



Smart Mobility Hubs as Game Changers in Transport

WP3. Development of co-creation, participatory planning and design tools.

T3.2. Needs of users and digitally excluded citizens

Deliverable 3.2

Needs of users and digitally excluded citizens

Version: 1.0

Date: 25 November, 2022

Responsible partner: Vrije Universiteit Brussel (VUB)

Authors: Lluis Martinez (VUB), Jesse Pappers (VUB), Imre Keserü (VUB)

Contributors : Camila Barquero (TUM), Karla Münzel (UT), Lukas Knott (IVS) and Martin Hinteregger (BOKU).



This project is supported by the European Commission and funded under the Horizon 2020 ERA-NET Cofund scheme under grant agreement N° 875022



Federal Ministry
of Education
and Research



Executive summary

This deliverable is part of the SmartHubs project, a JPI funded research project with living labs in Anderlecht, Eastern Austria, Munich, and Rotterdam-The Hague. The SmartHubs project examines mobility hubs, dedicated on-street locations where citizens can choose from different shared and sustainable mobility options. The main objective of the project is to assess if a co-designed, user-centric development can enable mobility hubs to act as game changer toward inclusive sustainable urban mobility and accessibility. In this regard, the needs and barriers of users of mobility hubs, including digitally excluded citizens, must be acknowledged. However, the literature on mobility hubs, which relates to shared mobility and digital mobility services, overlooks such needs and barriers.

This deliverable fills the knowledge gap identified in the literature and offers in-depth insights into the experience of users concerning mobility hubs. The needs and barriers of disadvantaged users are identified, and the usefulness of mobility hubs to improve the mobility of vulnerable citizens is investigated. The theoretical framework of this research resulted from the adaptation of the Capabilities Approach to the study of mobility hubs. In this regard, three main elements are studied: material access, skills and cognitive appropriation of mobility hubs shared mobility services and digital mobility solutions.

The data collection methods adopted are qualitative, aiming to grasp the complexity of a multidimensional and explorative topic. As a result, the experience and opinion of 85 participants have been collected through semi-structured interviews and focus groups, with experts and users, in the four living labs of the Smarthubs project. The data obtained has been transcribed, and systematically analysed through a deductive coding process in the language of origin. Afterwards, the quotes have been translated, the findings have been restructured, interpreted, and the results have been summarized in the conclusions.

Vulnerable citizens face additional disadvantages to exercise their mobility. Such disadvantages are related to personal characteristics which can be found in specific social groups. Although it can be stated that mobility hubs may improve the accessibility and mobility of vulnerable citizens, this cannot be equally sustained for all vulnerable groups. Some groups may benefit more than others. However, the benefits that vulnerable citizens may obtain from using mobility hubs will depend on how the facilities, services and vehicles are adapted to their needs. In this regard, a more inclusive design is considered a common need among most vulnerable groups, as it is the possibility of being assisted by someone at the hub or having access to training to use the services and facilities. The procurement of security and feeling of safety is commonly stated as necessary by participants. Likewise, having the possibility to use the hub through non-digital channels, and the provision of simple and understandable information (e.g., boards, screens, signage...) are also highlighted. As a continuation of this research, we propose to complete this study through a quantitative approach, (e.g., a questionnaire survey), and to develop participatory tools to enable the co-design of more inclusive and attractive mobility hubs.

DOCUMENT CHANGE RECORD

Version	Date	Status	Author	Description
0.1	29/07/2022	Reviewed	Lluis Martinez (VUB)	Draft version for internal review
0.2	30/08/2022	Reviewed	Lluis Martinez (VUB), Jesse Pappers (VUB)	Draft version for internal review
0.3	26/09/2022	Reviewed	Lluis Martinez (VUB), Jesse Pappers (VUB), Imre Keserü (VUB)	Final version for consortium review
1.0	25/11/2022	Reviewed	Lluis Martinez (VUB), Jesse Pappers (VUB), Imre Keserü (VUB)	Final version

Table of contents

Executive summary	2
Document change record	3
List of tables.....	6
List of figures.....	6
1 Introduction.....	7
1.1 Task description and relation to other tasks.....	7
1.2 Structure of the deliverable.....	7
2 Theoretical framework.....	8
2.1 Relevant concepts.....	8
2.2 Literature review	8
2.3 Conceptual framework.....	9
3 Methodology	12
3.1 Research design.....	12
3.2 Data collection method.....	12
3.2.1 Semi-structured interviews.....	13
3.2.2 Focus groups.....	13
3.3 Sample	14
3.3.1 Experts	14
3.3.2 End-users	16
3.4 Analytical process.....	18
4 Results	19
4.1 Experts	19
4.1.1 Children and teenagers	19
4.1.2 Digitally excluded citizens	19
4.1.3 Low-income citizens.....	20
4.1.4 Migrants and ethnic minorities.....	20
4.1.5 Informal caregivers.....	21
4.1.6 Older people.....	21
4.1.7 People with cognitive impairments	22
4.1.8 People with physical impairments.....	22
4.1.9 People with visual impairments.....	23
4.1.10 Peri-urban and rural inhabitants.....	23
4.1.11 Socially isolated citizens	24
4.1.12 Women.....	24
4.2 End-users	25

4.2.1	Children and teenagers	25
4.2.2	Digitally excluded citizens	26
4.2.3	Migrants.....	26
4.2.4	Older people.....	27
4.2.5	People with impairments	28
4.2.6	Peri-urban and rural inhabitants	31
4.2.7	Women	31
4.3	Synthesis of expert and end-user interviews.....	32
4.3.1	Children and teenagers	34
4.3.2	Digitally excluded citizens	36
4.3.3	Migrants and ethnic minorities.....	38
4.3.4	Older people.....	40
4.3.5	People with impairments	42
4.3.6	Peri-urban and rural inhabitants	46
4.3.7	Women	48
5	Conclusions.....	52
5.1	Mobility hubs.....	53
5.1.1	Material Access	53
5.1.2	Skills	53
5.1.3	Cognitive appropriation.....	54
5.2	Shared mobility.....	55
5.2.1	Material Access	55
5.2.2	Skills	55
5.2.3	Cognitive appropriation.....	55
5.3	Digital mobility services.....	56
5.3.1	Material Access	56
5.3.2	Skills	56
5.3.3	Cognitive appropriation.....	56
5.4	Limitations, implications and further research.....	57
6.	References.....	58
Annex 1	63
Annex 2	68
Annex 3	74
Annex 4	76

List of tables

Table 1. Expert interviews.....	15
Table 2. End-user interviews.....	16
Table 3. Synthesis of findings group ‘Children and teenagers’.....	34
Table 4. Synthesis findings group ‘Digitally excluded citizens’.....	36
Table 5. Synthesis findings group ‘Migrants and ethnic minorities’.....	38
Table 6. Synthesis findings group ‘Older people’.....	40
Table 7. Synthesis findings group ‘People with impairments’.....	43
Table 8. Synthesis findings group ‘Peri-urban and rural inhabitants’.....	46
Table 9. Synthesis findings group ‘Women’.....	48

List of figures

Figure 1. Applying the CA to the study of mobility hubs.....	10
Figure 2. Needs of children and teenagers.....	36
Figure 3. Needs of digitally excluded citizens.....	38
Figure 4. Needs of migrants and ethnic minorities.....	40
Figure 5. Needs of older people.....	42
Figure 6. Needs of people with impairments.....	46
Figure 7. Needs of peri-urban and rural inhabitants.....	48
Figure 8. Needs of women.....	51
Figure 9. Needs of vulnerable people.....	52

1 Introduction

Shared mobility and mobility hubs are emerging trends that could be a game changer affecting urban mobility. However, the needs and barriers of users of mobility hubs, including those using shared mobility services and digital mobility services, are overlooked in the literature. An explanation for this research gap may be that most authors study shared mobility services, or digital mobility services separately, without relating them to physical locations: mobility hubs. This study fills this knowledge gap and offers in-depth insights into the experience of users concerning mobility hubs.

1.1 Task description and relation to other tasks

This deliverable is an output of SmartHubs Task 3.2 'Needs of users and digitally excluded citizens'. This task is part of work package 3 (WP3) of the SmartHubs project, which aims to assess if a co-designed, user-centric development can enable mobility hubs to act as a game changer toward inclusive sustainable urban mobility and accessibility. This deliverable aims to fill the knowledge gap identified in the literature, offering in-depth insights into the needs and barriers of users and digitally excluded citizens regarding mobility hubs. Furthermore, the result of this task will inform the design of a questionnaire survey to study how the availability of more travel options creates a positive experience for travellers, and how mobility hubs can lead to changes in the mobility and accessibility of current users. The survey will be used in WP5, more specifically in task 5.1, 'Mobility hubs and virtual and physical mobility needs and patterns', task 5.3, 'SmartHubs equity assessment', and task 5.5 'Integration of mobility hubs and public transport'. Additionally, tasks from WP4 are also informed by the findings of this study, such as T4.1, 'Setup and evaluation framework of Mobility Hubs within Living Labs', and the implementation of the four living labs (tasks 4.2, 4.3, 4.4 and 4.5).

1.2 Structure of the deliverable

This deliverable has six sections. The following section comprises the theoretical framework, and section 3 explains the methodology. The latter is structured in four sub-sections about the research design, referring to the sampling, the data collection method, the analytical process, and the limitations of the methodology. Section 4 presents the results, comparing the findings obtained with the two main samples of this study: 'experts', and 'end-users'. And section 5 concludes with a summary of the results, completed with the implications and limitations of this study, and suggestions for further research.

2 Theoretical framework

This section defines in the first place, relevant concepts that are central to this study and recurrently used in this document: mobility hub, shared mobility, digital mobility services, and vulnerable groups. Secondly, a literature review concerning the theoretical framework used in this research is presented and lastly, the conceptual framework is explained.

2.1 Relevant concepts

A mobility hub is a physical location where different shared transport options are offered at permanent, dedicated, well-defined and well-visible locations (with a physical boundary or a geofenced digital boundary) offering a combination of shared transport modes and providing access to public or collective transport at walking distance (Geurs & Münzel, 2022). A hub can offer other mobility-related and non-mobility-related elements and services.

Shared mobility is defined as the services that allow users to have short-term access to a transportation mode, such as a vehicle or a bicycle, which is shared with other users (Shaheen & Cohen, 2018). This includes bike-sharing, carsharing, ridesharing and on-demand ride services, as well as shared mopeds, scooters and cargo bikes.

Digital mobility services are technology-driven transport services that rely on digital communication and information technologies (Acheampong, 2021). Such services may include transport services, provision of information and passenger support (e.g., navigation, trip planning, booking services...).

Vulnerable users are considered individuals that encounter additional difficulties and barriers to their use of transport services. Such difficulties can increase their vulnerability to some form of exclusion, such as social exclusion (Lucas, 2019). In this regard, vulnerable groups refer to all the individuals that face similar barriers due to common personal characteristics.

Although individuals may belong to several vulnerable groups and therefore suffer from several forms of disadvantages (Jeekel, 2018), the existing literature offers useful approaches to systematically distinguish them. Aspects such as age, education level, ethnicity, gender, income, and residential location have an impact on the disadvantages experienced by citizens (Durand et al., 2021). For instance, Venkatesh et al., (2012) consider age, education level, gender and income in their work, and Goodman-Deane et al., (2022) identify seven groups. The latter include age, education level, gender, having a disability, having migrant backgrounds, income and residential location. Kuttler & Moraglio, (2020) highlight that physical and mental impairments must be taken into consideration, and Horjus et al., (2022) refer to personal digital skills, as characteristics leading to disadvantages when using transport services. Wu et al., (2021), highlight the additional barriers and difficulties that informal caregivers encounter in their daily mobility. Additionally, the categorisations of vulnerable groups used in the Inclusion project (Lorenzini & Cottrill, 2018) and the Indimo project (Di Ciommo et al., 2020) have also been considered in this study.

2.2 Literature review

The needs and barriers encountered by users concerning mobility hubs are related to complex social processes depending on the abilities and needs of people, which are heterogeneous. This results in an unequal use of services and uneven accessibility (Pereira et al., 2017).

Thus, the theoretical framework adopted in this study must enable a comprehensive understanding of the needs and barriers of users of the mobility hub.

Traditional approaches to transport planning focus on the provision of resources, such as transport infrastructure and services, to increase accessibility as a means of enhancing the freedom of choice and equality of opportunities. However, the provision of resources and accessibility alone cannot ensure improved mobility of vulnerable individuals (Martens et al., 2019; Pereira et al., 2017). Thus, the CA shifts the focus from 'resources' to 'capabilities', arguing that all individuals should enjoy a level of 'capabilities' which allows them to fulfil their needs and develop their lives (Luz & Portugal, 2021; Pereira et al., 2017). For (Nussbaum & Sen, 1993), the focus on the distribution of resources neglects the diversity of preferences and needs of individuals. This is because resources are not ends in themselves, but rather means to achieve aims.

The Capabilities Approach (Nussbaum & Sen, 1993; Sen, 1992) has been identified as a theoretical framework for this study. This framework is considered especially useful to understand the unequal use of transport services depending on users' characteristics and to appraise the inclusivity of transport services. The Capabilities Approach (CA) is also useful to better understand the accessibility of users, as their exercise such accessibility. In this regard, Pereira et al., (2017) refer to accessibility as an individual attribute resulting from the interaction of personal characteristics, such as age, gender, socioeconomic conditions and ableness, with the person's environment, and sociocultural context.

An example of how the CA has been applied in transport studies is the work of (Smith et al., 2012), who studied the transport disadvantages encountered by rural inhabitants compared to urban inhabitants. The authors conclude that transport costs constitute most of the additional costs of living in a rural area. Likewise, (Cao & Hickman, 2019) adopted the CA to study the different uses that Beijing inhabitants make of metro line 1 depending on their socioeconomic characteristics and geographical location. The results show that the use of metro line 1 varies depending on the individual's geographical location and socio-economic characteristics, having a relevant influence on their opportunities to participate in life. Concerning shared mobility, (Sherriff et al., 2020) applied the CA to study the use of dockless shared bikes in Manchester and identified how personal and social characteristics play a role in the use of such services.

Within transport research, a range of diverging perspectives on how to apply the CA in practice has emerged, with two main strands of literature that diverge in the conceptualisation of capabilities. The first strand of literature refers to 'capability' as the ability of individuals to be mobile (Beyazit, 2011; Flamm & Kaufmann, 2006). From this perspective, the exercise of mobility is influenced by the context of individuals and limited or increased by the skills and knowledge they possess. Kaufmann, (2016) incorporates this perspective through the concept of 'motility', referring to how individuals appropriate the range of possible action concerning their mobility. The second strand focuses on the study of 'capability' as the ability of an individual to engage in a variety of activities outside their home through the use of transportation (Martens, 2016). This strand focuses on accessibility, which is understood as a means to achieve an objective and not as an end in itself, focusing on the person's ability to convert resources into participation in activities (Ryan et al., 2015; Vecchio & Martens, 2021).

2.3 Conceptual framework

This study adopts the approach that considers 'capability' as 'accessibility' because the authors consider that the aim of enhancing accessibility is not only to increase people's mobility but rather that they participate in society and reach opportunities. Therefore, this perspective lends itself better to transport research from the point of view of social inclusion (Luz & Portugal, 2021; Pereira et al., 2017).

Based on the literature mentioned in the previous paragraphs, such as the work of (Kaufmann, 2016; Luz & Portugal, 2021; Nussbaum & Sen, 1993) this research proposes a conceptual framework to study the needs and barriers of (vulnerable) citizens to the use of mobility hubs. The framework adapts the CA to enable a comprehensive understanding of the inclusivity of mobility hubs and to ease the operationalization of the theoretical framework previously explained. This framework implies that a person's use of mobility hubs, relies on three main factors (see Figure 1): 'material access', 'skills' and 'cognitive appropriation'. As shown in the figure, mobility hubs and the services provided within them can be conveniently used when the three factors are met. Thus, when only two factors are met, the use of the services might be difficult or impossible. For instance, when an individual is lacking the necessary skills to use a service, the service cannot be instrumentalised, and when someone cannot cognitively appropriate the service, it will be unattractive to this person. Likewise, when there is no material access to a service, the service remains unavailable for users. Moreover, the design of mobility hubs should take into account these three factors to the extent to which they will be useful for a person to freely fulfil an aim and reach a necessary destination.

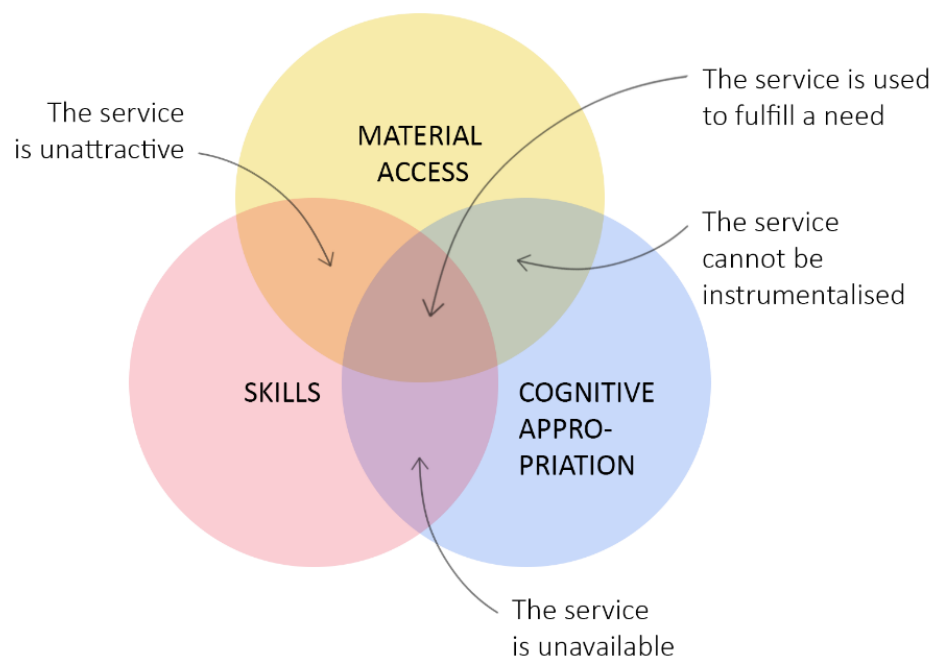


Figure 1. Applying the CA to the study of mobility hubs.

The first factor, 'material access', refers to the resources necessary to use mobility hubs, such as financial means to cover the costs of usage and the availability of the services offered at the hub (e.g., shared vehicles and public transport). Material access also refers to having a reliable internet connection and an adequate digital device, such as a smartphone or a tablet. In recent years, the smartphone has taken an increasingly central role in mobility services (Gebresselassie & Sanchez, 2018) with transport operators using a wide variety of applications that are often free. However, devices are not free of charge, and although there is available free wi-fi in some urban locations, having a reliable and permanent internet connection comes at a cost (Golub et al., 2019). Moreover, it is necessary to have an up-to-date operating system installed in the device, and enough battery or access to a charging point (Groth, 2019).

The second factor, 'skills', enables the instrumentalization of a resource to fulfil an objective. 'Skills', refer to the knowledge and the abilities necessary to use a mobility hub (e.g., facilities, digital and non-digital services...), including physical and cognitive abilities. Vecchio & Tricarico, (2019) argue that the skills necessary to use digital mobility services are permanently evolving, and they can be differentiated into two types of skills: medium-related skills, which are related to operating a digital device, and content-related skills, which refer to information and strategic skills. The latter allows an individual to make strategic choices and select the most convenient information, route, services and use of their data (Durand et al., 2021).

The third factor, 'cognitive appropriation', refers to the choice of using a specific service, which is informed by opinions, values, attitudes, and motivations. This is especially relevant regarding digital mobility services, such as many shared mobility services. Groth (2019) states that this factor is a crucial 'mental precondition' for individuals to engage with digital technologies and identifies five dimensions that enable it: the autonomy experienced by users; the flexibility of the service; the excitement that the use of such service produces; the impact on social status perception; and privacy-related concerns. In this regard, two main reasons that hamper the cognitive appropriation of an individual are highlighted in the literature. The first one is related to a lack of trust in the technology, and a fear of security, reliability, and privacy (Groth, 2019; Harvey et al., 2019). The second one is due to the lack of desire or interest in the technology, whether because the person does not know it or because the person does not want to use it (Zhang et al., 2020).

3 Methodology

This part of the research in the SmartHubs project was designed to answer the following research questions:

1. What are the barriers encountered by citizens when using mobility hubs and shared mobility?
2. What are the needs of vulnerable citizens regarding the use of mobility hubs and shared mobility?
3. To what extent are mobility hubs useful and attractive to vulnerable citizens?

This section describes the research design, the choices made throughout the process, and the analytical approach.

3.1 Research design

The research design was conceived by looking at previous research about transport disadvantages and shared mobility. The research approach adopted in this study is qualitative because it entails elements that can hardly be quantified, such as attractiveness and the meanings that people give to their use of transport and mobility hubs. Through a qualitative approach, in-depth insights into the experience and opinions of participants can be collected. Moreover, previous uses of the CA in transport studies have also adopted a qualitative approach.

The object of the study is the needs and barriers that vulnerable groups encounter to using mobility hubs, currently or in the future. This is because vulnerable groups are the users who face more disadvantages and difficulties concerning their mobility. In this regard, Kuttler & Moraglio, (2020) state that for vulnerable groups to benefit from transport services, their requirements, abilities, and motivations for mobility must be thoroughly understood. They highlight that any form of discrimination and marginalisation should also be considered.

The research design followed the stages and methods listed below:

1. Data collection
 - a. Interviews with 'experts': semi-structured interviews
 - b. Interviews with 'end-user': semi-structured interviews and focus groups
2. Analysis of transcripts: Software-based coding
 - a. Deductive coding: in the original language
 - b. Translation of coding results into English
 - c. Selection and reorganisation of findings

3.2 Data collection method

The data collection methods were selected by looking at the literature and adapting them to the experts' advice and the limitations experienced during the research. A sample was determined, considering that the study was performed simultaneously in four locations, the four living labs of the SmartHubs project: Anderlecht (Belgium), Munich (Germany), Rotterdam-The Hague (The Netherlands) and Eastern Austria. The choice of collecting data in these four locations corresponds to the area of study of the SmartHubs project, which is interested in the needs and barriers of users of European mobility hubs.

The first 'expert' sample participated through semi-structured interviews. The choice of conducting expert interviews served to shorten the data-gathering process and to gain access to the groups being studied (Bogner et al., 2009). The members of the groups studied, are referred to as 'end-users and they were interviewed in a second stage, through two methods: semi-structured interviews and focus groups. Interviews and focus groups were conducted in the four

locations previously mentioned, by eight researchers that performed the interviews and focus groups in three languages: Dutch, French and German.

3.2.1 Semi-structured interviews

Qualitative interviews are close to the approaches of interpretive sociology, and semi-structured interviews are particularly useful to understand the meanings and subjectivities (Flick et al., 2004). Furthermore, semi-structured interviews allow for adapting to unexpected reactions and findings during interviewing (Bryman, 2016).

The data collection process started by contacting persons related to the groups that were selected for the study. These persons were in some cases representatives, but most experts worked with vulnerable groups or within the fields that are closely related to these groups. This approach was intentional, as to obtain a more general understanding of the groups being studied, and also to facilitate the recruitment of participants for the interviews with end-users. The questionnaire (see Annex 1) was designed to identify the needs, barriers and motivations of vulnerable groups concerning mobility hubs. The semi-structured interviews contained 22 questions and they were expected to last less than 1 hour. Interviews were audio-recorded with the permission and informed consent of participants. The recording was transcribed and pseudonymised.

The interviews with 'end-users' were conducted after obtaining ethical approval from the Human Sciences Ethics Committee of the VUB. This approval was necessary due to the characteristic of the vulnerable groups included in the sample. The questionnaires of the interviews with end-users were designed considering the information and experience gained through the interviews with 'experts'. The questionnaire (see Annex 2) included 22 questions and interviews were expected to last less than 1 hour. Moreover, this questionnaire also included a Likert scale with 8 statements to be completed at the end of the interview. This Likert scale was aimed at comparing certain statements across groups and obtaining insights through a more quantitative approach. Interviews were audio-recorded with the permission and informed consent of participants. The recording was transcribed and pseudonymised.

3.2.2 Focus groups

The focus group method is an interview with several people at the same time, on a specific topic or issue, and interaction within the group enables to understand the joint construction of meaning (Bryman, 2016). The focus group contains elements of two other methods: the group interview, consisting of several people discussing certain pre-selected topics; and what is called a focused interview, in which interviewees are selected because they are affected by a particular topic (Kamberelis & Dimitriadis, 2013).

The use of focus groups as a methodology was advised by experts for the group 'migrants and ethnic minorities' because due to their language proficiency it would be difficult to recruit and interview participants individually. Moreover, due to cultural conditions, it could have happened that women within the area of study do not speak openly in the presence of male residents. Focus groups would allow participants to feel more comfortable, and participants with higher local language skills could translate the questions to other participants. Children and teenagers participated through focus groups, which enable them to freely engage in the debate while being solicited more informally and amusingly. No children under 10 years old were involved as their experiences with transport services might be limited and they might have difficulties reflecting on their experience.

In this study, focus groups were designed having several constraints in mind. For instance, the number of participants was not known in advance, as was the case of their level of literacy. Considering that groups were between 6 and 15 participants, it was important to be able to grasp the point of view of all participants, as it was expected that individuals with higher language

literacy and self-confidence would lead the debate. Thus, the focus groups were conceived to last 2 hours, being guided by a moderator and combining open questions to debate, with an individual structured interview. Due to practical considerations, the focus groups were not audio-recorded, but notes were taken by an observer. A paper questionnaire was used to guide the workshop, and it was explained at each step, allowing participants to openly ask questions about it, and obtain insights about their familiarity with the topic. The paper questionnaire also enabled the collection of data from participants that could not express themselves orally, and grasp the individual experiences of participants.

3.3 Sample

A total of 85 people participated in this study. Due to the aim of this study, two purposive samples (Weiss, 1995) were selected: experts and/or representatives of groups vulnerable to exclusion, and people belonging to one or more vulnerable groups that use mobility hubs or might potentially do it in the future. The first group is referred to as 'experts' and the second as 'end-users'.

Concerning the vulnerable groups included in the study, we have made a first broad selection that includes those groups mentioned in previous research (see section 2.1):

1. Children or teenagers
2. Digitally excluded citizens
3. Low-income citizens
4. Migrants or ethnic minorities
5. Informal caregivers
6. Older people
7. People with cognitive impairments
8. People with physical impairments
9. People with visual impairments
10. Peri-urban and rural inhabitants
11. Socially isolated citizens
12. Women

3.3.1 Experts

Experts are herein considered individuals who due to their professional activity, their social engagement, or their position in a community, have in-depth knowledge about the group being studied. In this regard, the experts interviewed were mainly professionals belonging to the groups being studied or working closely with such groups. For instance, social workers, coordinators of civic organisations and public officials were the experts included in this sample. For the interviews with experts, the selection of vulnerable groups to be studied included the 12 groups previously listed. This was to allocate as many groups as possible to obtain a more comprehensive overview of the different forms of disadvantages encountered by (potential) users. The sample of experts on vulnerable groups included 22 participants that have in-depth knowledge about one or more vulnerable groups. Table 1 shows the semi-structured interviews conducted with 'experts', indicating the group, the location, the date and the language of the interview.

Table 1. Expert interviews

Group	Location	Date	Language
Children	Eastern Austria	09/02/2022	German
Digitally excluded citizens	Rotterdam-The Hague	13/01/2022	Dutch
Digitally excluded citizens	Anderlecht	11/02/2022	French
Low-income citizens	Rotterdam-The Hague	13/01/2022	Dutch
Low-income citizens	Rotterdam-The Hague	20/01/2022	Dutch
Low-income citizens	Eastern Austria	28/02/2022	German
Migrants and ethnic minorities	Rotterdam-The Hague	20/01/2022	Dutch
Migrants and ethnic minorities	Rotterdam-The Hague	20/01/2022	Dutch
Migrants and ethnic minorities	Anderlecht	21/01/2022	French
Migrants and ethnic minorities	Munich	08/02/2022	German
Informal caregivers	Anderlecht	16/02/2022	French
Older people	Anderlecht	24/01/2022	French
Older people	Rotterdam-The Hague	22/02/2022	Dutch
People with cognitive impairment	Munich	10/02/2022	German
People with cognitive impairment	Munich	28/02/2022	German
People with physical impairments	Rotterdam-The Hague	11/01/2022	Dutch
People with visual impairments	Munich	21/01/2022	German
People with visual impairments	Munich	01/02/2022	German
Peri-urban and rural inhabitants	Eastern Austria	22/02/2022	German
Peri-urban and rural inhabitants	Eastern Austria	04/03/2022	German
Socially-isolated citizens	Munich	11/02/2022	German
Women	Anderlecht	15/02/2022	French

3.3.2 End-users

End-users are considered all individuals that currently, or in the future, would use mobility hubs. The findings of the interviews with experts have been used to reconsider the categories of vulnerable groups to include in this second sample. Thus, the number of groups was readjusted due to several reasons. Firstly, low-income citizens were identified among many other groups. Income-related barriers and needs were thoroughly identified with the first round of interviews and a certain degree of saturation was already reached. Similarly, due to their circumstances, two other groups were excluded because the characteristic that makes them vulnerable can hardly be addressed through the design of mobility hubs: socially isolated citizens and informal caregivers. As a result, nine groups were included in the sample of ‘end-user’ interviews:

1. Children or teenagers
2. Digitally excluded citizens
3. Migrants or ethnic minorities
4. Older people
5. People with cognitive impairments
6. People with physical impairments
7. People with visual impairments
8. Peri-urban and rural inhabitants
9. Women

The sample of end-users included 63 participants which were involved through two main approaches: semi-structured interviews and focus groups. 21 participants were interviewed and 42 participated in four focus groups. Two focus groups were conducted with ‘migrants and ethnic minorities’; a mixed group of 8 people, and a group of 13 women. And two ‘children and teenagers’; one with 15 children (10-12 years) and one with 6 teenagers (12-17 years). The focus groups were conducted in Anderlecht, the main language used was French and they took place on February 17th, May 23rd and 25th, and June 22nd 2022. Table 2 shows the semi-structured interviews and focuses groups conducted with ‘end-users’, indicating the group, the data collection method, the location, the date and the language of the interview.

Table 2. End-user interviews

Group	Method	Location	Date	Language
Children and teenagers	Focus group	Anderlecht	23/05/2022	French
Children and teenagers	Focus group	Anderlecht	22/06/2022	French
Digitally excluded citizens	Interview	Anderlecht	07/06/2022	French
Digitally excluded citizens	Interview	Anderlecht	16/06/2022	French
Migrants and ethnic minorities	Focus group	Anderlecht	17/02/2022	French
Migrants and ethnic minorities	Focus group	Anderlecht	25/05/2022	French
People with cognitive impairments	Interview	Munich	06/05/2022	German

People with physical impairments	Interview	Rotterdam-The Hague	03/05/2022	Dutch
People with physical impairments	Interview	Rotterdam-The Hague	03/05/2022	Dutch
People with visual impairments	Interview	Munich	06/05/2022	German
People with visual impairments	Interview	Munich	10/05/2022	German
People with visual impairments	Interview	Munich	31/05/2022	German
People with visual impairments	Interview	Munich	13/06/2022	German
Peri-urban and rural inhabitants	Interview	Anderlecht	23/03/2022	French
Peri-urban and rural inhabitants	Interview	Eastern Austria	22/02/2022	German
Peri-urban and rural inhabitants	Interview	Anderlecht	16/06/2022	French
Older people	Interview	Anderlecht	16/06/2022	French
Older people	Interview	Anderlecht	20/06/2022	French
Older people	Interview	Anderlecht	20/06/2022	French
Women	Interview	Eastern Austria	16/05/2022	German
Women	Interview	Eastern Austria	19/05/2022	German
Women	Interview	Eastern Austria	31/05/2022	German
Women	Interview	Eastern Austria	01/06/2022	German
Women	Interview	Eastern Austria	16/06/2022	German
Women	Interview	Eastern Austria	17/06/2022	German

3.4 Analytical process

The analytical approach adopted in this study is qualitative content analysis. The qualitative content analysis aims to classify text-based information following rule-based systematic principles. This approach allows the identification of relevant information in the text that enables answering the research questions (Mayring, 2015). Thus, the first requirement to conduct qualitative content analysis is to have a classification system, which is obtained through the coding process.

Codes provide the classification system for the analysis of qualitative data. Codes represent different concepts, which are related to the research topic, and may refer to processes, attitudes or beliefs that represent human activity (Coffey & Atkinson, 1996). The coding approach of this study is deductive, because the codes used were predefined, being obtained through the theoretical framework and research questions. The selected codes refer to the needs and barriers regarding material access, cognitive appropriation and skills (see section 2.2) concerning different elements of mobility hubs (e.g., shared mobility, digital mobility, multimodality...). Moreover, certain characteristics of the groups or individuals participating in the study are also coded, such as the current use of transport, the goal of their mobility and demographics. The complete list of codes used to analyse the data collected can be found in Annex 1 and Annex 2.

The execution of the analytical process has been done by the researchers of the VUB, authors of this deliverable. The analysis was software-based, using Nvivo (version 1.6.1), to systematically code specific quotes from the transcripts of the interviews. The coding process has been conducted in the original language of the interview, which was maintained in the transcript. This has been done to enable the understanding of nuances related to language that might be lost through translation. The predefined codes have been used to reorganize data in a way that facilitates interpretation and enables the retrieval of categories that are analytically useful to the study. Consequently, the data has been reduced, making the text more manageable and addressing the research question (Moser & Korstjens, 2018).

The data resulting from the previous processes has been translated into English, so it could be understood by all authors. The translation was conducted when the data was already coded to ensure the accuracy of the coding process and to avoid translating unnecessary quotes. The translation was analysed again, guided by the resulting codes and categories. During this phase of the analysis, codes are used to help re-assemble data in ways that enable a coherent and revised understanding or explanation, adopting an interpretive approach. Through this process, redundant and most relevant elements have been identified while placing them within the analytical framework (Sandelowski, 1995).

4 Results

This study was divided into two stages and therefore, two main samples were considered: 'experts' and 'end-users'. The results of the interviews conducted with 'experts' are presented in the section below. The findings of the interviews with 'end-users' are then presented separately in section 4.2 and both findings are compared in section 4.3.

4.1 Experts

The twelve sections below summarise the findings obtained concerning each of the groups considered in the first round of interviews. Each section explains the main disadvantages encountered by these groups when using transport services, followed by specific barriers and needs concerning mobility hubs, shared mobility and digital mobility services.

4.1.1 Children and teenagers

According to experts and representatives of children and teenagers, the disadvantages that this group encounters are related to their age. Members of this group are minors, and most of them cannot autonomously decide about their mobility and cannot drive a motorized vehicle. However, members of this group travel daily, mainly to go to school and do after-school activities. Thus, this group especially benefits from active mobility and public transport, being the latter sometimes subsidized for this group. The main barriers encountered by this group are economic and sociocultural since most of them depend on their parents or guardians to purchase a ticket and book a service. The understanding of information, such as text, boards, and announcements, can also be difficult for some members of this group. Although it depends on the age, spatial distribution and physical barriers (e.g., distance to a near stop, stairs...) are also relevant for this group because they may complicate the use and access transport services. Moreover, the latter may result in traffic safety risks, which can also result in fears that limit their mobility.

Concerning mobility hubs, safety is considered especially relevant for children and teenagers. Lighting, barriers, and intersections must be considered. For this group, perceived safety is as important as real safety. The usability of physical elements (e.g. position of buttons, screens...) is central for younger members of this group. Likewise, the language used in signage, digital interfaces, screens, and announcements must be simple and easy to understand. Shared mobility services that are useful for this group are mainly e-scooters and (e-)bicycles. Although digital skills are well-developed among members of these groups, especially among teenagers, when low digital literacy occurs, it often overlaps with low language literacy. Digital mobility services are useful for this group as far as they have a smartphone, internet connection, and the resources to book and pay for the services (e.g., access to a credit card). However, the legal and economic constraints related to age, difficult the use of shared mobility and digital mobility services by this group.

4.1.2 Digitally excluded citizens

The most recurrent barriers faced by this group are sociocultural factors. Since the use of digital tools is increasingly required to access transport services, people that have not developed digital skills encounter major difficulties. For instance, buying a transport ticket or booking a transport service often cannot be done without using a smartphone, a laptop or a ticket machine. Digitally excluded citizens often do not have digital devices or internet connection, and some do not have credit cards that are often required to pay for digital mobility services. Thus, digitally excluded citizens may also feel incapable to use a service that is highly digitalised. Likewise, the fear of scams, or choosing the wrong ticket taking the wrong vehicle increases when information is not

provided by non-digital means. Since this group is not used to working with digital tools, they need more time to do every necessary step to use a service, and they often require assistance from other passengers or staff.

Concerning mobility hubs, this group would benefit from assistance from a person, and/or a ticket office where they can buy their ticket and ask for information. A waiting or sitting area within a hub would also allow people with digital skills to find other users that are waiting and can assist them with the use of those services requiring digital skills. Likewise, timetables and maps that are visible at stations would be helpful. Thus, communication and signage must be simplified (e.g. with pictograms, pictures and limited use of text) for this group to find their way and access services easily. To encourage digitally excluded citizens to use digital interfaces, these should be made also simple and intuitive. Furthermore, digitally excluded citizens tend to get motivated to acquire digital skills when they find it necessary to fulfil a goal, and they have the tools and support to learn. Shared mobility services could propose some form of learning opportunity for users that might find such services useful. Nonetheless, if the services can only be booked or paid with a credit card, some digitally excluded citizens will not be able to use them.

4.1.3 Low-income citizens

The main difficulties for this group when using transport are related to the costs and resources necessary to access the services (e.g., having a bank account and a credit card). This group tends to use active modes of transport, especially walking, because they are more affordable. Likewise, public transport is widely used by the members of this group that can afford it. Low-income citizens do not always have a smartphone, internet connection at home, bank account or credit card. Another relevant barrier is related to socio-cultural factors because low-income citizens often also have low levels of education and/or a migrant background. Thus, proficiency in the local language, as the understanding of complex texts and uncommon words, may be limited. Furthermore, having limited resources brings members of this group to adapt and have less costly lifestyles, such as staying often at home and close to their residential locations.

Concerning mobility hubs, the information provided related to the services offered in the hubs should be simple and understandable by users with low language literacy, so they do not struggle when using the hub. Moreover, offering free Wi-Fi within the mobility hub would help users with a smartphone but without a data subscription to access information and use the services provided at the hub. Shared mobility services, such as shared cars, could be useful for members of this group. However, it might be necessary to subsidise these services because the costs of the services may be too high for them. The payment terms of shared mobility subscriptions are important for this group. For instance, subscriptions that require paying 6 or 12 months in advance may result in an amount that cannot be paid with a single purchase. People with low income would benefit from shared mobility subscriptions that are not linked to bank accounts or credit cards, that are flexible (e.g., personalised or without a contractual duration) and that do not require the use of a smartphone.

4.1.4 Migrants and ethnic minorities

The main barriers encountered by this group are socio-cultural and economic. The socio-cultural barrier relates to the use of language and behaviour that is culturally embedded. For instance, first-generation migrants do not always master the local language sufficiently to use transport services autonomously and confidently. Migrants and ethnic minorities often have limited incomes, which makes them wary of their spending. In this regard, people from this group tend to stay within their residential areas, and active mobility is attractive for people from this group because it is often the cheapest mode of transport. Likewise, owning a smartphone, a laptop or an internet connection at home is not always financially possible for members of this group, and due

to cultural differences, the use of bicycles is not common in some cases. Therefore, some members of this group also lack the necessary skills to use digital mobility services or ride a bicycle.

Concerning mobility hubs, shared mobility options such as cars, e-scooters and e-bikes could be useful for this group. Regarding signage and communication, as little text as possible should be used, while symbols, pictograms and numbers are encouraged. Likewise, digital interfaces should be made as simple as possible, and assistance from a person within the mobility hub would be also helpful for migrants who lack local language and digital skills. Moreover, due to limited financial resources, members of this group could benefit from subsidised ticketing schemes, and access to free Wi-Fi within the mobility hub. And nonregistered migrants, who often do not have a credit card and who cannot ask for subsidies due to their legal situation, require affordable and unproblematic access to transport services to reach highly necessary destinations and opportunities. Furthermore, main mobility hubs located in more dense and central areas might be used as a shelter, and even as sleeping areas, for migrants in precarious economic situations. The design of such mobility hubs should consider this. Services such as restrooms, changing rooms and lockers might be useful for these users as well.

4.1.5 Informal caregivers

The main barriers that this group faces concerning transportation are related to economic resources and the physical environment. Firstly, informal caregivers often have less time available because they spend time taking care of someone else. This has an impact on their level of income and available time to do other things. Moreover, this group often spends money purchasing things, and specific devices, for the person they are taking care of. Secondly, physical barriers are challenging for this group, who often transport or support a person with reduced mobility. Thus, some informal caregivers need adapted vehicles and on-demand services to do door-to-door trips.

Although the use of mobility hubs does not seem convenient for some members of this group, some elements would facilitate their use of the vehicles and facilities. For instance, barrier-free environments are crucial for this group, because informal caregivers sometimes travel with people with reduced mobility or in a wheelchair. Likewise, having the possibility to be assisted by someone that can help push the wheelchair and do the transfer and/or change of vehicle, can be also necessary. Adapted toilets, waiting rooms, benches and lockers might be also helpful for this group. Concerning shared mobility, services that are affordable and do not require maintenance can be useful for this group because informal caregivers often lack the time and financial resources to have and maintain a vehicle of their own. Nonetheless, in some cases, the vehicles need to facilitate the entrance of a person with reduced mobility or in a wheelchair.

4.1.6 Older people

This is a heterogeneous group, in which members encounter physical barriers, but also economic and sociocultural ones. The first type of barrier concerns access to facilities and vehicles, such as stairs, uneven pavements, or the lack of handrails. Likewise, some members of this group cannot drive anymore due to their physical ableness and health. Economic barriers are encountered by members with low incomes, which are often limited to state pension. Although public transport subscriptions for this group are often highly subsidised, this group encounters difficulties when having to pay the yearly subscription in a single purchase, which becomes too big of an amount. Shared mobility services are also often not included in the subscription. Lastly, sociocultural barriers relate to the digitalisation of transport services, which is a limitation for some members of this group. In addition, some members of this group suffer from limited physical and/or cognitive abilities, which limits their capacity to independently conduct all tasks required to use transport services. The members of this group also experience increased feelings of vulnerability,

increased stress under unexpected situations, and limited motivation to perform unknown tasks or to travel when not necessary.

Concerning mobility hubs, members of this group would not find them useful as a starting point for their journey if they are located too far from their homes. For this group, reliability and accessibility are very important. A barrier-free, step-free and self-explanatory design of facilities and vehicles in which they can sit is necessary. Likewise, public toilets, benches, and sheltered waiting rooms that are safe, and perceived as such, are recommended. This group would benefit from assistance and being able to buy the ticket at a ticket office, or a highly simplified ticket machine. Furthermore, information, signage and wayfinding should be made simple, self-explanatory, and adapted to people with visual and hearing impairments, so members of this group can find their way autonomously and unproblematically. Regarding shared mobility, the data collected does not allow us to clearly know if members of this group would broadly use them. Lastly, digital mobility services are considered useful for this group, as older people are increasingly acquiring digital skills for the services they consider necessary, such as planning a trip and booking a service. Nonetheless, this group would benefit from training and on-going support regarding digital mobility services.

4.1.7 People with cognitive impairments

People with cognitive impairments often face barriers concerning the physical environment and the spatial distribution of transport services. For instance, orientation might be difficult for this group, as well as carrying out the necessary tasks to use a service (e.g. buying a ticket, checking schedules...). Some members of this group can get over-stimulated by their environments, such as noise, lighting, crowding, and unexpected situations (e.g., delays or cancellations). Furthermore, this group can experience disadvantages related to language and the understanding of information, requiring additional time to perform tasks (e.g., looking for necessary information, booking a service...). This often leads to low or no digital skills. The unfamiliarity with digital devices and the fear of scams may prevent this group from booking a service online. Lastly, some members of this group cannot buy a transport ticket or book a service themselves, which can limit their mobility considerably.

Regarding mobility hubs, self-explanatory wayfinding and unproblematic signage are crucial for this group, and the use of pictograms and pictures is highly recommended. The necessary information, such as schedules or real-time updates, should be provided with as little text as possible, printed or shown permanently on a screen, and easy to read. The hub should be designed to avoid overcrowding and enable easy interchanges. Likewise, the transport network and network maps should be made simple to avoid misunderstandings. Additional features of mobility hubs that are helpful for this group are waiting rooms with benches, adapted toilets and secured areas, where they feel safe. People with cognitive impairment often need assistance or training to use a mobility hub, especially the first time. It is unclear to what extent people with cognitive impairment can benefit from shared mobility services, beyond public transport services, or services with a driver, because in many cases they cannot drive themselves and if they can, they need adapted vehicles or additional features that are costly. Furthermore, they may require dedicated subscription packages with prepaid cards.

4.1.8 People with physical impairments

This group mainly faces disadvantages related to the physical environment, such as stairs, e-scooters blocking the sidewalk, lifts that are out of service or dirty, and people crowding. The spatial distribution of transport services is also relevant for this group, who prefer using services located near their residence.

Concerning mobility hubs, they should be barrier-free, ideally on a single floor, and providing a self-explanatory and simple environment. For some members of this group, vehicles need to be adapted for people in wheelchairs. Moreover, for people with a hearing impairment, audio announcements are problematic. Thus, having the possibility to read what is said is relevant, such as knowing when the next vehicle arrives, and service disruptions. People with reduced mobility can benefit from a map of the mobility hub showing where the different services are provided, to conveniently reach them. Regarding shared mobility, it is unclear to what extent it can be useful for this group, as many members of this group cannot drive or cycle. People with reduced mobility may especially benefit from on-demand services and ride-sharing. However, this group is very heterogeneous and the needs differ between individuals. Lastly, digital mobility services are useful for the members of this group that are digitally literate. However, digital skills vary among members of this group, with a lower prevalence in older adults.

4.1.9 People with visual impairments

The main barriers for people with visual impairments are related to the physical environment, the spatial distribution of transport services, and potential obstacles (e.g., stairs, bollards, street furniture, garbage...). As in the case of people with physical impairments, members of this group often require assistance, whether from a person or a guide dog. The transport mode most used by members of this group is public transport, such as buses, trams or metro, and people with visual impairments tend to only use stops or mobility hubs that are close to their residential locations. Moreover, changing from one mode to another can be difficult for some members of this group, especially if the connection is long and complex. People with visual impairments can use navigation apps with audio instructions, but this requires owning a smartphone and the necessary digital skills. Digital literacy is not common among all members of this group, because many apps and interfaces are difficult for them to use, requiring training, and audio guidance at every step. Likewise, booking a service or buying a ticket can be problematic for this group, which often requires the assistance of a person, via phone or physically.

Mobility hubs should be barrier-free for people with visual impairments to move unproblematically. Signage situated at eye level can be helpful for members with a partial impairment, who could read them by getting closer to them. Self-explanatory spaces, adequate lighting, the use of colours, and audio announcements are crucial for this group. These announcements are helpful, for example, to indicate where the stairs are located, to know when a crossing light is green, and to obtain the necessary information to travel. The inclusion of the mobility hub, and the transport network, in existing audio-guided navigation apps for people with visual impairments, is important, and should be done accurately and include information necessary for using the transport service (e.g., disruptions in the service, when the next vehicle arrives and the different destinations). The design of a mobility hub should take into account interchanges, making them as simple as possible, and including tactile guidance paving, to allow people with visual impairments to move autonomously. Members of this group may require training on how to use a mobility hub, and assistance by a person could be also beneficial (e.g., when disruptions in the service and the provision of information). For instance, guide dogs are essential for some members of this group, and the facilities and transport operators should ease access to such dogs. Regarding shared mobility, the data obtained does not allow us to know to what extent it can be used by members of this group, for whom public transport might be a more convenient alternative.

4.1.10 Peri-urban and rural inhabitants

The main barriers encountered by this group are related to the spatial and geographical distribution of transport services. The residential location of members of this group can be far from public transport stops, and trips to necessary destinations can require several changes and

result in longer travel times. Furthermore, transport services provided in peri-urban and rural regions are less frequent and mainly limited to working hours, and when disruptions and problems occur, they may take longer to be fixed. Economic barriers are also relevant since the cost of transport to commute daily is more prominent than for urban residents.

Mobility hubs can be useful for peri-urban and rural residents if the transport service (e.g. train, bus or metro) can rapidly take them to the centre of the closest main city. Public transport in low-density areas faces the challenge of a lower number of users and often empty vehicles. While shared mobility such as shared bikes could be convenient for residents that leave near a mobility hub, their use will be constrained by the limited number of other hubs to which the bicycle can be returned. Car-sharing is considered to have a relevant potential for members of this group that do not need to use a car every day. The type of subscription and the flexibility of such subscriptions are crucial for members of this group, as is the possibility to use the service without digital devices. Shared e-scooters are not considered very helpful because paths are often not adequate for these vehicles in low-density areas due to their low maintenance. Concerning the facilities, parking spaces for cars and secured bicycle parking are very relevant for this group. Likewise, a shelter for rain or snow could be helpful in case they need to wait longer.

4.1.11 Socially isolated citizens

This group suffers mainly from economic barriers because their social isolation tends to be related to lower levels of employment and, consequently, income. The preferred mode of transport of this group is often walking, and socially isolated citizens tend to stay in their residential areas. This group faces barriers that are similar to the ones encountered by low-income citizens, such as the lack of economic and material means to use transport services. Concerning social interactions, members of this group might be afraid of asking for help or show they are struggling to use the service, which prevents them from asking for information and assistance. Furthermore, often members of this group have low digital literacy skills, which limits the number of transport services they can use.

Regarding mobility hubs, the data obtained does not allow us to know to what extent members of this group would make use of them. Nonetheless, the design and wayfinding of the hubs should be self-explanatory. Communication and information provided should be made as simple as possible so they can autonomously use it without having to ask for assistance from anyone else. Time schedules and the necessary information to use the hub should be provided in a very simple manner, printed or permanently shown on a screen. Moreover, socially isolated people could require an explanation of how the hub and the different services can be used before they try them by themselves. Concerning shared mobility services, bikes and cargo bikes could be useful for this group, because they don't require a driving license and the cost could be lower. Due to the lack of financial means, subsidies would be helpful for some members of this group. Lastly, mobility hubs could be conceived in a manner that enables social interactions and create public spaces where members of this group can meet other people and feel socially included.

4.1.12 Women

The main barriers for this group are socio-cultural, resulting from values and opinions associated with gender. Women also have more fragmented mobility and do more trips during the day, such as going to work, bringing children to school, and doing groceries. This results in trips in which they carry bags, have a trolley or travel with a child, facing all the physical barriers related to stairs and paving. Furthermore, migrant women from certain cultures may lack cycling skills because they have never received training, or because cycling may not be socially acceptable for women in their communities. Personal security and perceived safety are also relevant for women, as they are more frequently harassed or aggressed than men.

Mobility hubs are considered useful for this heterogeneous group to the extent that they can provide safe and reliable facilities, avoiding dark and desolate corners. Good lighting, self-explanatory design of spaces and vehicles, and cleanliness of facilities are relevant for some members of this group and can increase the feeling of safety. Likewise, human presence, such as an information desk or ticket office can also be helpful in this regard. Clean and functional toilets and safe waiting rooms would be useful for this group. Due to the diversity of this group, it is unclear what shared mobility services are preferred, as to digital mobility services that would be used depending on other aspects than gender (e.g., age, physical ableness, residential location...). Regarding cycling, some members of this group may benefit from cycling lessons in which they could learn how to use (shared) bicycles as well as other services of the mobility hub.

4.2 End-users

The following sub-sections refer to each of the groups considered in the sample which are listed in section 3.3.2. However, the three groups concerning people with impairments have been merged into a single group, reducing the total number of groups to seven

4.2.1 Children and teenagers

“Sometimes, when there are too many letters, numbers and signs, the signage is difficult to understand.” – Statement from a teenage participant.

4.2.1.1 Children

The main barriers for this group are related to their economic autonomy and their decision-making power. Although most of the participants from this group do not travel alone, they have a subscription to the local public transport network, with which they are familiar. Children are familiar with transport network maps and navigation apps, which they have already used. Concerning active mobility, all participants indicated to own a bicycle and that they like using it. However, traffic safety is a concern that limits their use of bicycles.

Some participants know what mobility hubs are and have already used them. Security and perceived safety are very relevant for this group, as the cleanliness of transport facilities and vehicles. Regarding digital skills, although this group is very familiar with digital devices and they know how to scan a QR code, they are not so familiar with touchscreens kiosks. It is unclear to what extent shared mobility services can be useful for children because they do not independently decide about their mobility and current services do not allow them to legally use them.

4.2.1.2 Teenagers

All participants from this group use public transport on their own, know how to cycle, can buy a public transport ticket, and use the maps found in public transport stations. The main barrier for this group is related to economic resources because many of them are not financially independent and depend on their family or guardians.

Teenagers are not familiar with the term mobility hub. However, they are familiar with the different modes found at mobility hubs and use some shared mobility services, but they do not find mobility hubs useful for them because they prefer dock-less services that can be found next to their homes. Likewise, they prefer to avoid crowding and the control or surveillance that might

take place at mobility hubs. Although all participants often take multimodal trips they prefer trips that do not require changing transport modes. Most participants use signage, and information provided through screens at stations, and the local network transport app to find their way, but signage is still helpful for them. However, signage and information boards can be difficult to read for them, when there are too many elements and text. A majority of participants do not show enthusiasm about mobility hubs and the possibility of using or co-designing a mobility hub.

Regarding shared mobility and multimodality, all participants have already used shared mobility solutions. Shared e-scooters and mopeds are the preferred shared mobility services because these modes are considered to be faster and more attractive, and their friends also use them. Although they know of the local docked shared bicycle service, they have never used it.

Concerning digital skills, all participants have a smartphone and most of them use navigation apps, such as the one from the local transport provider. They also know how to scan a QR code.

4.2.2 Digitally excluded citizens

“The first time I use a mobility hub, I would like to go with someone that can help me. Like that, after two or three times, I would get used to it and I could use it by myself. But I would not try it on my own.” –
Statement from a participant with low digital skills.

The main barriers for this group are related to a lack of digital skills which complicates their use of more digitalized modes of transport and their navigation within the transport network. Other barriers that hamper the use of digital tools are related to a lack of financial resources, such as not owning a laptop or not having an internet connection at home.

Regarding mobility hubs, although participants from this group do not know what a mobility hub is, they have used it and they are familiar with multimodality. Since members of this group rely on their previous experience and the presence of non-digital signage, information screens and/or printed maps are very relevant. Participants also stated that they prefer to travel autonomously and do not want to rely on support from others when travelling by public transport.

Concerning shared mobility, respondents know about the local bike and e-scooter sharing services, but they do not find them attractive or convenient for them. However, participants from this group expressed that they could be open to changing to other modes of transport if these modes would improve their accessibility.

The lack of digital skills might be a decisive barrier for this group to use mobility hubs and digital shared mobility services. In this regard, participants acknowledge that they could benefit from improving their digital skills and that they have access to courses to do so, but sometimes they prefer to stick to their habits and what they already know. To adopt digital mobility services, participants should find such services useful for them and they would need support to learn how to use them.

4.2.3 Migrants

“When I travel alone, I need the assistance of someone at the station to plan my trip and to purchase the ticket because I don’t know how to do it myself.” – Statement of a migrant participant from Morocco.

4.2.3.1 *Mixed group of migrants*

The main barriers for this group are sociocultural, such as having difficulties understanding the local language, in oral and written forms. Likewise, economic barriers are also relevant for this group. For instance, some participants state that transport for them is too expensive, and other participants do not have credit cards, a laptop, or a tablet. Thus, the most used mode of transport for this group is public transport and walking.

Although most participants do not know what a mobility hub is, all of them have been at a mobility hub and they think that mobility hubs are useful for them. Participants would like to have a mobility hub near their place of residence, but they would need some form of support to use the services found at the hub for the first time. Participants rely on signage rather than navigation apps, to find their way, to know the schedules, to know what line they should take and the destination. Signage with little text and more numbers and pictograms is crucial for this group.

Regarding shared mobility, participants know only about the local sharing service and have not used it. Moreover, they are not sure if shared mobility services are useful for them.

Most participants stated that they do not use digital mobility services and have limited digital skills. For instance, they do not know how to buy a transport ticket online, how to use a QR code, how to book a mobility service, or how to use touchscreen kiosks.

4.2.3.2 *Migrant women*

The main barriers for this group are sociocultural, due to language barriers, cultural differences, and the lack of digital skills, and economic, such as the cost of transport and not having access to a private car. Participants mainly travel by public transport and walking and although most participants do not have a driving license, they state that they would like to travel more often by car. Cultural barriers, and the lack of knowledge about transport services and the network, lead most participants from this group to not be autonomous and rely on someone from their family or someone at the transport stop to plan their trips, buy a ticket or even perform the trip. Lastly, many participants stated that it is difficult for them to get around the city.

Concerning mobility hubs, most participants do not know what they are, but many participants could only use them if someone assists them in using the hub, buying a ticket and booking a service. As they cannot use their smartphone for their mobility, due to the lack of internet connection or digital skills, signage and non-digital information are crucial for this group. Since they have difficulties with the local language, reading maps and situating themselves in an unknown space, signage, wayfinding and communication (e.g., audio announcements) should be made simple and as clear as possible (e.g., using pictograms, colour codes, numbers...).

Participants have little knowledge of and no experience with shared mobility, and a majority of participants do not know if shared mobility can be useful for them. Although most participants do not know how to ride a bike, some would like to learn it. Thus, training about how to ride a bike and use the bike-sharing service might be useful for this group.

Regarding digital mobility, members of this do not know how to use digital tools and most of them do not think that digital mobility services are useful for them. Moreover, most participants do not know how to use navigation apps (e.g., google maps, mappy or local transport providers apps) or buy a ticket online.

4.2.4 *Older people*

“Every now and then, the elevators and mechanical stairs are out of order, and this is very problematic for me. I also need to be able to sit

down when I am tired, and often there is no place to sit.” – Statement from an older participant.

The main barriers for this group are socio-cultural (e.g. digitalization, implementation of new technologies or perceived safety) and related to the physical environments, such as difficult access to vehicles and facilities, or having to walk long distances. The lack of knowledge about how to use a transport service is also considered a barrier, and limited physical abilities might prevent old people from using bicycles and e-scooters. Lastly, perceived safety and security are highly relevant for this group to the extent that a lack of safety and security can prevent them from using certain modes or even from travelling.

Mobility hubs are useful for this group because participants are familiar with multimodality. The design of mobility hubs should be barrier-free and self-explanatory. In mobility hubs that have more than one floor, the availability of working mechanical stairs and lifts is crucial for this group. Otherwise, changing from one mode to another might be too difficult for some participants. To facilitate multimodality for older bike users, access to vehicles with the bike should be eased (e.g., elevator with space for bikes, bike storage in vehicles...). Likewise, signage must be made simple and self-explanatory to avoid older users getting disoriented and confused when using mobility hubs. Participants from this group stated that they would prefer that staff is present at the hub to inform them, help them use the services and to grant the security of users. Perceived safety and security are relevant for this group, and mobility hubs should be designed accordingly, and well-maintained (e.g., cleanness, lighting, visibility...). As for additional facilities, a waiting room with seating and public toilets are also considered necessary.

Concerning shared mobility, participants from this group do not find e-scooters attractive and they explain that local bike-sharing is not convenient for them because bicycles are too heavy, the services are non-reliable and too expensive. Although most participants do not find car-sharing necessary for their mobility, car-sharing could be more attractive and useful if the subscription packages were more flexible. A participant states that the monthly fee is too expensive when only using the service a few times per year. Parcel lockers are not considered useful, because participants prefer to receive their parcels at home. Lastly, it is suggested to add ride-sharing and on-demand bus services to the hub, which are considered useful to reach destinations that public transport does not reach, or when the frequency is very limited.

Digital mobility services are known and used unevenly within this group. Some participants have well-developed digital skills while others do not. Participants know how to do online payments and they have done so before. However, they prefer to avoid paying online because they are concerned with the security of online payment platforms and the protection of their personal data. They prefer to buy tickets at an office or a ticket machine, and they appreciate having a yearly subscription that does not require them to buy individual tickets. Lastly, participants from this group showed interest in improving their digital skills but they state that they would need assistance and support to improve said skills.

4.2.5 People with impairments

“You have to call the train operator in advance because the trains are not wheelchair accessible. Sometimes the platform is wheelchair accessible, but there's no assistance... You always need to figure this out.” – Statement from a participant with reduced mobility.

The group 'people with impairments' includes people with cognitive impairments, physical impairments and visual impairments that participated in semi-structured interviews. The main barriers for this group are related to the physical environments, the spatial and geographic distribution of transport facilities and destinations, and sociocultural factors. Mobility hubs, shared mobility and digital mobility services are considered useful for members of this group to the extent they are accessible and adapted to their capabilities. Participants from this group also showed a high level of openness to change and to trying other transport services.

4.2.5.1 Cognitive impairment

Main barriers for this group concern the spatial and geographic distribution of transport facilities and destinations. For instance, if accessing a destination is not easy and comfortable, this will difficult their trip to the extent of deciding to not make it. Furthermore, this group also faces sociocultural barriers related to the provision of information, the functioning of the services and digitalisation. For instance, the use of language, the management of disruptions in the services, and the design of the digital interfaces often neglect the needs of this group. It is relevant for the members of this group to feel certain and safe about their trip and the modes of transport they use. Participants from this group also refer to the convenience of using public transport and their limitations when using digital devices.

Regarding mobility hubs participants from this group prefer intuitive and clear pathways, leading to their desired mode of transport in a self-explanatory manner. Complex mobility hubs with several pathways, corridors and floors might be confusing, especially for users that do not travel through them regularly. Signage and wayfinding are highly relevant for this group, to enable multimodality and increase their autonomy and perceived safety.

Concerning shared mobility, bicycles and scooters might be useful for some users with cognitive impairments. However, such users prefer having their own vehicle so they can always access it when necessary, avoiding uncertainties, potential breakdowns and related stress. Furthermore, some people with cognitive impairments cannot ride a bicycle or a scooter and might need to use transport accompanied by someone else.

Digital mobility services should be adapted to people with cognitive impairments, being made more intuitive and easy to understand. An app where all services from all transport providers are reunited (e.g. booking, planning a trip, buying a ticket...), with a simple common interface, is recommended because users with cognitive impairments would only need to learn and use a single app. However, the adaptation of the interfaces of digital mobility services might be useful only for some members because, for some others, potential hazards and exterior circumstances (e.g., disruption in the service, delays, safety concerns...) might prevent them to use such services anyhow.

4.2.5.2 People with physical impairments

Although participants encounter barriers mainly related to the physical environment, sociocultural barriers are also commonly faced by this group. Physical obstacles are very problematic for this group, including obstacles in the public space (e.g., furniture or abandoned objects, such as e-scooters or bicycles). Crowded spaces and narrow corridors are problematic for the participants. People with physical impairments can use public transport services if they are accessible and provide a place to sit or to place their wheelchair. If they cannot perform one necessary step, such as reaching the stop, the platform, or the vehicle, they will hardly be able to use the service. For instance, when one of the steps cannot be performed autonomously, participants need assistance, which often has to be asked in advance by the transport operator. Furthermore, public transport vehicles should provide space for more than one wheelchair or trolley, to prevent people in a wheelchair to wait for vehicles with available space. One participant

explained that they cannot hold a smartphone or use a touchscreen, which hampers the possibility of independently looking up information or booking a service.

Concerning mobility hubs, participants have not heard about this term but when explained, they believed they could use mobility hubs if they are accessible. In this regard, self-explanatory environments and step-free facilities are crucial for the participants. If a hub has several floors, available working elevators should be granted. Ticket machines, information and signage should be conceived having in mind people in wheelchairs and the maximum height that their hands and sight can reach comfortably. Likewise, information should be provided without having to use a smartphone or a touchscreen, to allow people with reduced arm or hand mobility to obtain the information they need. An overview of which parts of the hub are accessible by wheelchair could be helpful for the participants. People with physical impairments often require assistance from others. Being able to ask for help, or how to move within the hub, from the staff at the mobility hub could be very helpful. Moreover, in order to use transport services, they sometimes need an adapted behaviour from the staff and also other users (e.g., helping them to get in the vehicle, giving them more time to exit, freeing the space for wheelchairs when someone is occupying it...). This can only be ensured by educating and informing staff and other passengers. Lastly, participants would benefit from finding disabled parking spaces or vehicles adapted to people with reduced mobility, or in a wheelchair, in the mobility hub.

Regarding shared mobility, it is unclear to what extent it can be useful for participants due to their physical limitations which prevent them from driving or cycling. Lastly, digital mobility services may be useful for people with reduced mobility that can operate a digital device.

4.2.5.3 People with visual impairments

The main barriers for this group are related to the physical environment and the spatial and geographic distribution of transport facilities and desired destinations. Travelling becomes more difficult since previous knowledge about a journey or the use of assisting devices and accessories is necessary. Therefore, travelling long distances and having to change often to get to their destination might prevent them from travelling.

Participants consider mobility hubs useful because they concentrate many transport services in a single location. Mobility hubs would be more useful when located near their homes, although the barriers they face in transport will not be solved solely by adapted mobility hubs. The presence of barrier-free pathways with tactile guidance pavement is relevant for the mobility of people with visual impairments to access facilities and vehicles. People with visual impairments would feel safer in the mobility hubs if they find a secured and controlled shelter. Signage, wayfinding and transport-related information (such as departure times or delays) need to be simple, clear and easily understandable for people with reduced vision. Sound-based support that announces or indicates when a service is available and how to use it, and voice control features to use the ticket machines or touchscreens are recommended. Lighting and colours should be adequately chosen to facilitate the use of people with reduced vision. Moreover, to have access to the information shown on screens or boards, and to navigate inside facilities, mobility hubs should be made compatible with navigation apps and supporting devices for people with visual impairments.

Concerning shared mobility, people with visual impairment sometimes can drive a bicycle or a car, but special vehicles and the adaptation of the service and the platform would be necessary. In some cases, shared mobility services make sense for people with visual impairments when someone else is driving. Otherwise, they rather use public transport or services with a driver when they travel alone. Participants suggested adding ride-sharing or on-demand service stops to the hub.

The use of digital devices is problematic when the software is not adapted to the needs of users with visual impairments or when they have not acquired the necessary digital skills to use a

device or an interface for people with visual impairments. In this regard, navigation apps that have an audio guidance function, such as google maps, can be very useful for them, but such apps are not always reliable. Moreover, the availability of QR codes to obtain information related to the services offered in the hub is considered helpful. Participants from this group state that they could benefit from human support at stations to use digital devices such as ticket machines or touch screens.

4.2.6 Peri-urban and rural inhabitants

“I use the local car-sharing service because recently it became more affordable. [...] However, you have to drive many kilometres to make it pay off. Otherwise, you are paying for the time, even if you do not drive it.”

– Statemen from a resident of Pillichsdorf.

The main barriers for this group are related to the spatial distribution of transport facilities and the distances that they must travel daily. Peri-urban and rural inhabitants often do not have several available transport services near their homes, which limits their mobility besides using their private cars. Socio-cultural barriers are also relevant in this group as they perceive the use of the car as more comfortable or unavoidable, because alternatives are, or are perceived as problematic. This leads to a limited interest in public transport and shared mobility and a lack of knowledge about how to use it.

It is unclear to what extent mobility hubs can be useful for this group if they cannot reach them easily from their homes. However, members of this group are used to combining several forms of transport, and mobility hubs could be used as interchanges. For instance, they explain how they drive to the closest train station and then they take the train to a city. Mobility hubs for this group would require a parking area. Parcel lockers are not necessary because participants are used to receiving their parcels at home. Furthermore, it is advised to include e-bike charging stations and secured bicycle parking to facilitate the use of bicycles by peri-urban and rural inhabitants.

Concerning shared mobility, shared cars are only considered useful for occasional trips. However, a respondent explained that, considering that the car-sharing service is currently cheaper and if fuel prices keep rising, it would make sense for rural residents to only have one private car and to use the car-sharing system occasionally, as a second car. The subscription system must be considered because it can be a barrier to the use of this service. For instance, when the price is time-based, users might only consider it attractive when driving long distances without stops. Likewise, overly complex instructions to use the car-sharing service might prevent other rural residents to start using them.

The use of digital mobility services by this group depends on factors such as age and cognitive ability. Rural residents expressed limitations when using digital mobility services and are concerned about the protection of their data. Their familiarity with digital mobility services is related to their preferred transport mode, the car, which has not required the acquisition of digital skills for their mobility. However, the level of digital skills differs between different peri-urban and rural inhabitants.

4.2.7 Women

“In Vienna there are elevators everywhere, and there is always space for the bike. If the subway is not full, there is no problem with space in

the trains. But it would be cool if you could sit down, so that there are maybe special areas where you could park the bike safely.” – Statement from a female participant.

The main barriers for women are related to the physical environment and the spatial and geographical distribution of transport services. For instance, when carrying groceries, using trolleys, or accompanying children. Furthermore, participants find mobility options such as cycling attractive but are also experienced as dangerous, depending on the route, as well as exhausting. Participants from this group have more fragmented mobility, with several destinations per day, and make more and shorter trips per day than men, for which they rely on active mobility, especially walking.

When talking about mobility hubs, participants find it useful for them, and suggested additional facilities within the hub that would allow them to rest, wait and reduce the number of trips per day (e.g., public toilets, sheltered waiting rooms, grocery stores, parcel lockers and storage rooms). Accessibility to facilities and vehicles is considered important by participants. Ideally, all elements of a mobility hub should be at the same level, and the hub should be barrier-free. Likewise, the aesthetics of the hub (such as green elements and cleanliness) are relevant, and lighting and the design are considered important for safety reasons. Participants from this group are used to doing multimodal trips and feel confident about changing from one mode to another, but they prefer short and simple transfers. Participants explained that providing space for bicycles in public transport vehicles would enable the combination of both modes of transport. Additionally, having secured bicycle parking at the hub would allow them to use their personal bicycle to reach the hub. Lastly, mobility hubs could be promoted for women that don't know they exist, and not how to use them.

Concerning shared mobility, participants think that bike-sharing services are useful in some cases (e.g., to substitute a private bike that needs repair, or for specific trips), as is the case of shared cargo bikes. However, the local bike-sharing service is not perceived as reliable and comfortable, due to the weight of the bicycles, and the changing availability of vehicles. Regarding car-sharing, it is perceived as useful and attractive by participants because it allows transporting other passengers and objects, but it is judged useful for occasional uses. Being able to book the service in advance is highlighted. Participants explained that e-scooters are an attractive option because they do not require physical effort, but safety concerns are also mentioned. Ticket schemes are also highlighted as relevant, because having a single ticket to use on several or all services, such as the 'KlimaTicket'¹ in Austria, makes it easier for them.

Digital mobility services are used by some participants, who highlight that the protection of their personal data is important to them. Nevertheless, having the possibility of booking or interacting with the service physically, through a touch-screen or a kiosk, is deemed useful. One participant highlighted that only being able to access the car-sharing service with a smartphone prevents users without a smartphone to use it. Moreover, it is stated that navigation and wayfinding at the hub should be possible and effective both with and without using a smartphone.

4.3 Synthesis of expert and end-user interviews

This section synthesises the results previously explained, listing the findings obtained with each sample (expert participants and end-user participants), of the seven groups considered in section 4.2. The information found in the tables shortly explains the findings that have been identified through the coding process, which are further developed in sections 4.1 and 4.2. To do

¹ <https://www.klimaticket.at/>

so, the findings are summarised in short sentences, which are easier to read and compare among samples and groups. It may be possible that certain needs or barriers of a group are not mentioned in the table. However, it does not imply that they are not relevant to this group, but that none of the participants from such group referred to it.

Each table is followed by a radar chart or Kiviat diagram, that shows the needs of each group simply and directly. These charts may be useful for decision-makers and practitioners that have to decide what needs are targeted in the first place. However, as a simplified representation of the findings of this qualitative study, nuances are lost in an attempt to quantify the relevance of the needs of users. Thus, the charts must be understood as an indicative summary of the findings which facilitates the dissemination of the results and enables comparison across groups.

The radar charts are obtained from the tables found in this section, which contain barriers and needs that were mentioned by participants. The first step to draw the charts was to identify categories in which the needs referred by participants can be included. As a result, eight categories have been considered. In the following list, the eight categories are related to the three elements of the theoretical framework (see section 2.3), and are described by showing examples of the type of needs that would be included in each category.

- Material access (shown in clear blue)
 1. Availability and reliability of transport services offered at the hub
 - Reliable, functional and well-maintained services
 - Possibility to see available vehicles and booking in advance
 - Accurate information provided in advance
 2. Flexible fares and payment
 - Special subscription packages (e.g., under 18, occasional user...)
 - Flexible payment schemes
 - Subsidies and/or free access
- Skills (shown in blue)
 3. Obstacle-free spaces: hub and vehicles
 - Stair-free and obstacle-free: ramps and elevators if necessary
 - Space for trolleys, wheelchairs, bikes...
 - Self-explanatory spatial design
 4. Usability for all
 - Intuitive and self-explanatory design of objects and interfaces
 - Use of supporting devices (e.g. voice control audio guidance, tactile paving...)
 - When applicable, staff will be trained to better support disadvantaged users
 5. Simple and adapted communication
 - Self-explanatory wayfinding
 - Signage and/or digital interfaces adapted to users with low language literacy, and visual and cognitive impairments (e.g. fonts, colours, contrast, reduced text...)
 - Simple use of language, easy to understand orally and by text
 6. Non-digital accessibility to the services found at the hub
 - Information provided by non-digital means
 - Possibility to book and pay for a service by non-digital means
- Cognitive appropriation (shown in dark blue)
 7. Assistance, training and promotion
 - Support from an employee present at the hub, or other users

- Provision of information, tutorials and training on how to use a service/application
 - Marketing and promotion of the services and the hub (e.g., free trial)
8. Safety and security inside the hub and the vehicles
- Safety devices (e.g., fences, cameras...) and (security) staff
 - Visibility of other users and vehicles, lighting and cleanliness
 - Secured facilities (e.g., bike parking)
 - Protection of personal data and secured online payments

Secondly, the elements contained in the tables were placed in each category, doing it separately per each group. Once all elements are placed in their respective category, they were counted, obtaining a total amount of elements per category. To avoid overlap, conceptually identical needs, and referred to the same aspect of a mobility hub, were excluded. Finally, the counts of all groups were normalised to the same range of numbers, as a means to produce charts that are comparable across groups.

4.3.1 Children and teenagers

Table 3 summarises the findings about the group ‘children and teenagers’ obtained through the interviews conducted with ‘experts’ and with ‘end-users’.

Table 3. Synthesis of findings group ‘Children and teenagers’

	Category	Expert interviews	End-user interviews
General barriers	Economic	Lack of economic autonomy and limited decision-making power	Lack of economic autonomy
	Physical	Usability of vehicles and facilities, safety and security	
	Socio-cultural	Dependency on parent(s)/tutor	
Mobility hubs	Usefulness	Yes	Unclear
	Barriers	Fear for safety Reduced accessibility to services and limited usefulness Lack of autonomy/independence	
	Needs	To ensure safety and security: lighting, fences and purposely designed junctions Simplified use of language in signage, the information provided and communication. Inclusive design and usability	Information is also provided by non-digital means and simplified: wayfinding, maps, schedules... Perceived safety and security Cleanness of facilities and vehicles Direct single-mode trips

	Modes	Public transport, active mobility (also shared bicycles), and shared e-scooters	Public transport, active mobility, and shared e-scooters.
	Features		
Shared mobility	Usefulness	Yes: e-scooters and bicycles	Yes: e-scooters
	Barriers	Limited usability of interfaces and vehicles Lack of economic resources to pay for the service Legal constraints related to age	Location-based services are less flexible Crowding and possible control or surveillance (teenagers). Dependency on adults to book a services
	Needs		Traffic safety to enable cycling. Possibility of using the service without having a bank account (credit card).
Digital mobility services	Usefulness	Yes	Yes: to navigate, look for information and book a service.
	Barriers	Lack of necessary resources: smartphone and/or internet connection	
	Needs		Simplified and reduced use of text

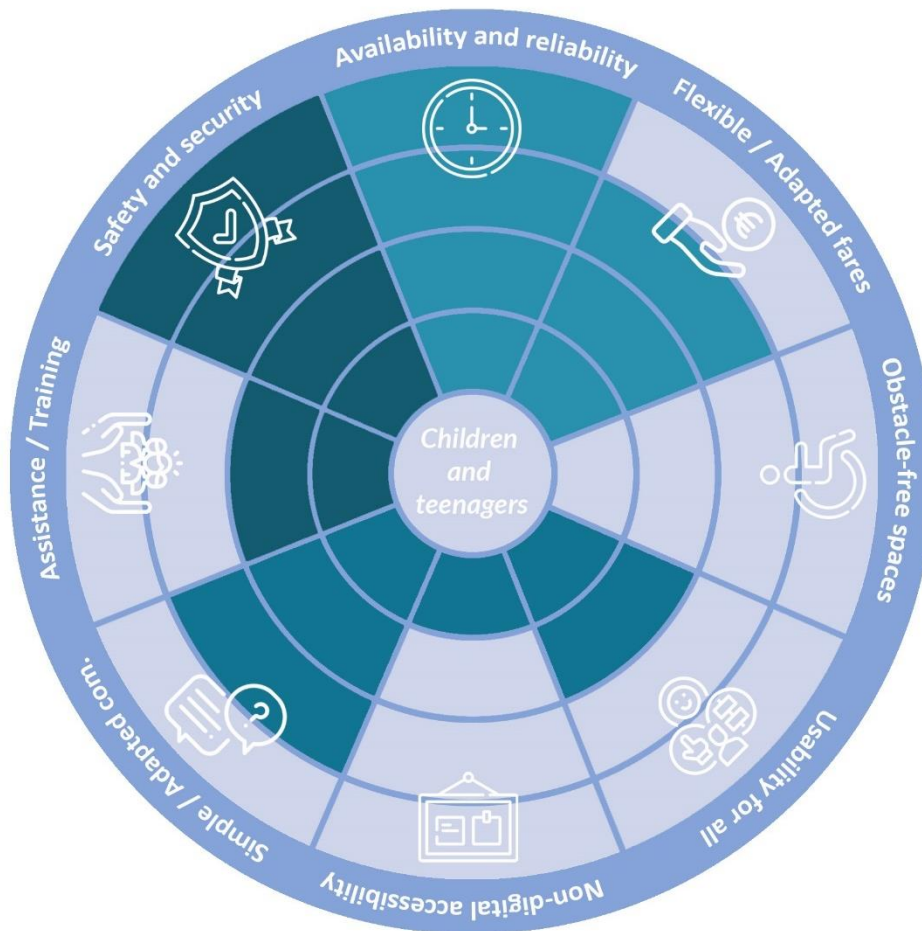


Figure 2. Needs of children and teenagers

4.3.2 Digitally excluded citizens

Table 4 summarises the findings about the group ‘digitally excluded citizens’ obtained through the interviews conducted with ‘experts’ and with ‘end-users’.

Table 4. Synthesis findings group ‘Digitally excluded citizens’

	Category	Experts interviews	End-user interviews
General barriers	Economic	Not having a laptop or internet connection	Not having a laptop or internet connection
	Socio-cultural	Lack of digital skills	Lack of digital skills
Mobility hubs	Usefulness	In some cases	Yes
	Barriers		Lack of knowledge about how to use the services and the network

	Category	Experts interviews	End-user interviews
	Needs	Information provided by non-digital means: timetables, maps... Simple communication and signage Assistance from another person	Information provided by non-digital means Promote/enable the autonomous use of services and facilities
	Modes	Mainly public transport	Mainly public transport and private vehicles
	Features	Information and ticket kiosk A waiting area with seats/benches	Signage, information screens and printed maps
Shared mobility	Usefulness	In some cases	Only if it improves their accessibility
	Barriers	Requirement of credit card to use the service	Requirement of digital skills and devices to use the services
	Needs	Training to use service	Non-digital access to services
Digital mobility services	Usefulness	Only to fulfil a necessary aim	Not having a laptop or internet connection
	Barriers	Not having a smartphone or internet connection Fear of mistakes and the unknown	Lack of digital skills
	Needs	Additional time to perform tasks necessary to use transport services Assistance to use services Simplified and intuitive interfaces Support and tools to learn digital skills	Training to use the service Possibility of finding assistance if necessary

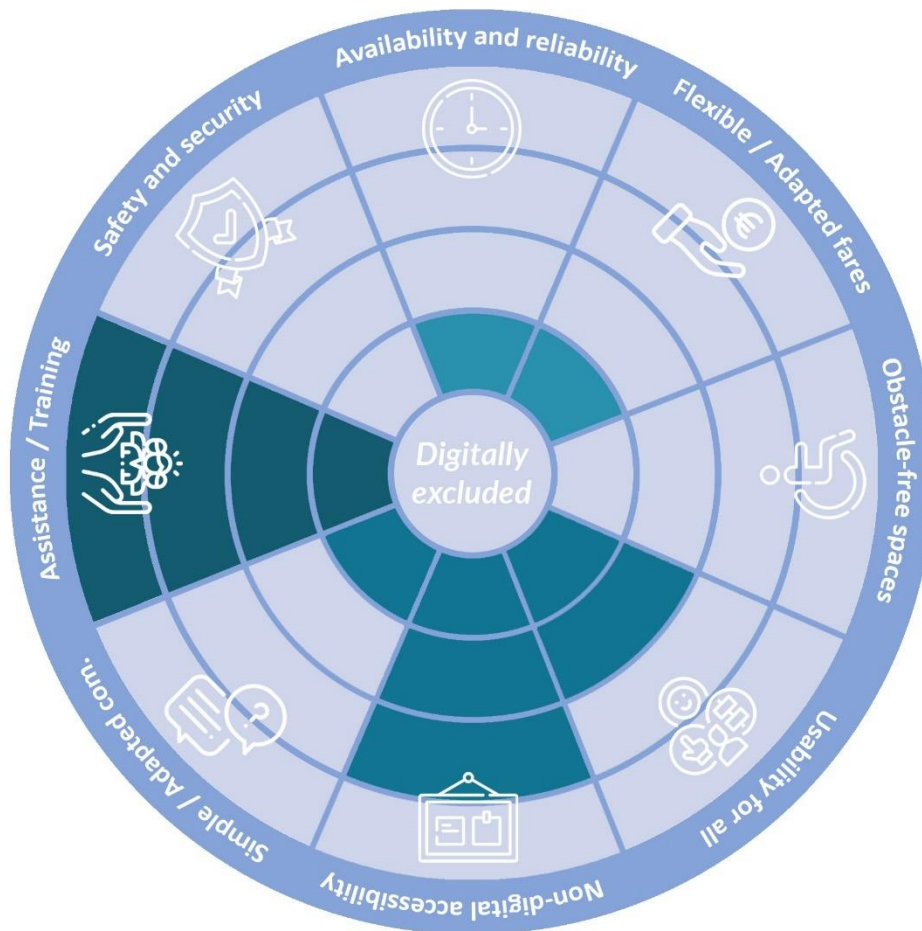


Figure 3. Needs of digitally excluded citizens

4.3.3 Migrants and ethnic minorities

Table 5 summarises the findings about the group ‘migrants and ethnic minorities’ obtained through the interviews conducted with ‘experts’ and with ‘end-users’.

Table 5. Synthesis findings group ‘Migrants and ethnic minorities’

	Category	Experts interviews	End-user interviews
General barriers	Economic	Lack of financial means	Cost of transport Lack of credit card and digital devices Not having access to a private car
	Socio-cultural	Limited or lack of local language literacy Opinions and fears about mobility services Lack of confidence	Limited or lack of local language literacy Lack of digital skills Fear and lack of confidence

Mobility hubs	Usefulness	Yes	Yes
	Barriers	Lack of knowledge about how to use public transport	Lack of knowledge about how to use transport
	Needs	Communication with limited and simple text Use of symbols, pictograms and numbers Assistance from a person	Close location to their homes Assistance to use the hub for the first time Text-free and signage and wayfinding, with pictograms and numbers Simple and clear communication, especially audio announcements Flexible and subsidised fares
	Modes	Public transport, active mobility and shared mobility	Public transport, active mobility, and private car
	Features	Free wi-fi Shelter Lockers Restrooms and changing rooms	Manned information and ticket kiosk Non-digital information provided, timetables and maps
Shared mobility	Usefulness	Yes: shared bikes, cars and e-scooters	Unclear
	Barriers	Cost and subscription Need of a credit card	
	Needs	Cycling courses and training to use the services Subsidised and flexible subscriptions	Training to use the services Cycling course
Digital mobility services	Usefulness	No	Sometimes
	Barriers	Lack of digital skills	Lack of digital skills Lack of internet connection Lack of laptop or tablet
	Needs	Training and course on digital skills and digital mobility services Simple and self-explanatory interfaces	Text-free interfaces

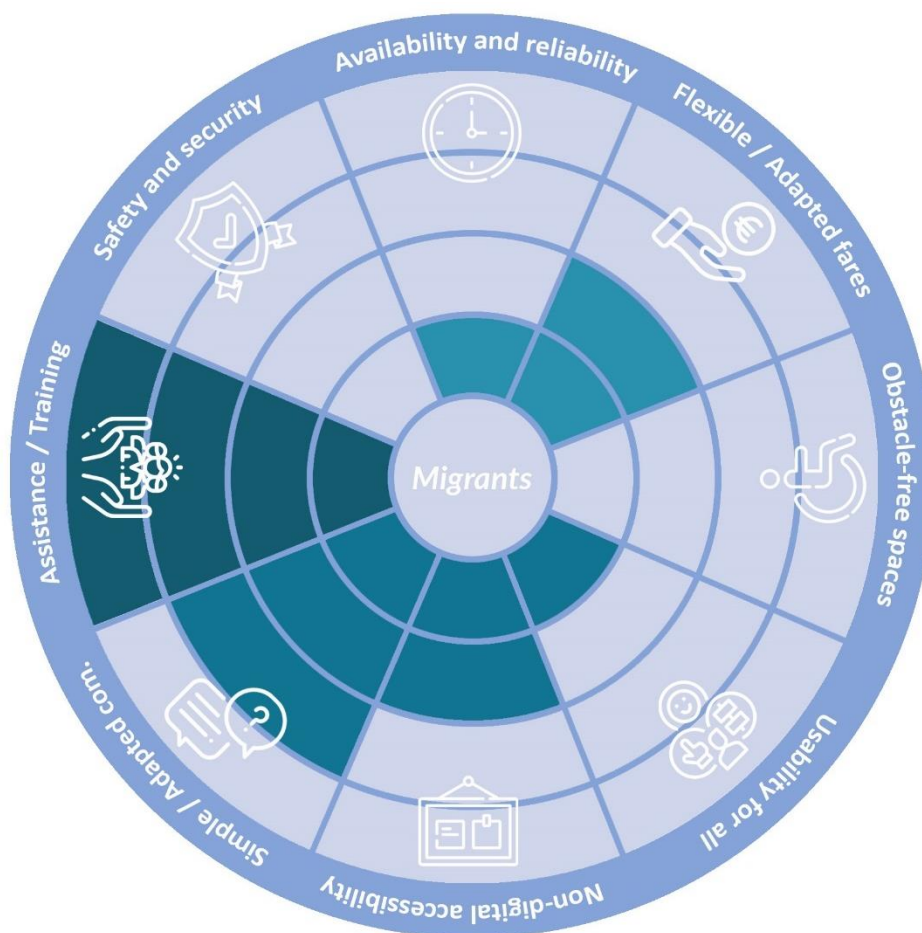


Figure 4. Needs of migrants and ethnic minorities

4.3.4 Older people

Table 6 summarises the findings about the group ‘older people’ obtained through the interviews conducted with ‘experts’ and with ‘end-users’.

Table 6. Synthesis findings group ‘Older people’

	Category	Experts interviews	End-user interviews
General barriers	Economic	Limited income Inflexible and expensive subscription packages	
	Physical	Difficult access to facilities and vehicles Limited physical ability preventing the use of certain modes and walking long distances	Difficult access to facilities and vehicles Limited physical ability preventing the use of certain modes and walking long distances

	Socio-cultural	Lack of digital skills	Lack of digital skills Perceived safety and security
Mobility hubs	Usefulness	Yes	Yes
	Barriers	Feeling of vulnerability Unexpected events and disruptions Long distance from their residential location	Lack of knowledge about how to use transport services
	Needs	Reliability of transport services Barrier-free environments Self-explanatory design of facilities Being able to sit and rest Secured spaces that enhance the feeling of safety Finding assistance from another person if necessary	Barrier-free environments Self-explanatory design of facilities Reliable mechanical stairs and elevators Accessibility of bikes in the hub and vehicles Design and maintenance of facilities to enhance the feeling of security and perceived safety: lighting, cleanliness, visibility of other users Reducing the ticket purchase and paying times Assistance from staff Training on how to use a mobility hub and the services present in it
	Modes	Public transport and services with a driver	Public transport, active modes, shared mobility and on-demand services
	Features	Stair-free facilities and vehicles Waiting rooms, public toilets, benches Manned ticket kiosk or simplified ticket machines Simple wayfinding and signage Information provided and announcements adapted to people with hearing and visual impairments	Simple and self-explanatory signage Information and ticket kiosk with a person that can assist users Waiting room with benches and public toilets
Shared mobility	Usefulness	Unclear	Unclear
	Barriers	Safety: risk of accidents	Usability of vehicles: weight, shape, features...

			High subscription costs
	Needs		Flexible subscription packages On-demand services Reliability of service and vehicles
Digital mobility services	Usefulness	Increasingly useful	Yes
	Barriers	Lack of digital skills and motivation	Mistrust and fear of scams
	Needs	Training to acquire digital skills Support to solve problems after the training	Assistance and support to improve digital skills Security of online payments Protection of personal data

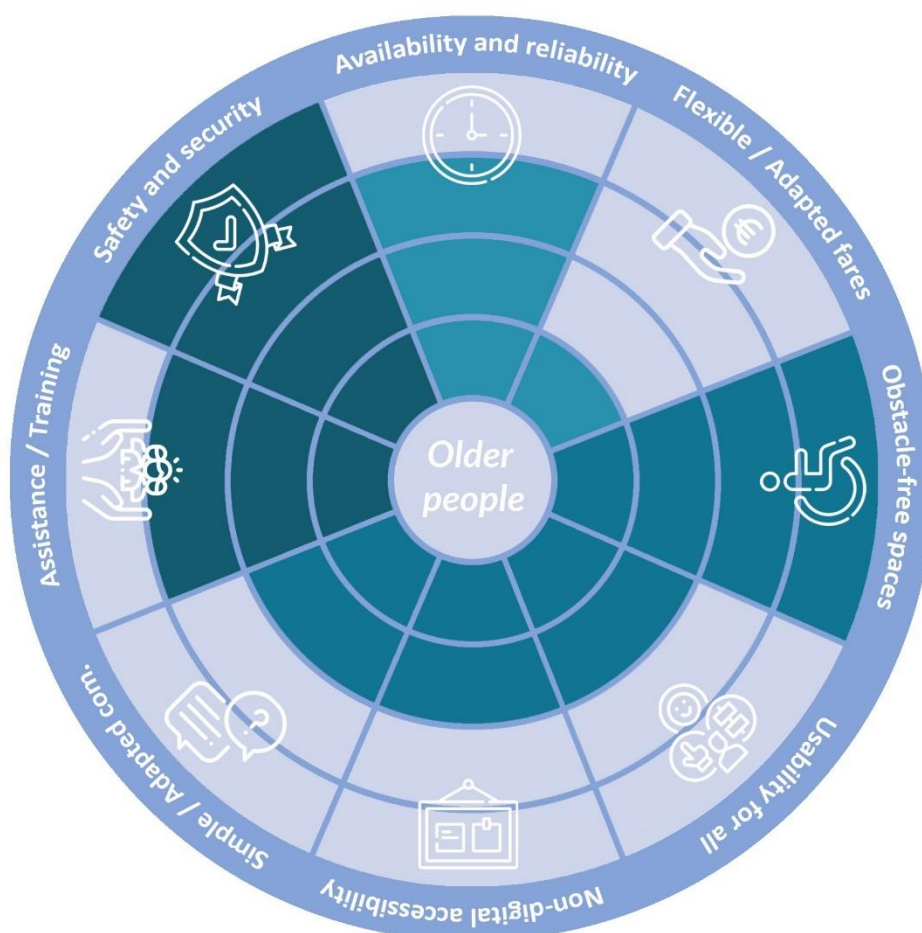


Figure 5. Needs of older people

4.3.5 People with impairments

Table 7 summarises the findings about the group ‘people with impairments’ obtained through the interviews conducted with ‘experts’ and with ‘end-users’. In case an element refers to a specific

type of impairment, it will be indicated as follows: cognitive impairment (CI), physical impairment (PI) and visual impairment (VI).

Table 7. Synthesis findings group 'People with impairments'

	Category	Experts interviews	End-user interviews
General barriers	Economic	Lack of economic autonomy (cognitive impairment) Limited income	
	Physical	Physical obstacles (e.g., stairs, objects, furniture, crowding...)	Difficult accessibility to facilities and vehicles Physical obstacles (e.g. stairs, objects...)
	Spatial	Complex distribution of spaces and services Long distance to stations or services	Long distance to stations or services
	Socio-cultural	Difficulty to understand information (CI) Acceptance of guide dogs (VI)	Complex and/or unclear information (CI) Lack of digital skills Disregard of drivers, staff and other passengers towards people with impairments
Mobility hubs	Usefulness	Yes	Yes
	Barriers	Difficult tasks that require complex interactions and physical ableness Overstimulation by noise, light, other users and unexpected situations Crowding and narrow spaces Limited knowledge of transport services (CI) Obstacles and long distances	Physical obstacles and long distances Difficult accessibility Lack of necessary information or not clearly provided Lack of available information about the trip, the modal changes and existing disruptions before the departure A feeling of uncertainty and insecurity (CI)
	Needs	Spaces should be secured and enhance the feeling of safety Additional time to prepare and perform the task necessary to use a mobility hub	A feeling of safety and certainty (CI) Reliability of transport services

	<p>Assistance from another person</p> <p>Easy and direct interchanges</p> <p>Location of the hub at a short distance from home</p> <p>Granted access to guide dogs (VI) in vehicles</p> <p>Barrier-free and stair-free spaces and vehicles</p> <p>Open spaces that allow free movement</p> <p>Self-explanatory and simple signage and wayfinding, with pictograms and pictures.</p> <p>Prepaid systems that do not require a credit card</p> <p>Training to use the hub</p> <p>Information is provided permanently, visible and in a simple manner, with little text and without having to use a smartphone</p> <p>Accurate information to navigate within the hub, on the network, and real-time announcements made available for audio-guiding software (VI)</p>	<p>Assistance from another person, for instance, to use digital devices and touchscreens</p> <p>Raising awareness about the needs of people with impairments and how staff, and users, can better support them</p> <p>Adapted vehicles and dedicated seats in vehicles (PI)</p> <p>Self-explanatory and clear pathways, wayfinding and signage</p> <p>Barrier-free and stair-free spaces and vehicles</p> <p>Reliable mechanical stairs and elevators if necessary</p> <p>Machines and buttons should be placed having in mind the height of people in a wheelchair</p> <p>Additional devices and features to compensate for the visual impairment (e.g. audio guidance).</p> <p>Accurate information to navigate within the hub, on the network, and real-time announcements made available for audio-guiding software (VI)</p> <p>Information is provided permanently, visible and in a simple manner, with little text and without having to use a smartphone</p>
Modes	Public transport and vehicles with a driver (e.g., on-demand transport or ridesharing)	Public transport, private vehicles and vehicles are driven by someone else (e.g., on-demand transport or ridesharing)
Features	<p>Information boards/screens at the level of the eyesight to allow people with reduced visibility to approach them and read the information</p> <p>Adequate lighting and use of colours (VI)</p>	<p>Adequate lighting and use of colours (visual impaired)</p> <p>Vehicles should have space for a wheelchair, ideally for more than one</p> <p>A map where the different services of the hub are indicated,</p>

		<p>Presence of tactile guidance paving (VI)</p> <p>Audio and visual devices that adapt the information, interactions and announcements to people with hearing or visual impairments</p> <p>Waiting rooms with benches, public toilets</p> <p>A map where the different services of the hub and surroundings are indicated.</p>	<p>such as how to easily move around the hub (also with a wheelchair)</p> <p>Presence of tactile guidance paving (VI)</p> <p>Safe and secured shelter</p> <p>Audio-based support to obtain necessary information (e.g., when a service is available, and how to use it)</p> <p>Voce-control for ticket machines and touchscreens</p> <p>QR codes to obtain relevant information (VI)</p>
Shared mobility	Usefulness	Unclear	Unclear
	Barriers	<p>Physical ableness and reduced vision hamper the use of active modes</p> <p>Regulations may impede the use of motorized vehicles (cognitive impairment)</p> <p>Requiring the use of digital devices</p>	<p>Physical ableness and reduced vision hamper the use of active modes</p> <p>Requiring the use of digital devices</p>
	Needs	<p>Vehicles and parking spaces need to be adapted</p> <p>Adapted, flexible subscription packages, and subsidies</p> <p>Someone else driving the vehicle</p>	Someone else driving the vehicle
Digital mobility services	Usefulness	Yes, for some people	Yes
	Barriers	<p>Difficult to use digital devices and software (cognitive impairment)</p> <p>Fear of mistakes or scams (cognitive impairment)</p>	<p>Lack of digital skills (cognitive impairment)</p> <p>Lack of self-confidence and fear of mistakes and problems (cognitive impairment)</p> <p>Impossibility to hold or manipulate a digital device (in some cases)</p>
	Needs	<p>Voice control, audio guidance and adapted interfaces (visually impaired)</p> <p>Training to use specific apps and services</p>	<p>Simple and intuitive interfaces</p> <p>A single application which allows using all services and features related to transport. This would</p>

			<p>require learning only one application</p> <p>Adapted to visually impaired: voice-control and audio guidance to use the software</p>
--	--	--	--

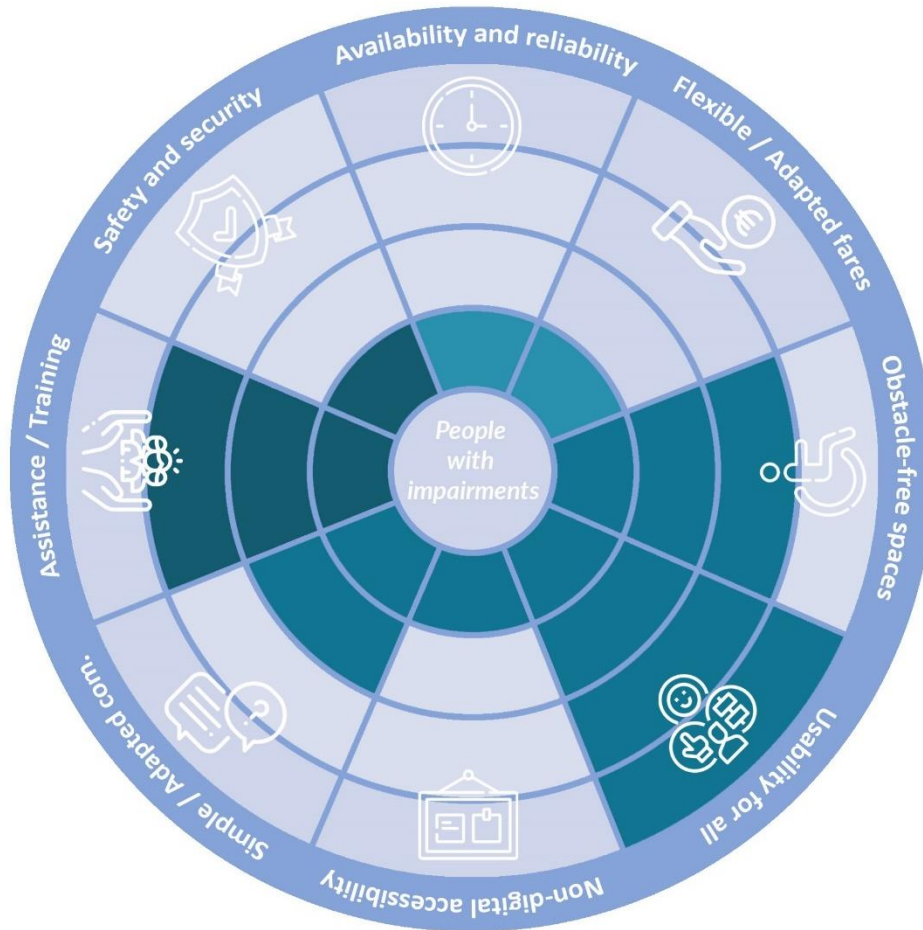


Figure 6. Needs of people with impairments

4.3.6 Peri-urban and rural inhabitants

Table 8 summarises the findings about the group ‘peri-urban and rural inhabitants’ obtained through the interviews conducted with ‘experts’ and with ‘end-users’.

Table 8. Synthesis findings group ‘Peri-urban and rural inhabitants’

	Category	Experts interviews	End-user interviews
General barriers	Economic	Cost of transport	
	Spatial	Distance to closest transport services or stop	Distance to closest transport services or stop Distances to destinations

		Distances and complexity of trips to reach destinations	
	Socio-cultural		Car-centric planning Values and meanings associated with the private car
Mobility hubs	Usefulness	Yes, if increasing accessibility	Yes, for some people
	Barriers	Low frequency of services Limited schedule of operational services Longer wait for a problem/disruption in the services to be fixed	Distance from their residential location
	Needs	Available mobility hub at a short distance A network that enables simple multimodal trips	Available mobility hubs at a short distance from home
	Modes	Public transport, on-demand shared services, and private car	Public transport, shared mobility, and private car
	Features	Parking spaces at the hub Secure bicycle parking Shelter and waiting area	Car parking spaces at the hub Charging station for e-bikes and e-cars Secure bicycle parking
	Shared mobility	Usefulness	Yes, car sharing and sometimes bike sharing
Barriers		Having to drop off the vehicle far from their residential location Inadequate and unsafe infrastructure (e.g., paths, bike lanes...)	Lack of knowledge and/or interest
Needs		Adapted and flexible subscription packages Reliable service that functions more often and within a broader schedule Dock-less services are preferred	Adapted and flexible subscription packages Simplified instructions on how to use the service

		Using the service through non-digital channels	
Digital mobility services	Usefulness		Yes
	Barriers		
	Needs		Protection of personal data

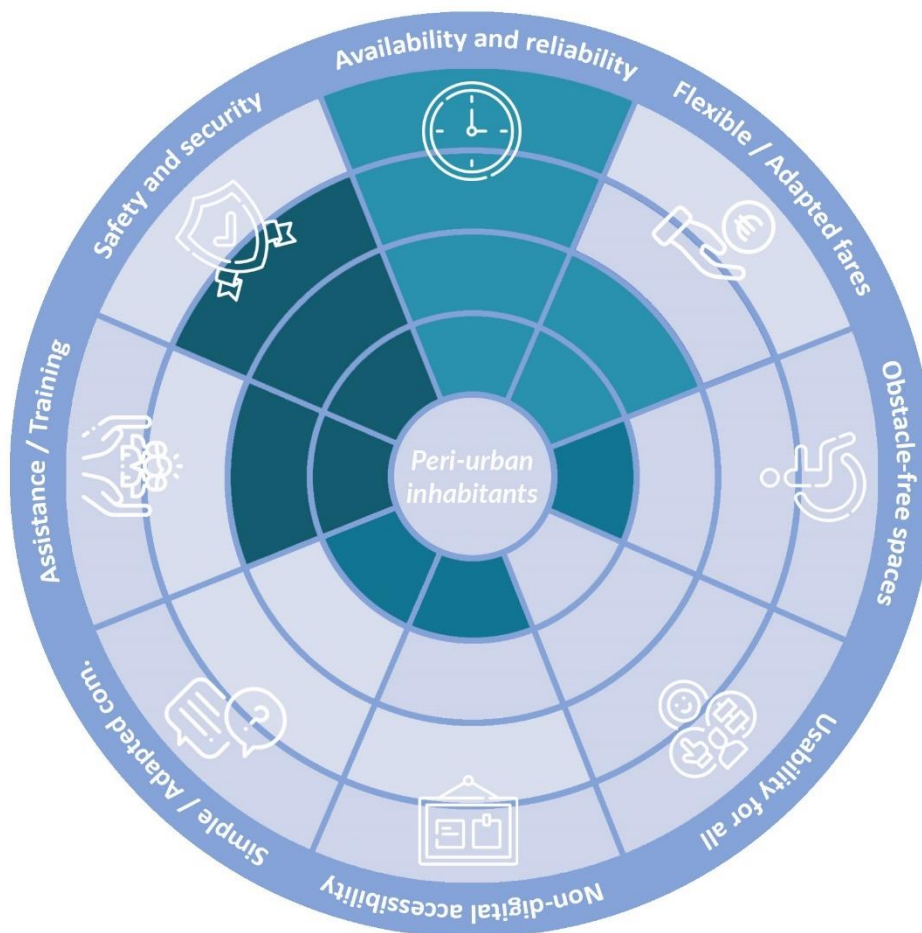


Figure 7. Needs of peri-urban and rural inhabitants

4.3.7 Women

Table 9 summarises the findings about the group ‘women’, including the group ‘migrant women’. It has been obtained through the interviews conducted with ‘experts’ and with ‘end-users’.

Table 9. Synthesis findings group ‘Women’

	Category	Experts interviews	End-user interviews
	Economic	Economic autonomy	

General barriers	Physical	Physical obstacles, when carrying groceries or with children	Physical obstacles, when carrying groceries, with children and/or trolleys
	Spatial		Unavailable services at a short distance from home
	Socio-cultural	Social pressure In charge of more tasks (e.g. work, house, children) than men Fear for safety and security	Fear for safety and security
Mobility hubs	Usefulness	Yes	Yes
	Barriers	Physical obstacles and reduced accessibility	Physical obstacles and reduced accessibility Lack of knowledge about the existence and how to use mobility hubs
	Needs	Reinforced safety through design or human presence Reliable facilities and services Barrier-free facilities	Availability at a short distance Aesthetics is important Information and promotion of mobility hubs Easy paying/ticketing system Integrated ticket with all modes Training to use the hub Simple signage and wayfinding Information also provided by non-digital means Barrier-free and stair-free facilities Short and simple transfers from one mode to another Enhancement of safety: adequate lighting, cleanliness...
	Modes	Active modes and public transport	Active modes, public transport and shared mobility
	Features	Spaces without dark and isolated corners Space for trolleys Clean spaces and vehicles	Information is provided through a touchscreen or a kiosk, without using a smartphone Public toilets, sheltered waiting spaces, grocery stores, and storage rooms. Parcel lockers

		<p>An information kiosk and/or ticket office with a person</p> <p>Clean and functioning public toilets</p> <p>Waiting rooms</p>	<p>Green elements, and pleasant design</p> <p>Secured bicycle parking</p> <p>Accessibility of bicycles into the hub and vehicles</p>
Shared mobility	Usefulness	Yes, for some	Yes: bike-sharing, shared cargo bikes, car-sharing
	Barriers	Lack of cycling skills	<p>Unattractiveness due to unreliability and usability</p> <p>Safety concerns (e-scooter)</p>
	Needs	<p>Cycling course</p> <p>Training to use the service</p>	<p>Reliability of services</p> <p>Comfortable and easily usable vehicles</p> <p>Advances booking to make sure the vehicle is available</p> <p>Being able to book and use the service without a smartphone</p> <p>Cycling course</p>
Digital mobility services	Usefulness	Yes, for some	Yes, for some
	Barriers		
	Needs		Protection of personal data

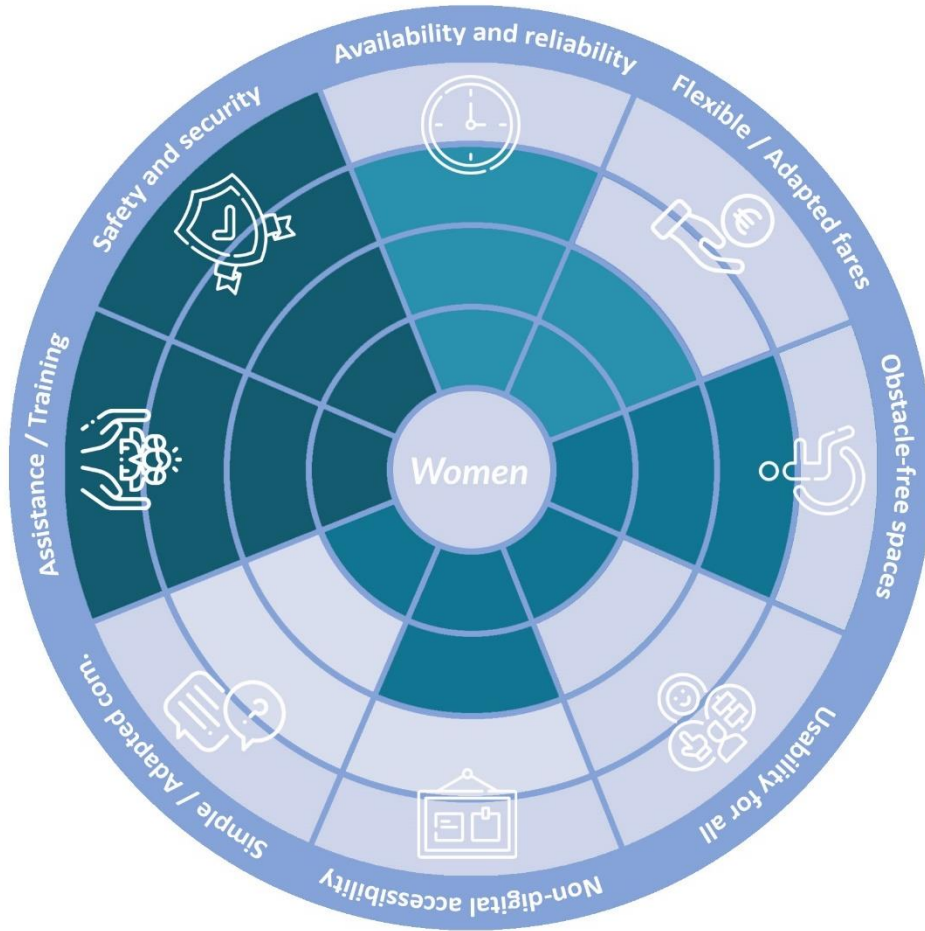


Figure 8. Needs of women

5 Conclusions

This deliverable has aimed at answering the following research questions:

- What are the barriers encountered by citizens when using mobility hubs and shared mobility?
- What are the needs of vulnerable citizens regarding the use of mobility hubs and shared mobility?
- To what extent mobility hubs are useful and attractive to vulnerable citizens?

In the previous section, these questions have been answered separately by social groups, which face more disadvantages when using transport and are more vulnerable to exclusion. Through the data collection process, the number of groups has been reduced for two reasons: the merging of groups, and data saturation reached through the interviews with experts. The latter concerns the groups 'low-income citizens', 'socially isolated citizens', and 'informal caregivers.'

This section summarises the findings regarding the seven groups mentioned in section 4.3, moving beyond the specific needs and barriers of each vulnerable group, into more general needs and barriers. Thus, the results of this study are summarised in Figure 9, aggregating the seven charts shown in section 4.3. To produce this chart, the degree of relevance of all groups has been put together for each category of needs. We can conclude that 'Assistance and training', 'Availability and reliability', and 'Safety and security' are the type of needs most referred to by participants.

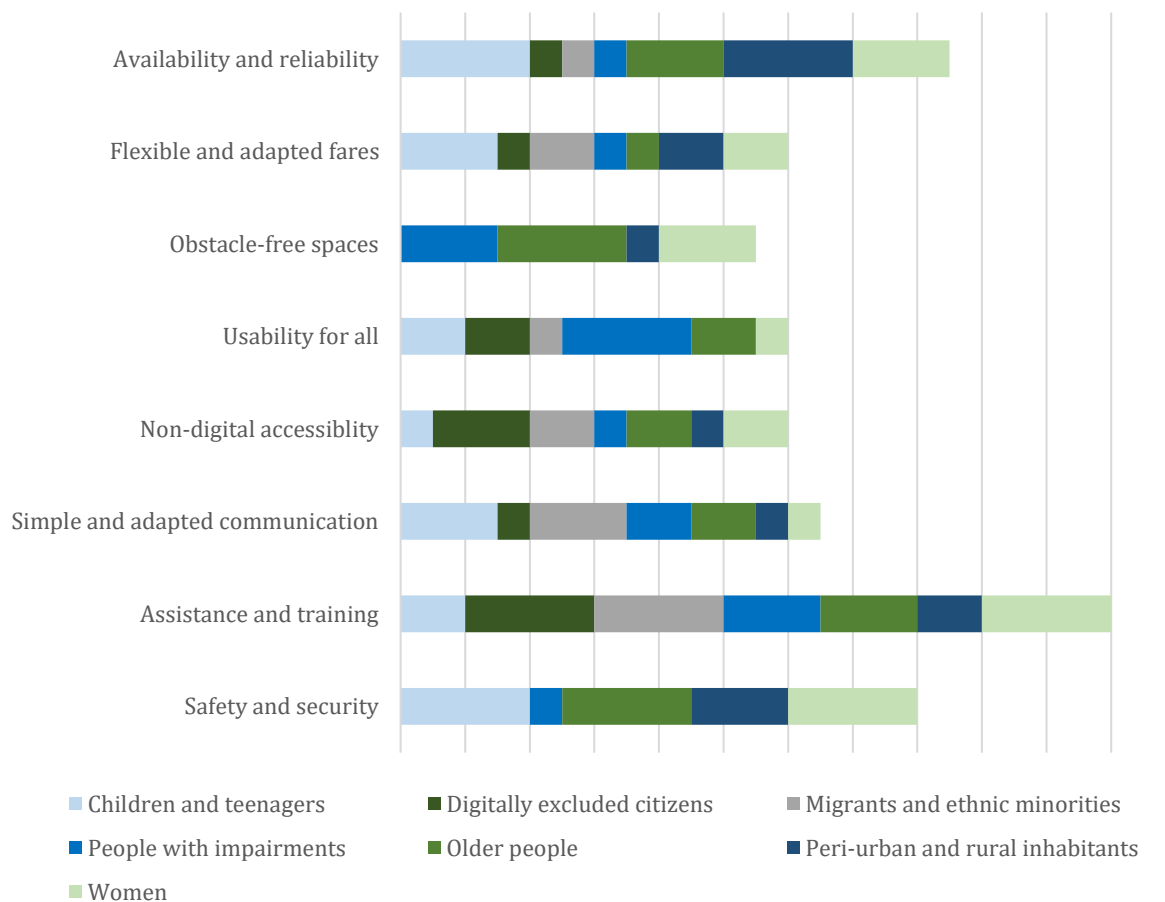


Figure 9. Needs of vulnerable people

The Capabilities Approach as theoretical framework used to design this study was applied to structure the findings of this study. Therefore, the following sub-sections will refer to the capabilities concerning *material access*, *skills* and *cognitive appropriation* of mobility hubs and the services offered within them. As explained in section 2, the main elements of the hubs that have been studied are the facilities of mobility hubs and the transport services offered at the hub, with a special focus on shared mobility services and digital mobility services. These elements are separately considered in the following sub-sections.

5.1 Mobility hubs

5.1.1 Material Access

For citizens to use a mobility hub it must be available, functional, and reliable. Services and facilities must be completed and operational, and vehicles must be available and usable. Accessing mobility hubs requires that users have the economic autonomy to pay for the service, which is lacking for children and teenagers and some people with cognitive impairment. Moreover, for some groups, subsidies and adapted ticketing schemes must be considered by transport providers and policymakers.

Other resources that may hamper the use of a mobility hub are related to digital devices, which are increasingly relevant to the use of transport services. Having a smartphone and a laptop or a tablet is not possible for everyone, as having a reliable internet connection and an up-to-date operating system. Thus, available free wi-fi may be useful for some users, although the mobility hub should be made useable without having to own a digital device e.g. through touch-screen information terminals.

5.1.2 Skills

The facilities and vehicles of a mobility hub must be accessible to a broader public, allowing users with different physical and cognitive abilities to reach and use mobility hubs. The design must be preferably free of stairs and without obstacles that impede the movement of users. People in wheelchairs require the placement of buttons to interact with machines at lower levels. In case of having more than one floor, operational mechanical stairs and elevators should be provided, and the access of bicycles to the vehicles should be facilitated. Spaces within the hub should be preferably open to allow users to freely move and to avoid overcrowding. The design should be self-explanatory, facilitating the understanding of the spaces. Applying universal design principles to the design of the hub and vehicles is recommended to enable inclusivity. The universal design principles aim at maximising the usability of products, environments or interfaces by the greatest number of people, considering the diverse range of needs and avoiding adaptation (Story, 1998). Likewise, space for wheelchairs and trolleys should be guaranteed in public transport vehicles. People with visual impairments will benefit from tactile guidance paving, QR codes that provide audio guidance, voice control to use machines, and being able to access facilities and public transport vehicles with a guide dog. Lastly, users with limited physical abilities will rarely use a mobility hub as a starting point for their trip if it is not situated at a short distance from their homes.

Other skills that are crucial to using a mobility hub concern the language and the level of understanding of information. Due to limited language literacy or cognitive impairments, users may have additional difficulties and mistaken behaviours. This can have a relevant impact on their autonomy to perform the necessary tasks to use the mobility hub. Thus, simple and clear information is required, using pictograms, pictures, colour codes and numbers to facilitate

understanding. Announcements should also be made easy to understand and listen to while allowing to read what is being said by people with hearing impairments. Moreover, the possibility of being assisted by someone else is highlighted by interviewees belonging to several groups.

Due to limited digital skills and habits, non-digital signage and wayfinding are essential. Likewise, all information necessary to use the facilities and the service should also be provided by non-digital means, through boards or screens that do not require interaction with software or a smartphone. Furthermore, all the necessary information should be made available for people with visual and hearing impairments, (e.g., audio guidance, voice-control, pictograms, and text). Such information should also be provided accurately to navigation software for people with visual impairment. Likewise, facilities and vehicles should be equipped with audio devices that indicate to people with visual impairment when they can execute certain actions, such as getting into the vehicle or crossing a road. The choice of colours and lighting of the hubs and the vehicle should consider the visual perception of people with visual impairments.

Additional features that enable citizens to conveniently use the mobility hub are information and ticket kiosks, sheltered waiting spaces, benches, clean public toilets, changing rooms, storage rooms, parcel lockers and retail outlets. Moreover, printed maps of the network and a map of the mobility hub and the surroundings, explaining where each service is located and how to reach it with a wheelchair, is highlighted. Concerning transport infrastructure, secured bicycle parking is relevant, and parking for cars with e-charging stations is highlighted by peri-urban and rural citizens.

5.1.3 Cognitive appropriation

Mobility hubs are public places where different people meet, and where individuals go for different reasons. The attractiveness of mobility hubs is related to their features and their aesthetics, design, and green elements. For practical and safety reasons, the hub should have purposely designed lighting, without any dark corners. Safety and security are crucial for many children, people with impairments, women and older adults, and the design of a mobility hub should provide them. In this regard, the presence of staff from the transport operator or other forms of social control would enhance the feeling of safety, would enable users with difficulties to be assisted when necessary and give information and explanations relevant to the use of the services.

Mobility hubs can be places with a lot of stimuli, and overstimulation can be challenging for some people. In this regard, the reliability of services and having certainty about the trips are crucial for people with impairments. In this regard, the information required to travel and use a service should be made available in advance, to allow people with impairments to prepare accordingly. Likewise, for users that are not familiar with a mobility hub and transport services, self-confidence and fear of making a mistake are relevant barriers, preventing them from using it in some cases. In order to allow more citizens to use mobility hubs, training could be offered, to explain what services can be found and how to use them. This would also be the opportunity to advertise and make mobility hubs known to people that have never used them.

People with cognitive impairments may experience more difficulties when using the mobility hub, to the extent that it is adapted to their capabilities and the interactions with other people are also adapted. For instance, drivers and staff should know how to interact with people with impairments, and users should be informed to also facilitate these people's use of vehicles and facilities. Although this recommendation entails socio-cultural dynamics that cannot be changed solely through mobility hubs, informing and educating users and professionals could already improve the experience of disadvantaged users.

5.2 Shared mobility

5.2.1 Material Access

The cost of transport, fares and type of subscription packages can be a barrier for certain users. Some participants stated that their local shared mobility services are too expensive, especially the car-sharing service. It is recommended to consider subsidies and adapted pricing for users with low or limited income, and increase the flexibility of subscription packages. For instance, users that only need a vehicle rarely would subscribe to the service if they did not have to pay a monthly fee. Moreover, requiring a credit card or a bank account is a barrier for some citizens. Pre-paid cards or services that can be purchased without a credit card may be useful, especially for low-income citizens, children and teenagers, migrants and people with cognitive impairments.

Access to shared mobility services is dependent on the availability of vehicles, which is highlighted as unreliable by participants of this study. Besides car-sharing and bike-sharing, other types of services available are relevant for some vulnerable groups. For instance, on-demand services are highlighted by informal caregivers, older people, and people with impairments. Shared mopeds and e-scooters are the preferred options for teenagers. Dockless services are considered by some participants as more attractive and convenient than services that location-based services.

5.2.2 Skills

Vehicles must be usable by people with different physical abilities. For instance, shared bicycles should not be heavier than normal bicycles, and shared cars should allow the entrance of passengers with reduced mobility, or even in a wheelchair. The lack of skills to use a service, such as having a driving licence or cycling skills, will impede the use of shared mobility by a relevant number of users. This is also the reason why teenagers prefer shared e-scooters or mopeds because they can use motorized vehicles without having a driving licence. Regarding cycling, some participants expressed the desire of learning to cycle for occasional trips. It is recommended to offer cycling lessons, and maybe also training about the bike sharing service, to citizens that would like to start cycling but lack the necessary skills and self-confidence to do so. Likewise, training and free tests of other shared mobility services could enable more people to know about them and start using them.

As explained in the previous sub-section, the information and announcements necessary to use a shared mobility service should be accessible to citizens with different literacy levels and cognitive abilities. Thus, boards should limit text and use pictograms and pictures as much as possible. The instructions to use a shared mobility service should be made simple and clear, using symbols, numbers and colour codes, and provided by digital and non-digital means. Moreover, video tutorials, audio guidance and voice control may ease the access of citizens, being especially necessary for people with visual or hearing impairments. Lastly, the booking of the service should be possible by non-digital channels and through a screen, without requiring the use of a smartphone.

5.2.3 Cognitive appropriation

Shared mobility is often perceived as unreliable or not well-maintained, which makes it unattractive for a lot of citizens. Shared mobility operators could revert this conception by ensuring the maintenance of vehicles and their availability. Moreover, users could benefit from knowing in advance if vehicles are available in their closest mobility hub and having the possibility to book them, so they find them when arriving at the hub. Lastly, an integrated ticket

that included all forms of transport present at the hub could make the user experience more comfortable and encourage the use of shared mobility services.

Certain shared mobility services can be more attractive than others for certain users due to opinions, values, and meanings. Shared bicycles will not be used by people that are concerned about road safety in cities where the cycling infrastructure is lacking. Teenagers find e-scooters cool, fast, and socially accepted. Although such opinions entail other dimensions beyond the shared mobility service, the attractiveness of shared mobility might be increased by the design of the services, and marketing campaigns. In this regard, the usability of vehicles, such as bicycles, e-scooters or cars, should never be more difficult than the one of an equivalent private vehicle, because this would make the service unattractive, as participants from Brussels and Vienna have stated in their local bike-sharing services. Lastly, some citizens may be more reluctant to change their transport mode due to the values and meaning associated with car ownership. This is especially the case for peri-urban and rural inhabitants, who face to a greater extent the results of car-centric urban and regional planning.

5.3 Digital mobility services

5.3.1 Material Access

Digital mobility services require the use of digital devices, such as a smartphone or a tablet, a reliable internet connection and an up-to-date operating service. Thus, available free wi-fi at mobility hubs would be useful for some users, as well as the possibility to charge their devices. On-site touchscreen information terminals that allow access to services without needing a smartphone would be helpful too for people without a smartphone or internet connection. Moreover, for people that want to improve their digital skills, free or inexpensive courses are recommended.

5.3.2 Skills

To use digital mobility services, digital skills as well as the ability to perform them are essential. For instance, people with physical impairments may, in some cases, not be able to fully use a digital device due to their physical disabilities. People with low digital literacy would benefit from courses and training on how to use the services. On-site human support in case they have difficulties in the long term is also considered necessary by participants. Moreover, people with visual impairments often need training before using a service, as is sometimes the case for people with cognitive impairments.

Digital mobility services should have inclusive interfaces, complying with universal design principles. The text should be limited, and the use of pictograms and pictures recommended. For people with visual impairments, audio guidance and voice control are often necessary. Lastly, the integration of all transport services in a single app, with a single interface, would be very useful for citizens with learning barriers, as in the case of some forms of impairment or low literacy.

5.3.3 Cognitive appropriation

Digital mobility services are attractive for users that are familiar with digital devices if the service allows them to fulfil an objective relevant to them. Self-confidence and fear of making a mistake, or a hazard, can prevent people without digital skills to use digital mobility services. However, people with low literacy will find the motivation to learn how to use a digital mobility service if

they need it and if they have the tools and support to do so. In this regard, communication and education are central.

The protection and use of personal data by transport providers is a general concern. And some people, especially citizens with low digital literacy, may mistrust the services and refuse to make online payments. Moreover, the social dimension of transport is relevant for some users, preferring interactions with other people over interactions with a machine. The latter may be a reason for some users to not adopt digital technologies.

5.4 Limitations, implications and further research

The findings of this study offer new insights into how mobility hubs are experienced by users and how the inclusivity of the hubs could be improved. Although the object of the study is complex, this document provides valid and reliable findings, resulting from the data collected through two interviewing processes; with 'experts' and 'end-users'. This allows the comparison of the results and the verification of the findings. Nonetheless, the researchers acknowledge the limitations of this research, which are explained in the following paragraphs. Likewise, the theoretical and practical implications, and suggestions for further research, are also mentioned in this section.

The first limitation concerns the focus of this study, which aims at gaining insights into the needs and barriers of vulnerable groups. As these groups are often hard to reach, the recruitment of participants was quite time-consuming. Moreover, the resulting sample does not reflect the proportion of each vulnerable group in society, and not all groups are equally represented. This is because transport disadvantages and vulnerabilities are intersectional and multidimensional: they involve members of multiple social groups for whom they have different types of impact. It is almost impossible to recruit a participant that only belongs to a group, as it is very difficult to correlate certain barriers and needs solely with a vulnerable group or form of disadvantage. Secondly, as interviews were conducted in four locations by different people and in different languages, certain nuances might have been lost in the process. To overcome this limitation, the coding of the transcripts was conducted in the original language to reduce any potential loss. Thirdly, a part of this study was conducted when Covid-19 related measures were still active, resulting in an additional barrier to meeting participants in person, some interviews were conducted remotely, and others physically. Likewise, although most interviewees participated in semi-structured interviews, others did it through focus groups. Although the difference in data collection method may result in difficulties to compare the findings, the researchers were aware of this and conducted the coding and the analysis procuring comparison and validity of the findings.

The theoretical implications of this deliverable concern the theoretical framework that was constructed for this study, and confirm the validity and relevance of the Capabilities Approach to gain in-depth insights into transport disadvantages and more specifically those related to mobility hubs. The practical implications of this deliverable are related to the data collection method, which demonstrates how by adopting a qualitative approach, in-depth knowledge about transport disadvantages can be produced. Moreover, it also proves that gathering data in different languages, and combining different data collection methods, may offer interesting and valid results. However, this must be done consciously and putting into place strategies to ensure the comparability of the findings.

As a continuation of this study, further research will be conducted in WP4 and WP5 of the SmartHubs project. Firstly, the results of this deliverable will be used to inform the design of a questionnaire survey to be distributed in WP5 (tasks 5.1, 5.3 and 5.5). The findings of this survey could be compared with the results of this study, with the aim to enhance validity and generalisation. Secondly, a co-creation process will be conducted in the Anderlecht living lab, applying the knowledge produced in this study, and using co-design methods to further understand the needs and barriers of current and potential users of mobility hubs.

6. References

- Acheampong, R. A. (2021). Societal impacts of smart, digital platform mobility services—An empirical study and policy implications of passenger safety and security in ride-hailing. *Case Studies on Transport Policy*, 9(1), 302–314.
<https://doi.org/10.1016/j.cstp.2021.01.008>
- Beyazit, E. (2011). Evaluating Social Justice in Transport: Lessons to be Learned from the Capability Approach. *Transport Reviews*, 31(1), 117–134.
<https://doi.org/10.1080/01441647.2010.504900>
- Bogner, A., Littig, B., & Menz, W. (2009). Introduction: Expert Interviews — An Introduction to a New Methodological Debate. In A. Bogner, B. Littig, & W. Menz (Eds.), *Interviewing Experts* (pp. 1–13). Palgrave Macmillan UK. https://doi.org/10.1057/9780230244276_1
- Bryman, A. (2016). *Social Research Methods*. Oxford University Press.
- Cao, M., & Hickman, R. (2019). Understanding travel and differential capabilities and functionings in Beijing. *Transport Policy*, 83, 46–56.
<https://doi.org/10.1016/j.tranpol.2019.08.006>
- Ciommo, F. D., Rondinella, G., & Kilstein, A. (2020). *D1.3—Users capabilities and requirements*.
- Coffey, A., & Atkinson, P. (1996). *Making sense of qualitative data: Complementary research strategies* (pp. x, 206). Sage Publications, Inc.
- Durand, A., Zijlstra, T., van Oort, N., Hoogendoorn-Lanser, S., & Hoogendoorn, S. (2021). Access denied? Digital inequality in transport services. *Transport Reviews*, 1–26.
<https://doi.org/10.1080/01441647.2021.1923584>
- Flamm, M., & Kaufmann, V. (2006). Operationalising the Concept of Motility: A Qualitative Study. *Mobilities*. <https://doi.org/10.1080/17450100600726563>
- Flick, U., Kardoff, E. von, & Steinke, I. (2004). *A Companion to Qualitative Research*. SAGE.

- Gebresselassie, M., & Sanchez, T. W. (2018). "Smart" Tools for Socially Sustainable Transport: A Review of Mobility Apps. *Urban Science*, 2(2), Article 2.
<https://doi.org/10.3390/urbansci2020045>
- Goodman-Deane, J., Kluge, J., Roca Bosch, E., Nesterova, N., Bradley, M., Waller, S., Hoeke, L., & Clarkson, P. J. (2022). Toward Inclusive Digital Mobility Services: A Population Perspective. *Interacting with Computers*, 33(4), 426–441.
<https://doi.org/10.1093/iwc/iwac014>
- Groth, S. (2019). Multimodal divide: Reproduction of transport poverty in smart mobility trends. *Transportation Research Part A: Policy and Practice*, 125, 56–71.
<https://doi.org/10.1016/j.tra.2019.04.018>
- Harvey, J., Guo, W., & Edwards, S. (2019). Increasing mobility for older travellers through engagement with technology. *Transportation Research Part F: Traffic Psychology and Behaviour*, 60, 172–184. <https://doi.org/10.1016/j.trf.2018.10.019>
- Horjus, J. S., Gkiotsalitis, K., Nijënstein, S., & Geurs, K. T. (2022). Integration of shared transport at a public transport stop: Mode choice intentions of different user segments at a mobility hub. *Journal of Urban Mobility*, 2, 100026.
<https://doi.org/10.1016/j.urbmob.2022.100026>
- Jeekel, H. (2018). *Inclusive Transport: Fighting Involuntary Transport Disadvantages*. Elsevier.
- Kamberelis, G., & Dimitriadis, G. (2013). *Focus Groups: From structured interviews to collective conversations*. Routledge. <https://doi.org/10.4324/9780203590447>
- Kaufmann, V. (2016). *Re-Thinking Mobility: Contemporary Sociology*. Routledge.
<https://doi.org/10.4324/9781315244303>
- Kuttler, T., & Moraglio, M. (2020). *Re-thinking Mobility Poverty: Understanding Users' Geographies, Backgrounds and Aptitudes* (1st ed.). Routledge.
<https://doi.org/10.4324/9780367333317>

- Lucas, K. (2019). A new evolution for transport-related social exclusion research? *Journal of Transport Geography*, 81, 102529. <https://doi.org/10.1016/j.jtrangeo.2019.102529>
- Luz, G., & Portugal, L. (2021). Understanding transport-related social exclusion through the lens of capabilities approach. *Transport Reviews*, 0(0), 1–23. <https://doi.org/10.1080/01441647.2021.2005183>
- Martens, K. (2016). *Transport Justice: Designing Fair Transportation Systems*. Routledge.
- Martens, K., Bastiaanssen, J., & Lucas, K. (2019). 2 - Measuring transport equity: Key components, framings and metrics. In K. Lucas, K. Martens, F. Di Ciommo, & A. Dupont-Kieffer (Eds.), *Measuring Transport Equity* (pp. 13–36). Elsevier. <https://doi.org/10.1016/B978-0-12-814818-1.00002-0>
- Mayring, P. (2015). Qualitative Content Analysis: Theoretical Background and Procedures. In A. Bikner-Ahsbals, C. Knipping, & N. Presmeg (Eds.), *Approaches to Qualitative Research in Mathematics Education: Examples of Methodology and Methods* (pp. 365–380). Springer Netherlands. https://doi.org/10.1007/978-94-017-9181-6_13
- Moser, A., & Korstjens, I. (2018). Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis. *European Journal of General Practice*, 24(1), 9–18. <https://doi.org/10.1080/13814788.2017.1375091>
- Nussbaum, M., & Sen, A. (1993). *The Quality of Life*. Clarendon Press.
- Pereira, R. H. M., Schwanen, T., & Banister, D. (2017). Distributive justice and equity in transportation. *Transport Reviews*, 37(2), 170–191. <https://doi.org/10.1080/01441647.2016.1257660>
- Ryan, J., Wretstrand, A., & Schmidt, S. M. (2015). Exploring public transport as an element of older persons' mobility: A Capability Approach perspective. *Journal of Transport Geography*, 48, 105–114. <https://doi.org/10.1016/j.jtrangeo.2015.08.016>

- Sandelowski, M. (1995). Sample size in qualitative research. *Research in Nursing & Health*, 18(2), 179–183. <https://doi.org/10.1002/nur.4770180211>
- Sen, A. (1992). *Inequality Reexamined*. Clarendon Press.
- Shaheen, S., & Cohen, A. (2018). Overview of Shared Mobility. *ITS Berkeley Policy Briefs*, 2018(01). <https://doi.org/10.7922/G2WH2N5D>
- Sherriff, G., Adams, M., Blazejewski, L., Davies, N., & Kameråde, D. (2020). From Mobike to no bike in Greater Manchester: Using the capabilities approach to explore Europe’s first wave of dockless bike share. *Journal of Transport Geography*, 86, 102744. <https://doi.org/10.1016/j.jtrangeo.2020.102744>
- Smith, N., Hirsch, D., & Davis, A. (2012). Accessibility and capability: The minimum transport needs and costs of rural households. *Journal of Transport Geography*, 21, 93–101. <https://doi.org/10.1016/j.jtrangeo.2012.01.004>
- Story, M. F. (1998). Maximizing Usability: The Principles of Universal Design. *Assistive Technology*, 10(1), 4–12. <https://doi.org/10.1080/10400435.1998.10131955>
- Vecchio, G., & Martens, K. (2021). Accessibility and the Capabilities Approach: A review of the literature and proposal for conceptual advancements. *Transport Reviews*, 41(6), 833–854. <https://doi.org/10.1080/01441647.2021.1931551>
- Vecchio, G., & Tricarico, L. (2019). “May the Force move you”: Roles and actors of information sharing devices in urban mobility. *Cities*, 88, 261–268. <https://doi.org/10.1016/j.cities.2018.11.007>
- Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly*, 36(1), 157–178. <https://doi.org/10.2307/41410412>
- Weiss, R. S. (1995). *Learning From Strangers: The Art and Method of Qualitative Interview Studies*. Simon and Schuster.

Wu, X., Cao, J., & Douma, F. (2021). The impacts of vehicle automation on transport-disadvantaged people. *Transportation Research Interdisciplinary Perspectives*, 11, 100447. <https://doi.org/10.1016/j.trip.2021.100447>

Zhang, M., Zhao, P., & Qiao, S. (2020). Smartness-induced transport inequality: Privacy concern, lacking knowledge of smartphone use and unequal access to transport information. *Transport Policy*, 99, 175–185. <https://doi.org/10.1016/j.tranpol.2020.08.016>

Annex 1

Interview guidelines – Experts interviews

1. About the representative

[These might be known before the interview since this information could be public or provided prior to the meeting]

What is your position/role as a representative? (In case we are not sure if he/she is a representative: where do you work and what is your job?)

What is your relationship with the group you are “representing”?

How long have you been doing this role?

How many members are in the group you are “representing”?

What is your area of influence (neighbourhood, city, region...)?

2. About urban transportation

As has been explained before, this interview aims to collect information about the needs and barriers encountered by members of the group you represent concerning urban transportation. By urban transportation, we understand any form of travelling from one place to another within the city. For instance, to reach the workplace, the doctor, family, friends and other necessary destinations.

What are the goals and needs of this group concerning transportation? (For instance, where do they need to travel and what opportunities they reach or could reach using transport).

What are the main problems that this specific group encounters concerning the use of transport services (e.g. difficulty to reach necessary destinations or lack of available services)?

What modes of transport do they use more often? Could you explain why?

Which modes of transport would they like to use, but do not/cannot use? Could you explain why?

To what extent can the availability of more transport options (shared car, public transport, shared bike...) have an impact on the daily life of this group?

To what extent the members of this group are familiar with digital mobility services: transport services accessed through a digital platform/device (e.g., smartphone or tablet)?

Within this group, are there specific profiles or sub-groups that are especially disadvantaged concerning their access to transportation?

If there are clear sub-groups, the interviewer can proceed to refer to them in the following questions. If not, the following questions refer to the entire group that the interviewee represents. Even if the interviewee does not refer to sub-groups, they could be indirectly referred to during the interview. It is important that the interviewer pays attention to it and identifies them when it is the case.

3. About access to transportation

The next topic we will discuss is the access to different transport modes. This refers to how easy it is for someone to use any form of transport and what barriers are experienced by the members of this group.

[Reminder of potential user types >> Since we are talking about a diverse group of people, you can refer to different types of users. Please let me know when you refer to one or another].

What are the main barriers that impede the access to transportation of this group?

[The following list serves to guide the interviewer and help the interviewee after his/her reply, if necessary]

Economic: related to resources and costs

Car ownership

Access to reliable internet connection

Smartphone ownership

Laptop/tablet ownership

Cost of transport (tickets, fuel cost...)

Spatial: related to the spatial distribution of transport options.

Access to different transport options (e.g., proximity to the nearest stop/station, available transport modes, existing infrastructure).

Access to desired destinations

Connection between modes of transport (e.g., shape of the network and placement of existing hubs)

Temporal: related to time requirements.

Transport schedule (e.g., frequency of public transport, availability at night)

Working hours

Caregiving requirements

Physical: related to physical barriers.

Usability of modes

Access to vehicles

Access to facilities

Sociocultural

Discrimination

Digitalisation

LIST OF SKILLS

Knowledge

Local language

Reading a map

Familiarity with shared transport (for instance public transport, shared cars/bicycles...)

Driving licence

Cycling skills

Cognitive skills

Ability to read

Ability to orient yourself in an unknown space

Ability to understand the transport network and the combination of different modes

Digital skills [important to ask thoroughly]

Ability to use a smartphone

Ability to scan QR codes

Ability to use navigation apps

Ability to use shared mobility apps

Ability to buy a ticket/pass or book a service through the phone

Physical abilities

Physically fit (able to walk for a distance, go down the stairs, carry luggage, etc.)

Visual ability

Hearing ability

Now that we have listed skills and abilities, would you add another one? [this information might have been given previously]

5. About appropriation of transport solutions

To conclude this interview, we are going to talk about how the members of the group you represent feel about different transport services. Thus, I invite you to refer to their opinions, habits, values, and sociocultural factors.

To what extent are they open to using different modes of transport than the ones they currently use? Could you explain why?



How attractive are shared modes of transport for this group (for instance, in terms of safety, comfort and convenience)?

Public transport

Shared bikes

Shared cars

Shared e-scooters

[N.B.: an e-scooter is , not 

How attractive are active modes of transport for this group (for instance, in terms of safety, comfort and convenience)?

Cycling

Walking

How do you think that mobility hubs could be made more attractive for this group (for instance, in terms of safety, comfort and convenience)?

How can the members of this group be involved in the design process of a mobility hub to make sure their needs are well-considered?

[This question aims at understanding the type of participation the interviewee considers to be necessary, for instance, consultation, participation, co-creation, decision-making...]

Annex 2

Interview guidelines – End-user interviews

The interview guidelines for end-users were adapted to each group. However, the structure and most questions remain the same. The guide shown in this annex is the guideline to interview people with physical impairments.

1. About current mobility

First, we are going to talk about your daily mobility. By current mobility, we refer to any form of travel from one place to another within the city, or your local area if you do not live in a city. For instance, to reach the workplace, the doctor, family, friends, and other necessary destinations. We are also interested in knowing how easy it is for you to have access to any form of transport.

For what purposes do you usually travel on a regular day (study, work, do groceries, accompany someone, leisure, visit family, go to the doctor...)?

How familiar are you with the local transport network? [the following sub-questions might guide the interviewee]

Do you know the different modes that are available?

What do you think about public transport?

What do you think about walking and cycling?

Do you know how to buy a ticket or rent a vehicle?

Do you know how to find the schedules?

What modes of transport do you use most? Could you explain why?

What modes of transport would you like to use but don't or cannot? Could you explain why?

What are the main problems that you encounter when using your usual mode of transport?

[The following sub-questions serve to guide the interviewer and help the interviewee after his/her reply, if necessary]

Economic: related to resources and costs

Do you own a car?

Is transport expensive for you (tickets, fuel cost...)?

Spatial: related to the spatial distribution of transport options.

How far do you need to walk to the stop or station that you most often use?

Does the current network provide access to the destinations you want to reach?

Is it easy to transfer between different modes of transport?

Temporal: related to time requirements.

Is the transport schedule suitable to your needs (e.g., frequency of public transport, availability at night/over the weekend)?

How often do you encounter delays?

Is the transport mode that you use reliable for you?

Physical: related to physical barriers.

What modes of transport you cannot use?

Can you easily access vehicles (e.g. board, get off)?

Can you easily access facilities (e.g. use stops and stations with multiple levels).

From the following skills, can you explain how confident you are?

[You can give the following cues as possible answer options:

I'm (very) confident - I can do it, but I do not like doing it - I cannot do it.]

Knowledge

Car driving skills

Cycling skills

Using a (e-)scooter

Reading a map (e.g. transport network map)

Finding your way in the city

Digital skills

Ability to use a smartphone

Ability to scan QR codes

Ability to look up the best route to reach your destination on your phone (e.g. Google Maps)

Physical abilities

Physical fitness (ability to walk longer distances, go up/ down the stairs, carry luggage, etc).

Visual ability

Hearing ability

Have you ever used the following services:

bike sharing,



e-scooter sharing,

car sharing,

a parcel locker (to pick up a parcel ordered online)

If the response is yes: *which one and how often?*

If the response is no: *do you know what these services are?*

[N.B.: an e-scooter is , not ]

[In case the respondent does not know how any of the above services work, please ask her/him to explain her/his understanding of the services.]

[In case the concepts are unclear to the respondent, you can mention here services that are available in the area.]

*Would you like to use
bike sharing,
car sharing,
e-scooters sharing?*

Why would you like to use the service?

[the interviewer can refer to the following aspects to encourage the respondent to reflect on them: attractiveness, trust, comfort, autonomy, safety, affordability, convenience...]

How do you feel about changing between different modes of transport during a single trip: e.g., cycling and then taking the metro, or combining bus and trams)?

[the interviewer can refer to the following aspects to encourage the respondent to reflect on them: attractiveness, trust, comfort, autonomy, safety, affordability, convenience...]

*Do you use your smartphone, tablet or computer (if you have any) to
get information about transport options (e.g. check the timetable, plan a route)
book and pay for a ticket online
book a shared car/e-scooter or bicycle
use UBER [if available] or other taxi services
If yes, which one and how often?
If no, why?*

[the interviewer can refer to the following aspects to encourage the respondent to reflect on them: attractiveness, trust, comfort, autonomy, safety, affordability, convenience...]

2. About mobility hubs

Now we are going to talk about mobility hubs, barriers and necessary skills to make use of mobility hubs.

Have you ever heard of mobility hubs?

Have you ever been to a mobility hub?

[Show picture of the mobility hub and explain different elements]



What is your first impression of a mobility hub based on the images above?

[Here the interviewer can let the respondent freely explain her/his feelings. You can continue with the following questions]:

At mobility hubs you can change between different modes of transport and use shared cars, bikes and scooters. Can you imagine that you would use a mobility hub for your everyday journeys [if it is not already the case]?

If no, why?

Would you find it useful if there was such a hub in your neighbourhood?

What would be important for you to find in a mobility hub in order to easily use it?

What transport services would you like to use at a mobility hub if it was available in your neighbourhood?

Mobility hubs can also include additional services such as shops, parcel lockers, toilets, waiting rooms etc. Which of these additional services would you find useful?

What form of support would you need in order to first use a mobility hub?

What about human support?

What about support for the long term?

If a mobility hub was built in your neighbourhood, would you like to be involved in its design or other parts of the process?

If yes, in what form (e.g. by attending an information event, workshop, filling in a survey, etc.)?

3. Likert scale

To conclude this interview, I will say 8 statements which refer to yourself, could you please say to what extent you agree with them or not. The scale goes from strongly disagree to strongly agree, with the possibility to agree or disagree and slightly agree or disagree. In case you are unsure, you can also say you do not know or do not want to answer.

Check only one box per row.	1.	2.	3.	5.	6.	7.
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	I don't know
I could easily switch to other transport modes for my daily trips.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The transport services that I use satisfy my needs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mobility hubs would improve the way I move around the city.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I feel that it is difficult for me to get around in the city.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Digital solutions, such as shared transport apps and navigation apps, help me get around the city.

The protection of my personal data (name, phone number...) is important to me.

I do not like to do online payments (e.g. paying through an application).

I am actively involved in improving transportation (e.g., writing suggestions, participating in events, demonstrating...)

Annex 3

Coding tree – Experts interviews

Name	Description
Access	Concerning barriers to access and suggested/potential solutions
Economic (resources) barriers	Related to obtaining access through material resources
Physical environment barriers	Related to obtaining physical access
Socio-cultural barriers	Related to cultural behaviours and dynamics: digitalization and discrimination are included
Spatial and geographic distribution barriers	Related to the availability of options within a geographical zone
Temporal (schedule) barriers	Related to frequency and time schedules of transport and also users (e.g. working at night).
Appropriation, opinion and values	Concerning values, social norms, beliefs and subjective opinions
About active mobility	Opinion and experience with active mobility
About desired mobility	What modes and types of mobility would they prefer?
About digital services	Opinion and experience with digital mobility services
About mobility hubs	Anything that the group believes or thinks about mobility hubs and their design
About multimodality	Opinion and experience on multimodality
About shared mobility	Opinion on shared mobility: including public transport and shared vehicles
About their current mobility	How do they like their current mobility? How do they feel about it?

Name	Description
Openness to change	About how eager are to try alternatives and see a potential positive impact
Safety-Security	How safe do they feel? Any security-related concerns?
Group characteristics	
Current involvement in obtaining better mobility and accessibility	Complaints, demonstrations, communication with transport providers...
Group's current use of transport	What modes and frequencies do they use?
Group identity and demographics	Age, origin, gender and similar characteristics of the group being referred to
Ideal form of involvement and participation	How would they like to participate in citizen engagement? And in the co-creation process?
Needs and goals of mobility	What this group is obtaining through their mobility, why do they need to move/travel?
Relation interviewee with group	What is the role/position of the representative and interaction with the group. This is a specific question.
Sub-groups of vulnerable users	What sub-groups of users are more vulnerable or have specific needs/barrier?
Skills	
Cognitive abilities	Related to cognitive impairments or limitations that hamper the acquisition of skills.
Digital skills	Apps, smartphones, QR codes, GPS navigation, online shopping...
Knowledge	Language, reading maps, understanding a network... everything that can be learnt, excluding digital skills
Physical abilities	Related to the ability to move in the physical spaces and with the senses: moving, listening, seeing...

Annex 4

Coding tree - End-user interviews

Name	Description
Access (resources)	Concerning barriers to access and suggested/potential solutions
Economic barriers	Related to obtaining access through material resources
Physical environment barriers	Related to obtaining physical access
Socio-cultural barriers	Related to cultural behaviours and dynamics: digitalization and discrimination are included
Spatial and geographic distribution barriers	Related to the availability of options within a geographical zone
Temporal (schedule) barriers	Related to frequency and time schedules of transport and also users (e.g. working at night).
Appropriation, opinion and values	Concerning values, social norms, beliefs and subjective opinions
About active mobility	Opinion and experience with active mobility
About desired mobility	What modes and types of mobility would he/she prefer?
About digital mobility services	Opinion and experience with digital mobility services
About mobility hubs	Anything that the person believes or thinks about mobility hubs and their design
About multimodality	Opinion and experience on multimodality
About shared mobility	Opinion on shared mobility: including public transport and shared vehicles
About their current mobility	How does he/she like his/her current mobility? How does he/she feel about it?

Name	Description
Openness to change	About how eager is to try alternatives and see a potential positive impact
Safety-security	How safe does he/she feel? Any security-related concerns?
Person's characteristics	
Current involvement in obtaining better mobility and accessibility	Complaints, demonstrations, communication with transport providers...
Current use of transport	What modes and frequencies does he/she use?
Desired involvement in the co-design of a mobility hubs	How would she/he like to participate in citizen engagement? And in the co-creation process?
Identity and demographics	Age, origin, gender and similar characteristics of the person
Needs and goals of this person's mobility	What this person is obtaining through his/her mobility, why do they need to move/travel?
Skills	Concerning abilities necessary to use the mobility service and facilities: can be acquired or not (e.g., physical/cognitive ableness, cycling, reading a map...)
Cognitive abilities	Related to cognitive impairments or limitations that hamper the acquisition of skills.
Digital skills	Apps, smartphones, QR codes, GPS navigation, online shopping...
Knowledge	Language, reading maps, understanding a network... everything that can be learnt, excluding digital skills
Physical abilities	Related to the ability to move in the physical spaces and with the senses: moving, listening, seeing...