Intellectual Disability, Digital Technologies, and Independent Transportation – A Scoping Review

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Abstract

Transportation is an essential aspect of everyday life. For people with intellectual disabilities transportation is one the largest barriers to community participation and a cause of inequality. However, digital technologies can reduce barriers for transportation use for people with intellectual disabilities and increase community mobility. The aim of this scoping review was to identify and map existing research on digital technology support for independent transport for people with intellectual disabilities and identify knowledge gaps relevant for further research. The authors conducted a scoping review of articles presenting digital technologies designed to assist in outdoor navigation for people with intellectual disabilities. The results show that while a variation of design elements was utilized, digital technologies can effectively support individuals with intellectual disability in transport. Further research should focus on multiple contexts and types of transportation, different support needs during independent travel, real-world settings, participatory approaches, and the role of user training.

Keywords: Transport, Intellectual disability, Digital technologies, Navigation.

1. Introduction

Transportation is crucial for maintaining quality of life (Fresher-Samways, Roush, Choi, Desrosiers, and Steel, 2003), independent living and participation in the community (Graham, Keys, McMahon, and Brubacher, 2014; Rosenkvist, Risser, Iwarsson, Wendel, and Ståhl, 2009). It is critical in accessing services such as healthcare, maintaining employment and participating in social activities. Reduced access to transport may have a negative impact on our overall well-being (Fresher-Samways et al., 2003), restrict community participation (Verdonschot, De Witte, Reichrath, Buntinx, and Curfs, 2009), and increase inequalities. Transportation problems have been identified as a barrier to access self-advocacy activities, integrated employment, religious participation, volunteering, physical activity, leisure activities, and health care (Davies, Stock, Holloway, and Wehmeyer, 2010).

Despite the importance of transportation, people with a disability are often excluded from accessing and utilizing transportation services. This is particularly a challenge for people with intellectual disabilities due to required skills such as the ability to read schedules, memory, attention, time management, literacy, multitasking, and problem-solving (Davies, Stock, Holloway, and Wehmeyer, 2010; Price, Marsh, and Fisher, 2018). In addition, people with intellectual disabilities are hindered by unsupportive networks and communities (Friedman and Rizzolo, 2016; Mechling and O'Brien, 2010) and at the same time they need to rely on others for their transportation needs (Price et al., 2018). These aspects along with inadequate training (Friedman and Rizzolo, 2016) and the lack of driver's license (McCausland, Stancliffe, McCallion, McCarron, 2019), result in a dependence on special transport. Studies show that transportation is one of the largest barriers to achieve independence, employment, and social inclusion (Dymond, 2011; World Health Organization, 2001).

Digital technology has the potential to address and facilitate independent transport for people with intellectual disabilities. Studies show that digital technologies may help to circumvent cognitive challenges (McMahon, Cihak and Wright, 2015), including for instance time management (Green, Hughes, and Ryan 2011), employment tasks (Collins et al. 2014), communication (Saturno et al. 2015), completion of daily tasks (Mechling 2007), and engagement in daily and leisure activities (Lancioni et al. 2020). The use of digital technologies and inventions can enable people with intellectual disabilities to achieve greater self-determination, higher levels of participation, and enhanced social inclusion (Wehmeyer, Tassé, Davies, and Stock, 2012) and empower citizens. Digital technologies have been used to assist people with intellectual disabilities to independently access and/or use transportation and prior research shows that digital

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technologies may reduce barriers for independent transportation (Verdonschot et al., 2009).

There is an increasing amount of literature on digital technologies as support for independent transportation for people with intellectual disabilities. To the best of our knowledge, no previous review has synthesized previous research on people with intellectual disabilities, digital technologies, and transportation. Given the different variations in digital technologies, functions, and aims, as well as the heterogeneity of people with intellectual disabilities, it is important to identify existing literature in this area. The fast pace of new innovations and designs around digital technologies calls for an updated overview to keep track of existing innovations and their empirical support or lack thereof. Also, due to the complexity of independent travel for people with intellectual disability, it is essential to note the study designs and the contexts in which past research were done. An overview and understanding of the topic can assist and inform researchers' and practitioners' future work. In this scoping review, we aim to identify and map existing research on digital technology support in independent transport for people with intellectual disabilities and present an agenda for further research.

Research questions:

- What type of digital technology and design elements are used to support independent transport?
- What research designs and evaluation methods are applied to explore digital technology support in independent transport?
- What is the impact of digital technology support on independent transport?

2. Methods

A scoping methodology (Arksey and O'Malley, 2005; Levac, Colquhoun, and O'Brien, 2010), was considered the most suitable approach to provide an overview of a broad topic and to comprehensively and systematically map existing research to identify research gaps (Munn et al., 2018). We followed a methodological framework that included the following stages (a) identify the research question; (b) identify relevant studies; (c) select studies; (d) chart the data; (e) collate, summarize, and report the results.

Initially, a review protocol was developed and is available upon request. A short version of the review protocol is published in the Current Research Information System In Norway (Cristin project-ID: 2044721).

2.1. Search Strategy

The first author and a librarian conducted a series of literature searches using the following databases: Ovid, Embase, Medline, Scopus, and ERIC. We used a building block search strategy and combined search words/phrases, text words, and index terms/descriptors using the Boolean operators "and" and "or". A search strategy was developed and customized to fit into the different databases and maximize sensitivity and specificity. In addition, related subject headings were included in the database searches. Our search, undertaken 16.11.2021 involved a broad list of search terms related to the three categories: intellectual disability, technology, and transport/mobility were as follows: Intellectual disability (*intellectual disability, cognition disorder, cognitive dysfunction, developmental disabilities, cognitive defect, cognitive impairment, intellectual impairment, mental deficiency, developmental disorder, developmental delay, autism, pervasive developmental disorder not otherwise specified, mental handicap, mental retardation, downs syndrome*), technology (*computer, technology, iPhone, tablet, PDA, personal digital assistant, apps, mobile phone, iPod, computer peripheral devices, handheld, virtual reality, augmented reality, GPS, Geographic information systems, self-help devices, communication aids, rehabilitation equipment*) and transport (*transport, pedestrian, walking, bus, buses, travelling, travel, wayfinding, public transit, subway, metro, cycling, railway*).

To be comprehensive in identifying relevant studies (Arksey and O'Malley, 2005), we included qualitative, quantitative, mixed-methods, and grey literature. Furthermore, no start date was chosen as a starting point. We performed a Google Scholar search with the same combinations as used for the other databases to find grey literature. However, no new documents were found. With the aim to ensure that as many as possible of the relevant studies were included, we increased comprehensiveness (sensitivity) of the searches which in turn reduced precision. As a result, more non-relevant studies were included in the screening phase of the process.

2.2. Study Selection

To exclude studies that did not address this scoping review's aim, we used an inclusion/exclusion criterion based on the research question as suggested by Arksey and O'Malley (2005). The inclusion and exclusion criteria are presented in Table 1.

A total of 3195 publications were identified (Ovid, MEDLINE, Embase, 850; ERIC, 39; Scopus, 2306). The articles were imported into EndNote, where we followed the steps developed by Wichor Bramer to remove duplications (items excluded due to duplicates n=304). A total of 2890 publications were screened for relevance by reviewing the title and abstract. By independently applying the exclusion and inclusion criteria (table 1), 45 publications were subjected to a full-text review.

	Inclusion criteria	Exclusion criteria
Publication type	Articles (a peer-reviewed journal), Book chapters, Doctoral theses, Master's theses, Reports, Conference papers (Abstracts)	Newspaper articles, Letters, Commentaries, Editorials, Meeting abstracts, Literature reviews
Language	English, Norwegian, Swedish, Danish	Any other language
Focus	Technology-supported solutions designed to assist in outdoor navigation for people with intellectual disabilities, Any research designs, Empirical studies.	Only on behaviour interventions or systematic training, not clearly intellectual disability, only indoor navigation, no digital technologies, not empirical studies.

Table 1. Inclusion and exclusion criteria

Thirty-three of these publications were excluded: ten had another population or did not clearly state that participants had an intellectual disability, five did not describe digital technology support, four only described technology support in a training phase, and one was not about transport. In addition, seven publications did only describe the technology design process, one was not found, two focused on indoor mobility, one had the wrong language, one was a dissertation with the same results presented in an included article, one was an assessment of assistance and wayfinding in a virtual environment, and one did only present design requirements. However, two publications were added because of a manual search in the references of included articles. The search strategy and process are summarized in Figure 1.

All publications were screened independently by two authors at title, abstract and full-text screening. Any disagreements were resolved by involving a third author who had not been involved in the screening. A total of 13 articles met our inclusion criteria.

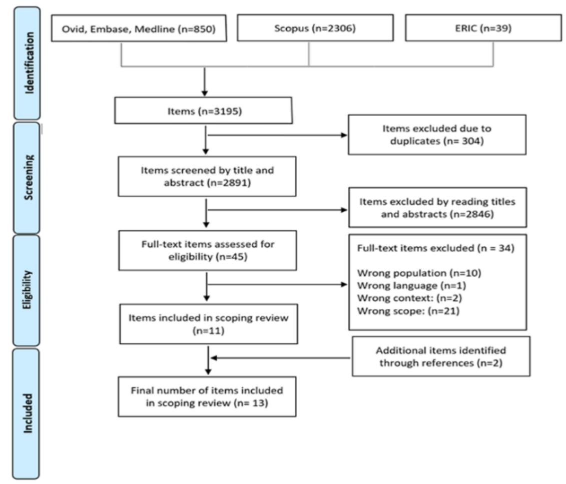

Figure 1. Flow chart of the process of selection of items for the scoping review

2.3. Charting the Data

The research questions guided the process of data charting and result reporting (Levac et al., 2010). All the authors were involved in determining which variables to extract. The charted information included authors, year, country, publication type, focus/aim of the study, sample size, age of participants, gender, disability (IQ if known), other participant characteristics, study design, the context of study/transportation, technology (device), main findings, and user involvement in design development. An overview of the identified studies is presented in table 2.

Author, country	Participants, age	Disability (IQ scores)
Carmien et al. (2005), US	6, 16-21	Moderate intellectual disabilities (40-82)
Chang et al. (2008), Taiwan	6, 19-76	Mental retardation (?)
Davies et al. (2010), US	23, 18-49	Intellectual disability (average 54,32)
Flores et al. (2018), France	Specialists, -	-
Flores et al. (2019), France	2, children	Moderate intellectual disability
Gomez et al. (2015), Spain	18, mean 23.72	Cognitive disabilities
Kelley et al. (2013), US	4, 18-26	Intellectual/Developmental disability
Krainz et al. (2016), Austria	12 (2 intellectual disability), -	Intellectual disability (70-79)

Lachapelle et al (2011), Canada	1, 19	Down syndrome and moderate intellectual disability
Landeros-Dugourd (2012), US	31, 19-27	Cognitive disabilities (54 % Down Syndrome)
McMahon et al. (2015), US	6, 18-24	Mild and moderate intellectual disability
Mechling, Seid (2011), US	3, mean 21.1	Moderate intellectual disability
Smith et al. (2017), US	3, 22-25	Intellectual disability (48-65)

Table 2. Identified studies

3. Results

In this section, we present digital technology and the impact of such support on transportation for this population. Thirteen publications satisfied the inclusion criteria: 7 empirical articles, 4 conference papers, one doctoral thesis, and one conference abstract. One study was described across two publications, a doctoral thesis (Kelley, 2012) and an article (Kelley, Test, and Cooke, 2013), and therefore only the article was included. The publication years of the included publications range from 2005 to 2019. Seven studies had the United States as the research context, two were set in France, and the remaining studies were carried out in Austria, Canada, Taiwan, and Spain (see Table 2).

A total of 115 participants participated in the included publications. The sample size varied from one to 31. Most participants were female, while two publications did not report gender distribution. The age of the participants ranged from 16 to 47 years and in one article the informants were described as children (Flores et al., 2019). Most publications included participants with intellectual disability and some publications focused on a specific diagnosis such as Down syndrome (Gomez et al., 2015). Across publications, the symptom severity and severity of intellectual disability were not specifically described. The study by Flores et al. (2018) had specialists as informants.

Study & country	Study design	Technology	Context	Main findings
Carmien et al. (2005), US.	Experiment	PDA	Public transport	Participants were successful completing tasks in a single trial.
Chang et al. (2008), Taiwan.	Experiment	PDA	Pedestrian	Success ratio 93.3 % with PDA.
Davies et al (2010), US.	Experiment	PDA	Public transport	Users with GPS more successful (73% versus 8%).
Flores et al. (2018), France.	Experiment	Smartphone	Public transport	70% faster compared to the current method.
Flores et al. (2019), France.	Test	Smartphone	Public transport, pedestrian	Users answered correctly on actions to do.
Gomez et al. (2015), Spain.	Experiment	Smartphone	Pedestrian	17 of 18 participants reached destination and identified it correctly.
Kelley et al (2013), US.	Experiment	iPod	Pedestrian	A functional relation between prompts and navigation skills
Krainz et al (2016), Austria.	Field study	Smartphone	Pedestrian	Various disabilities can be supported by one system.
Lachapelle et al (2011), Canada.	Experiment	Smartphone	Public transportation, pedestrian	User needed 3 trials to travel alone within the city.
Landeros-Dugourd (2012), US.	Experiment	Smartphone	Pedestrian	No significant difference in travel autonomy
McMahon et al. (2015), US.	Experiment	Smartphone	Pedestrian	Level of independent direction checks increased to 87%.
Mechling, Seid (2011), US.	A multiple probe design	PDA	Pedestrian travel	Uses successful in self-prompt pedestrian travel without external prompting.
Smith et al. (2017), US.	Experiment	Smartphone	Pedestrian travel	Navigation skills improved with 100% non-overlapping data.

Table 3. Summary of identified studies

3.1. Type of Technology and Design Elements

A variety of digital technologies and devices were used to support people with intellectual disabilities in transportation. Four studies included hand-held devices and personal digital assistants (PDA) (Carmien et al., 2005, Davies et al., 2010, Chang et al. 2008, Mechling and Seid, 2011), and another used iPods (Kelley et al. (2013). Eight studies used smartphones to support and enhance independent navigation (Flores et al., 2018, Krainz et al., 2016, Lachapelle et al., 2011, Flores et al., 2019, Gomes et al., 2015, Smith et al., 2017, McMahon et al., 2013, Landeros-Dugourd, 2012).

Four types of design elements were identified in the articles: visual and auditory prompts, user triggered interaction, context awareness, and assistance options (Table 4).

Ten of the included studies used visual and auditory prompts to support users during transportation. Examples included step-by-step guidance (Lachapelle et al., 2011) and personalized route-by-route travel instructions (Davies et al., 2010; Landeros-Dugourd, 2012) through image and voice prompts. In the article by Kelley et al. (2013) photographs of landmarks in combination with arrows were used as prompts for navigating predetermined routes and to show directional turns. The solution presented in Krainz et al. (2016) gave the user two options: follow a turn by textual prompts or follow a path on a map with arrows showing the next turning point. Two solutions used augmented reality, where the user could see both the real-world and the virtual objects such as markers and cues, to support navigation (Smith et al., 2017; Carmien et al. 2005). While Carmien et al. (2005) used visual and auditory prompts triggered by real-world events, Smith et al. (2017) used augmented reality to give real-time navigation prompts in the form of visual arrows and named landmarks. These prompts could be seen when the iPhone camera was pointed towards a specific destination. In addition, there was a small, embedded map at the bottom of the screen showing the current location of the users.

In six of the studies the users were required to actively act to be supported during transportation (Chang et al., 2008; Davies et al., 2010; Gomez et al., 2015; Kelley et al., 2013; Landeros-Dugourd, 2012; Mechling and Seid, 2011). For example, Kelley et al. (2013) delivered prompts on a predetermined route only when the participant pressed a forward button to display the prompt. Chang et al (2008) used QR-code tags that were placed where the person was expected to decide on which direction to take. These tags were to be scanned by the PDAs built-in camera to trigger prompts.

Context-aware technologies use design elements to determine the state of the user in their environment. For instance, the device presented in Carmien et al. (2005) produced just-in-time instructions triggered by real-world events. By using information about the location and movement of the device, it detected if the user missed the bus or boarded the wrong bus. The device instructed the person to wait for the next bus or notified a caregiver if the person boarded the wrong bus. Krainz et al. (2016) provided support based on routing data that guided the user on a selected path to navigate to a given target selection. Similarly, both Smith et al (2017) and McMahon (2015) used google maps to give real-time navigation prompts to the users. Two studies used GPS coordinates to provide prompts sequentially (Flores et al., 2018; Flores et al., 2019). Lachapelle (2011) used step-by-step procedures to support the user during transportation. The solution provided prompts only when needed, it was however unclear how support was triggered.

In four of the studies, design elements for different assistance options were presented (Carmien et al., 2005; Flores et al., 2018; Lachapelle et al., 2011; Landeros-Dugourd, 2012). This included an embedded panic button which summoned the caregivers' assistance and initiated person-to-person communication between the user and the support communities (Carmien et al., 2005). In Flores et al., (2018), a similar emergency button gave the user the possibility to call an assigned person and also send an SMS with information about the latitude and longitude of his or her location. While the support tool presented in Lachapelle et al., (2011) did not support communication automatically, it was possible to call home for assistance if needed.

Design element	Description
Visual and auditory prompts	The user is supported by visual and/or auditory prompts during transport.
User triggered interaction	The user needs to actively engage with the technology to be supported.
Context awareness	The state of the user is determined by the ICT.
Assistance options	The user can digitally reach out for assistance to next-of-kins.

Table 4. Types of design elements

3.2 Study Design and Evaluation Methods

All included publications were empirical studies. Four publications described their design as experimental (Chang et al., 2008; Flores et al., 2018; Flores et al., 2019; Lachapelle, Lussier-Desrochers, Caouette, and Therrien-Bélec, 2011) and two used multiple probe designs (Kelley et al., 2013; Mechling and Seid, 2011). Additional designs included single trial experimental design (Carmien et al., 2005), randomized experimental design (Davies et al., 2010) ABAB reversal design (Smith et al., 2017), counter ordered repeated measures experimental design (Gomez et al., 2015), adapted alternating treatment design (McMahon et al., 2015), quantitative and quasi-experimental design (Landeros-Dugourd, 2012), and a field study design (Krainz et al., 2016). Only two studies described user involvement in the design of the technology. Carmien et al. (2005) involved the users in user needs assessment and to collect user insights and Flores et al. (2018) involved the users to validate the user interface. Three publications had a particular focus on developing technology and prototypes (Carmien et al., 2005; Chang, Tsai, and Wang, 2008; Flores et al., 2018) and one publication emphasized both the development process and testing of a technology-supported solution (Flores et al., 2019).

Regarding the context, six of the studies focused on pedestrian travel (Chang et al., 2008; Gomez et al., 2015; Kelley et al., 2013; Krainz, Moser, Lind, and Dornhofer, 2016; Mechling and Seid, 2011; Smith, Cihak, Kim, McMahon, and Wright, 2017), one study focused on the navigation of a bus route (Davies et al., 2010), and two focused on both on and off pedestrian campus navigation (Landeros-Dugourd, 2012; McMahon et al., 2015). Flores et al. (2019) studied a hybrid of bus and pedestrian travel, Lachapelle et al. (2011) included three different types of transportation - walking, bus, and subway, and Flores et al. (2018) included a bus route, a bus change, and a pedestrian crossing. One study was conducted in a safe setting (school) as a single-trial context (Carmien et al., 2005).

In six of the included studies, user training was described or briefly mentioned. In one of the studies, a training system was designed to brief the person about the routes. Using a blog platform, the person could access training material such as wayfinding photos and their associated QR code tags (Chang et al., 2008). In another study, the participants were taught how to look at the displayed photograph and navigate on the iPod (Kelley et al., 2013). Similar training was done in three other studies to ensure they could use and independently access the application (McMahon et al., 2015; Mechling and Seid, 2011; Smith et al., 2017). In one study, the participants performed a daily travel task using a script prepared by an instructor and to familiarize the users with the iPhone, they practiced using the iPhone by following a simple in-campus trip (Landeros-Dugourd, 2012).

3.3 Impact of Digital Technology

In terms of impact, although the results varied across the studies, digital technology support improved independent travel for people with intellectual disabilities. Five studies found an improvement in independent pedestrian travel. More specifically, Chang et al. (2008) found that when using a PDA with directions and instruction triggered by QR-code tags, the participants succeeded 93.3% in wayfinding. In contrast, four of six participants failed to arrive at the selected destinations without navigation aid. Meanwhile, Kelley (2013) found a functional relation between picture prompts displayed on an iPod and the participants' pedestrian navigation skills. In the study by Mechling and Seid's (2011), the participants independently used the PDA to self-prompt pedestrian travel without the need for external prompting. The participants were also able to use the device on other pedestrian routes. Further, in Lachapelle et al. (2011), the device successfully helped the participant travelling alone within a city and assisted in completing other tasks. Smith et al. (2017) found that augmented reality improved all participants' navigation skills immediately when using the mobile application.

Digital technology-supported assistants were also effective in other settings than pedestrian travel. In Davies et al. (2010), the GPS-enabled device successfully helped the participants to get off at the correct bus stop and 8 of 11 participants were successful at completing the bus route when using the assistant. While in the control group, with no GPS, only one of 12 participants successfully got off at the correct stop. Further, Flores et al. (2018) reported that their app led to a gain in time compared to the current method (paper book) as assistance during travel for children with intellectual disabilities.

Outcomes comparing digital technology support and other non-digital support types were rare, although McMahon et al. (2015) evaluated three different navigation aids, a printed map, Google Maps, and an AR navigation app, and found that the AR treatment was the most effective. Meanwhile, Gomez (2015) reported that the participants using a mobile system designed to help people with cognitive disability surpassed a standard navigation tool's (Google Maps) performance in terms of the number of users who reached and identified their destination correctly. Whereas 17 of the 18 participants using AssisT-OUT reached the destination and identified it, only 9 of 18 using Google Maps did so (Gomez et al., 2015).

However, Landeros-Dugourd (2012) reported that, based on the study's compared responses, there were no significant outcome differences between the participants who used iPhones with pictures and verbal instructions and those with only written instructions and a printed map. In Carmien et al. (2005), the multimodal hand-held prompter successfully delivered script directions and helped the participants complete their different tasks in the single trial. In the articles by Krainz (2016) and Flores (2019), the participants scored the application as positive; however, they did not present any results related to wayfinding. In Flores (2019), alarms for preventing pressing the stop button in the bus were understood by the children.

4. Discussion

Our review demonstrates that digital technology can support independent transportation for people with intellectual disabilities in specific contexts. This was achieved through design elements such as visual and auditory prompts, active interaction, context awareness, and assistance options. While transportation is a dynamic process that tends to involve several modes (e.g., walking, biking, transit etc.), most studies focused on merely single contexts such as pedestrian travel or public bus transport. Overlapping modes of transportation were not covered. Aspects such as infrastructure (e.g., unfamiliar environments, misleading route information, inaccessible infrastructure such as stairs, crowds, obstacles) and social interaction (e.g., purchasing tickets, standing in line, asking passengers for a seat) were not sufficiently explored and how it could be supported by design elements.

As an example, communication and interaction during independent transportation was a minor concern in the included studies. People with intellectual disabilities encounter several barriers that may not be solved solely through digital technology-supported tools (Hunter-Zaworski and Hron, 1999). Such barriers include scheduling problems, time spent on bus or transportation means, inadequate times of service, attitudes of drivers and other travelers (Bezyak, Sabella, and Gattis, 2017). Consequently, there is a need for studies that explore if additional design elements can solve challenges beyond navigation that people with intellectual disabilities face during independent transport.

Moreover, the described impact was largely achieved through context-aware digital technology and digital technology that required user action, with design elements such as visual and auditory prompts, text and maps, and augmented reality. Still, it may be difficult to keep some participants engaged and motivated when using digital technology that requires user action. It is crucial to recognize that while digital technology support can enhance independent transportation for some people with intellectual disabilities, others may not have access and skills to use such support. People with intellectual disabilities are not a homogenous group. For example, in the included studies, there was little attention given to people with a combination of intellectual and physical disabilities. In addition, for people with profound intellectual disability, the required abilities such as reading and interpreting text and symbolic messages, understanding maps, using digital technology, and listening might make it difficult to realize the intended impact.

This suggests that the digital technology support included in the studies are mostly tailored for specific types of participants, and contexts, and will therefore only fit some people with intellectual disabilities. Due to the specific adaptive and cognitive challenges that people with intellectual disabilities can have, a more detailed description of the study samples and contexts is needed and how it relates to the impact of the design elements. To effectively appraise the digital technology and area of use, future studies should describe the participants beyond the diagnosis and demonstrate both personal and cultural sensitivity in their use of language.

Only a few of the included studies described if and how the participants had been provided instructions on how to use the digital technology. Research shows that without proper training on how to navigate and use digital technology support, users may fail or stop using the technology. While navigation apps can be useful for people with intellectual disabilities, they may need training in using digital technology (Price et al., 2018). It seems unclear if the participants had a social and technological background that made them able to use digital technology easily or if challenges were encountered but not reported. Nevertheless, people with intellectual disabilities tend to be more digitally excluded than other groups in society and face barriers such as poor ICT skills (Chadwick, Chapman, & Caton, 2019). Thus, there is a need for future research that presents recommendations on how to include support and user training as an element of design and development processes.

While twelve of the included studies tested digital technology solutions with people with disabilities, only two studies involved the participants in the design of the digital technology (Carmien et al. 2015, Flores et al. 2018) This may imply that the included design elements and user needs were identified by stakeholders, designers, and researchers. While stakeholders, designers, and researchers can provide ideas and input that betters the digital technology, the exclusion of the user in the design process can lead to the development of tools based on other people's understanding of their needs (Brereton, Sitbon, Abdullah, Vanderberg, and Koplick, 2015).

In addition, it is known that user involvement can increase the usability of the service, positively contribute to user satisfaction, and design outcomes, and enhance the performance and quality of the technology (Bano and Zowghi, 2015). Consequently, there is a need for more studies that provide in-depth descriptions of user involvement in the design of digital technology. The use of visual support such as photovoice, and evaluations in a naturalistic manner could be considered when designing with people with intellectual disabilities (Wass, Hansen and Safari, 2020). Such studies can provide valuable information about the need for additional design elements.

Even if the context and design elements varied across the studies, our review demonstrates that digital technology support can positively impact independent transport for people with intellectual disabilities. These results are important as they demonstrate the potential of digital technology support. However, few studies reported results of implemented digital technologies in real settings and the impact should therefore be taken cautiously. In addition, most studies described the development process or initial results from testing. While the studies showed promising results, most of the studies did not employ methods that include a comparison group. This suggests that it may be difficult to recruit or find participants similar to the ones already included in the studies. However, Davies et al (2008) included a comparison group and showed that the outcomes were significantly more successful at completing a bus route for participants using digital technology support than controls. Several studies did however use a multiple probe design, which allowed the participants to serve as their own controls when evaluating the effectiveness of the technology support tool (Kelley et al., 2013; Mechling and Seid, 2011). Still, there is a need for more studies using both comparison groups as well as multiple probe designs in evaluation of digital technology support. Moreover, there is a need for longitudinal approaches to adequately evaluate the digital technologies.

4.1. Strength and Limitations

One of the strengths of this scoping review is that prior to the current study, a study protocol was published to allow for transparency and replication. In addition, four researchers, as well as a university librarian, contributed to the identification and screening of the articles which added rigour to the process. A possible limitation is that for scoping reviews in general, all studies are included, regardless of quality. It should also be noted that the lack of recently published articles may indicate that digital technology support can have been developed in the industry, without the being published. In addition, another possible limitation is that the findings of this study may not be generalized to developing countries where conditions and challenges can be different.

5. Conclusion

Independent transportation is important in increasing empowerment, quality of life, well-being, and community participation. This scoping review has explored the existing research on digital technology used to support transportation for people with intellectual disabilities. Our findings show that digital technology support has a positive impact on independent transportation and has the potential to help achieve the sustainable development goal number 11 which aims to make cities and human settlements inclusive, safe, and sustainable. Nevertheless, societal attitudes and structures remain significant barriers for people with intellectual disabilities. While aspects of how digital technologies can assist in overcoming the complexities connected to transport were not addressed in the studies, this scoping review can be a starting point for novel discussions.

We recommend future research to address a wider scope of technology support and transportation for people with intellectual disabilities. This includes research on:

- independent transportation that includes multiple contexts and types of transportation.
- how different skills and abilities affect the support needs during independent transportation.
- technology support during daily life and in real-world settings.
- design, development and evaluation of technology-supported supports from a participatory research approach.
- how digital technologies for independent transportation can impact other factors such as community livability and social sustainability.
- the role of user training to enhance the understanding of support needs.

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