please specify	Q13→ Yes
Q8	Can you ride an e-scooter? 	Select one	○ No ○ Yes ○ Do not know/have never tried	Q5 → is Austria OR Belgium OR Germany
Q32	How often do you use the vehicles you own in your household?	Matrix table		Q142→bike OR e-bike OR Car OR Moped/Motorcycle Q142→ e-bike IF Q5→ not NL

	4 or more days per week	1-3 days per week	1-3 days per month	1-11 days per year	Never
Car as a driver or passenger					
E-scooter					
Bike/e-bike					
Moped/motorcycle					

Q153	How often do you walk to reach activities (excluding leisure walks)?	Select one	○ 4 or more days per week ○ 1-3 days per week ○ 1-3 days per month ○ 1-11 days per year ○ Never	-
shared_modes_intro	In the remaining of the survey many questions will refer to Shared transport modes:  Shared bike/e-bike: provides users with access to bicycles at a variety of pick-up and drop-off locations. Bikes are available via an application, a customer card, or a machine.  Shared e-scooter: allows access to e-scooters at various locations. E-scooters are available via an application, a customer card, or at a machine.  Shared car: usually offered at dedicated locations. Users need to have a driving license. Payment is common via an application, an online account on a website or at a machine.  Shared moped/scooter: allows access to mopeds/scooters at various locations. Most commonly, people can access a scooter via a mobile application.  Shared cargo bike/e-bike: provides users with access to cargo bicycles at a variety of pick-up and drop-off locations. Cargo bikes are available via an application, a customer card, or at a machine.			Q5→ Austria, Germany, Belgium
shared_modes_intro_NL	In the remaining of the survey many questions will refer to Shared transport modes:			Q5→ is NL

<table>
<tr>
<td></td>
<td colspan="3"> 
Shared bike/e-bike: provides users with access to bicycles at a variety of pick-up and drop-off locations. Bikes are available via an application, a customer card, or a machine.

 
Shared car: usually offered at dedicated locations. Users need to have a driving license. Payment is common via an application, an online account on a website or at a machine.

 
Shared moped/scooter: allows access to mopeds/scooters at various locations. Most commonly, people can access a scooter via a mobile application.

 
Shared cargo bike/e-bike: provides users with access to cargo bicycles at a variety of pick-up and drop-off locations. Cargo bikes are available via an application, a customer card, or at a machine</td>
<td></td>
</tr>
<tr>
<td>Q39</td>
<td>How often do you travel by the modes listed below?</td>
<td>Matrix table</td>
<td>
<table>
<tr><th></th><th>4 or more days per week</th><th>1-3 days per week</th><th>1-3 days per month</th><th>1-11 days per year</th><th>Never</th></tr>
<tr><td>Taxi/Uber</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bus, tram, metro</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Train</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>*Shared e-scooter</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared bike/e-bike</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared moped/motorcycle</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared car as driver or passenger</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
<td>* Q5→ is not NL</td>
</tr>
</table>

<table>
<tr><td>Q38</td><td>How satisfied are you overall with travelling by the following modes in your everyday life?</td><td>Matrix table</td><td><table><tr><th></th><th>Very dissatisfied</th><th>Dissatisfied</th><th>Neutral</th><th>Satisfied</th><th>Very satisfied</th></tr><tr><td>Bus, Tram, Metro</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Own car</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Own bike</td><td></td><td></td><td></td><td></td><td></td></tr></table></td><td>Q142</td></tr>
<tr><td>Q59a</td><td>What are the main reasons why you never travelled by shared e-scooter in the last year? Check all that apply</td><td>Multiple choice; text</td><td>☐ Have never heard of it
☐ It is too expensive
☐ I have to walk to far to reach a vehicle
☐ I think it is too dangerous
☐ I do not trust using this vehicle
☐ I do not feel that this vehicle can fulfil any of my travel needs
☐ I tried in the past and was disappointed with the experience
☐ I prefer using my own vehicle
☐ Other (please specify)</td><td>Q5→ is not NL AND Q39 →e-scooter is NEVER</td></tr>
<tr><td>Q198</td><td>What are the main reasons why you never travelled by shared scooter/moped in the last year? Check all that apply</td><td>Multiple choice; text</td><td>☐ Have never heard of it
☐ It is too expensive
☐ I have to walk to far to reach a vehicle
☐ I think it is too dangerous
☐ I do not trust using this vehicle
☐ I do not feel that this vehicle can fulfil any of my travel needs
☐ I tried in the past and was disappointed with the experience
☐ I prefer using my own vehicle
Other (please specify)</td><td>Q39 →shared moped/motorcycle is NEVER</td></tr>
<tr><td>Q42</td><td>What are the main reasons why you never travelled by shared car in the last year? Check all that apply</td><td>Multiple choice; text</td><td>☐ Have never heard of it
☐ It is too expensive
☐ I have to walk to far to reach a vehicle
☐ I think it is too dangerous
☐ I do not trust using this vehicle
☐ I do not feel that this vehicle can fulfil any of my travel needs
☐ I tried in the past and was disappointed with the experience
☐ I prefer using my own vehicle
Other (please specify)</td><td>Q39 →shared car is NEVER</td></tr>
</table>

Q43	What are the main reasons why you never travelled by **shared bike/e-bike** in the last year? Check all that apply	Multiple choice; text	☐ Have never heard of it ☐ It is too expensive ☐ I have to walk to far to reach a vehicle ☐ I think it is too dangerous ☐ I do not trust using this vehicle ☐ I do not feel that this vehicle can fulfil any of my travel needs ☐ I tried in the past and was disappointed with the experience ☐ I prefer using my own vehicle Other (please specify)	Q39 →shared bike/e-bike is NEVER

5. Mobility hubs: awareness and future use				
ID	Question	Answer Type	Answer set	Routing
Q143a	This part of the survey is focused on mobility hubs. A mobility hub can be a small neighborhood hub or a large hub at a train station, with different services and features: 1. Shared modes (bike, scooter, car) and public transport (bus, tram, metro, train) within walking distance 2. Digital display with live information and signage for all modes 3. An attractive hub design (with landscaping features (benches, art, green) and services (cafe, information kiosk, parcel locker) 4. An integrated mobile application for planning, booking and paying different transport modes  Examples from Austria:  			Q5→ Austria

Q143b	This part of the survey is focused on mobility hubs. A mobility hub can be a small neighbourhood hub or a large hub at a train station, with different services and features: 1. Shared modes (bike, scooter, car) and public transport (bus, tram, metro, train) within walking distance 2. Digital display with live information and signage for all modes 3. An attractive hub design (with landscaping features (benches, art, green) and services (cafe, information kiosk, parcel locker) 4. An integrated mobile application for planning, booking and paying different transport modes  Example from the Netherlands: 	Q5→ Netherlands
Q143c	This part of the survey is focused on mobility hubs. A mobility hub can be a small neighbourhood hub or a large hub at a train station, with different services and features: 1. Shared modes (bike, scooter, car) and public transport (bus, tram, metro, train) within walking distance	Q5→ Germany

	2. Digital display with live information and signage for all modes 3. An attractive hub design (with landscaping features (benches, art, green) and services (cafe, information kiosk, parcel locker) 4. An integrated mobile application for planning, booking and paying different transport modes  Examples from Germany:  	
Q143**a** (should have been d)	This part of the survey is focused on mobility hubs. A mobility hub can be a small neighbourhood hub or a large hub at a train station, with different services and features: 1. Shared modes (bike, scooter, car) and public transport (bus, tram, metro, train) within walking distance	Q5→ Belgium

	2. Digital display with live information and signage for all modes 3. An attractive hub design (with landscaping features (benches, art, green) and services (cafe, information kiosk, parcel locker) 4. An integrated mobile application for planning, booking and paying different transport modes  Example from Belgium:  		
Q49	Have you ever seen a mobility hub during your daily trips in **[Q5]**?	Select one	○ No ○ Yes ○ I'm not sure	
Q50	Have you ever used a mode of transport at a mobility hub in **[Q5]**?	Select one	○ No ○ Yes ○ I'm not sure	Q49→Yes

Q52	You have indicated that you travel by public transport and/or shared modes. How many of your trips with these modes of transport started or ended at a mobility hub?	Matrix table		None	A few	About half of them	Most of them	All		Q50→Yes Q39 * Q5→ NOT NL
			Bus, tram, metro							
			Train							
			*Shared e-scooter							
			Shared bike/e-bike							
			Shared moped/motorcycle							
			Shared car as driver or passenger							
Q154	Out of all the mobility hubs trips that you conducted by **shared e-scooter**, how many were for each trip purpose?	Matrix table		None	A few	About half of them	Most of them	All		Q50→Yes AND Q52 → shared e-scooter
			To/from Work							
			To/from Education							
			To/from Shopping							
			To/from Leisure							
Q156	Out of all the mobility hubs trips that you conducted by **shared car**, how many were for each trip purpose?	Matrix table		None	A few	About half of them	Most of them	All		Q50→Yes AND Q52 → shared car
			To/from Work							
			To/from Education							
			To/from Shopping							
			To/from Leisure							
Q157	Out of all the mobility hubs trips that you conducted by **shared bike/e-bike**, how many were for each trip purpose?	Matrix table		None	A few	About half of them	Most of them	All		Q50→Yes AND Q52 → shared bike/e-bike
			To/from Work							
			To/from Education							
			To/from Shopping							
			To/from Leisure							

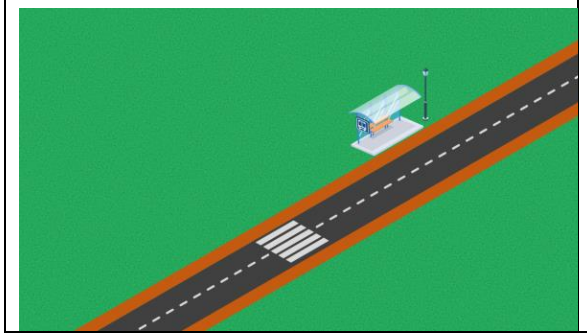
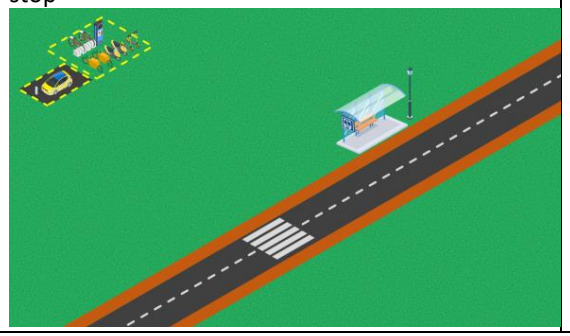
	Out of all the mobility hubs trips that you conducted by **shared scooter/motorcycle**, how many were for each trip purpose?	Matrix table		None	A few	About half of them	Most of them	All	Q50→Yes AND Q52 → shared scooter/motorcycle
			To/from Work						
			To/from Education						
			To/from Shopping						
			To/from Leisure						
Q59	How likely is it that you will use the modes below in case they are present at mobility hubs in your area in the future?	Matrix table		Very unlikely	Unlikely	Neutral	Likely	Very likely	
			Shared car						
			*Shared e-scooter						
			Shared bike						
			Shared e-bike						
			Shared cargo bike						
			Shared e-moped						
Q62222	Which characteristics of a mobility hub are the most important for you?	Matrix table		Extremely unimportant	Unimportant	Neutral	Important	Extremely important	
			Different shared mobility options						
			Availability of different services						
			An attractive design						
			Information (digital display, signage)						
			One mobile app to plan, book and pay for using different modes of transport						

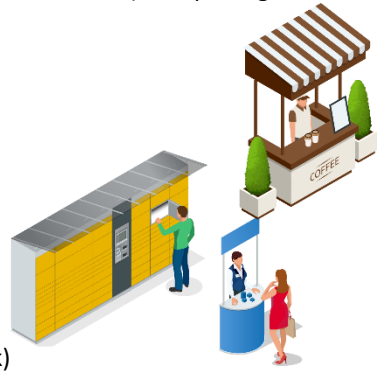
<table>
<tr>
<td>Q66</td>
<td>Latest mobility hub trip
Please provide information on your most recent trip during which you used any mode(s) of a mobility hub.
Modes of transports
Select all the modes that you used across your trip in the order that you used them. In case you used only a single mode, fill in only the information on the 1st mode.
Note: walking is also considered a separate mode of transport</td>
<td>Side by side</td>
<td>
<table>
<tr><td></td><td>Mode of transport</td><td>Trip duration</td></tr>
<tr><td>1st mode</td><td>(drop-down list)</td><td>(drop-down list)</td></tr>
<tr><td>2nd mode</td><td></td><td></td></tr>
<tr><td>3rd mode</td><td></td><td></td></tr>
<tr><td>4th mode</td><td></td><td></td></tr>
<tr><td>5th mode</td><td></td><td></td></tr>
</table>
Modes of transport: own bike, own car, shared bike, shared e-scooter, shared car, public transport, walking, other

Trip duration: up to 10min, 11-20min, More than 20min
</td>
<td>Q50→yes</td>
</tr>
<tr>
<td>Q92</td>
<td>In case that the shared modes were not available for your latest trip, which mode(s) could you have used alternatively to conduct the trip? Select all that apply</td>
<td>Multiple choice</td>
<td>☐ Own bike
☐ Own car
☐ Own e-scooter
☐ Walking
☐ Public transport
☐ Could not have conducted the trip
☐ Other, specify:</td>
<td>Q66</td>
</tr>
</table>

6. Democratic Integration				
ID	Question	Answer Type	Answer set	Routing
Dem1	Have you ever been involved in plans to improve mobility offers in your neighbourhood?	Select one	○ Never ○ Yes	
Dem2	What best describes your participation?	Select one	○ Got information in a workshop/public hearing ○ Got information on a proposal and provided feedback on it in a workshop/survey ○ Proposed solutions to a specific problem in a workshop/similar event ○ Collectively identified issue(s) and proposed solutions ○ Ongoing cooperation to identify issue(s) and develop solutions ○ Other type of participation process	Dem1→Yes
Dem3	How was your input/participation valued? Select all that apply	Multiple choice	☐ My input wasn't heard ☐ My input was valued ☐ I received feedback on how my input was used ☐ I still participate in an ongoing cooperation/network of citizens	Dem2
Dem4	How would you like to participate in decision-making to improve the mobility offers in your neighbourhood in the future? Select all that apply	Multiple choice	☐ Get information in a workshop/public hearing without providing input ☐ Get information on a proposal and provide feedback on it in a workshop/survey ☐ Propose solution(s) to a specific problem in a workshop./similar event ☐ Cooperate to identify issue(s) and develop solutions ☐ Cooperate to identify issue(s) and develop solutions regularly ☐ Other type of participation process ☐ I do not wish to participate in any process in the future	
Dem5	And at which planning phase(s)?	Multiple choice	☐ Working together on a solution for a specific issue ☐ Working together on a proposal for a new overall planning strategy ☐ Feedback to a plan of a responsible organization e.g. municipality, mobility provider ☐ Other planning phase (please specify)	Dem 4→ I do not wish to participate in any process in the future IS NOT SELECTED

<table>
<tr><th colspan="5">7. Stated Preference Experiment – Hub Design</th></tr>
<tr><th>ID</th><th>Question</th><th>Answer Type</th><th>Answer set</th><th>Routing</th></tr>
<tr><td>SP_UT Intro</td><td colspan="4">In this part of the survey, we are interested in understanding your preferences for different elements of mobility hubs.
Please analyse the figures below carefully. We consider 5 hub elements, each varying according to 3 levels:

1. Modes available
<table><tr><td>Level 1: public transport stop only (shared modes are all scattered and not within walking distance)
  </td><td>Level 2: shared modes are placed together, but not within walking distance from public transport stop
  </td><td>Level 3: public transport stop and shared modes at walking distance
  </td></tr></table>
2. Information
<table><tr><td>Level 1: no signage, no digital display</td><td>Level 2: signage for all modes
  </td><td>Level 3: digital display and signage for all modes
  </td></tr></table>
3. Design</td></tr>
</table>

Level 1: no landscaping, no services	Level 2: landscaping (green, benches, art) 	Level 3: services (cafe, package locker, information kiosk) 

4. Mobile app

Level 1: No integration between the modes 	Level 2: modes are integrated for trip planning 	Level 3: modes are fully integrated for trip planning, booking and payment 

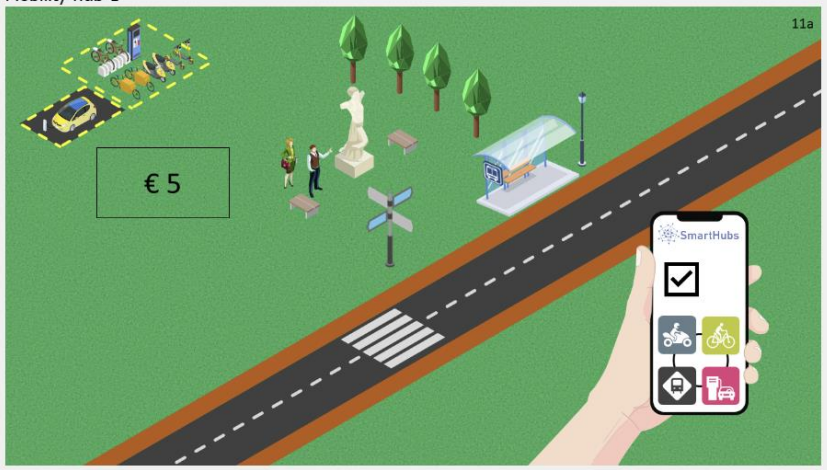
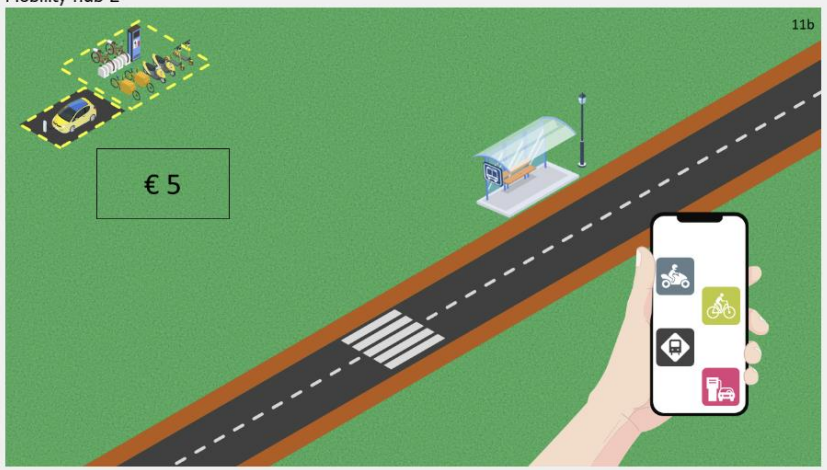
5. Cost

	Level 1: No increase in monthly municipal taxes € 0	Level 2: 5 euros per month extra in municipal taxes € 5	Level 3: 10 euros per month extra in municipal taxes € 10

The following 6 questions will show you two hypothetical mobility hubs. You are asked to choose one that best represents your preferences.

ID	Question	Answer Type	Answer set	Selection criteria
CS11 (EXAMPLE)	The table shows two mobility hubs with different characteristics and represented (below) as figures.	Select one	○ Mobility hub 1 ○ Mobility hub 2 ○ None	A random selection of 6 out of 36 CS (choice sets) per respondent.

	Mobility hub 1	Mobility hub 2
Modes available	shared modes are placed together, but not within walking distance from public transport stop	shared modes are placed together, but not within walking distance from public transport stop
Information	signage for all modes	no signage, no digital display
Design	landscaping (green, benches, art)	no landscaping, no services
Mobile App	modes are integrated for trip planning	no integration between the modes
Costs	5 euros per month extra in municipal taxes	5 euros per month extra in municipal taxes

	Which mobility hub would you choose? Mobility hub 1  Mobility hub 2  ○ None of these			

8. Stated Preference Experiment – Mode Choice (BOKU)				
ID	Question	Answer Type	Answer set	Routing
Ref1	In the next questions please provide some information on the latest trip you conducted by one of the following modes. The trip that you consider should have been between 500 meter (0.5km) and 10000 meter (10 km): - Own car (driver or passenger), - Own bike - Public transport - Walking			
Ref2	Mode of transport?	Select one	○ Own car (driver or passenger) ○ Own bike ○ Public transport Walking	
Ref3	Main trip purpose?	Select one	○ From/to work ○ From/to education ○ From/to shopping ○ From/to leisure	
Ref4	How long was your trip, in meters? For example, 1km=1000meters.	Numeric text input		
Ref5	How many minutes did you walk to reach the **public transport stop**? Please fill in **only the rounded number of minutes**, for example 9.	Numeric text input		Ref2→ Public transport
Ref11	How did you pay for your trip?	Select one	○ I bought a ticket for this trip. ○ I payed via a subscription	Ref2→ Public transport

			such as an annual/monthly card or similar.	
Ref6	Total trip cost (in Euros)?	Numeric text input		Ref2→ Public transport and Ref11→ I bought a ticket for this trip.
Ref8	How many minutes did you wait at the public transport stop? Please fill in **only the rounded number of minutes**, for example 5	Numeric text input		Ref2→ Public transport
Ref9	How many minutes did you walk to reach your **own car**? Please fill in **only the rounded number of minutes**, for example 9.	Numeric text input		Ref2→ Own car
Ref7	Which of the following best describe the circumstances of your trip? Select all that apply	Multiple choice	○ Travelling alone ○ Travelling with a child/children ○ Travelling with at least one more adult ○ Great weather conditions ○ Unpleasant weather conditions	

SPintro	In the next 6 questions, we ask you to answer what mode would you choose under different hypothetical scenarios. The scenarios vary in terms of transport modes available for you and the characteristics of these modes (travel time, waiting time, access time, cost, payment method). For all scenarios, imagine a trip in the future that will be similar to the trip you just described: A trip • From/to Work • Travelling alone In total, you will face six(6) different scenarios.			

ID	Question	Answer Type	Answer set	Selection criteria
SPcar1_1 (Choice task example for country of residence: Austria, Germany, or Belgium. In case of location in the Netherlands, instead of an e-scooter, an e-moped was presented.)	**New scenario!** For your trip, you can choose any of the modes below. They are all available for you to travel by. Make sure you check the time (minutes), cost (€), and payment method values before you decide which transport mode you prefer for this new trip. **Shared modes** Bike  Car  E-scooter  Public transport  Own Car Travel time: 27 min | 12 min | 24 min | 16 min | 12 min Walking time to the vehicle: 3.5 min | 3.5 min | 3.5 min | 3.5 min | 2 min Waiting time for the vehicle: 1.5 min | 3 min | 0 min | 1 min | - Cost: 0.9 € | 2.3 € | 4.8 € | 1.2 € | 5.5 € Payment only via a mobile app: No | Yes | No | No | - Which transport mode do you prefer in this scenario? ○ Shared bike  ○ Shared car  ○ Shared e-scooter  ○ Public transport  ○ Own Car	Select one	○ Shared bike ○ Shared car ○ Shared e-scooter ○ Public transport ○ Own car	1) Based on the mode in Ref1, people are assigned to one out of three sets of blocks. The first set is for reference trips by walking or by own bike, the second and third are for reference trips by public transport and own car, respectively. 2) A random selection of one block out of 12 available blocks in the assigned set. Each block consists of 6 choice tasks/questions.